

WRITING A THESIS FOR SCIENCE AND ENGINEERING STUDENTS THE METHODS SECTION

The Methods & Materials section describes the steps you took in conducting your research and the materials you used at each step. It is not only useful to readers who want to know what methods you used and how this may have influenced your results, but also to those who are interested in replicating your study or doing similar research. Consequently, it should be sufficiently detailed to allow them to do so.

The main part of the methods section is a description of the procedural steps that were used in your study and the materials used at each stage. However, other elements are commonly present in this section as well.

This handout considers the following topics:

- A The constituents of a Methods section
- B Writing about Procedures
- C Choice of Active and Passive in the Methods section

A THE CONSTITUENTS OF A METHODS SECTION

The elements included in the methods section and the order in which they are presented are not fixed.

However, the list in the following boxⁱ presents possible sections and provides a good model for empirical analysis:

Overview of the experiment (Design)
Population/Sample
Location
Restrictions/Limiting conditions
Sampling technique
Materials
Procedures
Variables
Statistical Analysis

Often the pattern is not that straightforward. In many PhD. theses, there may not be a clear 'methods' section.

Here is an example of a PhD. thesisⁱⁱ that has more than one section of 'methods' (and more than one literature review) but where the word 'methods' is not used in the titles or subtitles:

...

CHAPTER 3 MODELLING FLOW IN SIMPLE CHANNELS WITH HOMOGENEOUS ROUGHNESS

- 3.1 Introduction
- 3.2 Experimental data
 - 3.2.1 Smooth rectangular channel data
 - 3.2.2 Smooth trapezoidal channel data
- 3.3 Modelling simple rectangular channels
 - 3.3.1 One panel solution
 - 3.3.2 Four channel solution
 - 3.3.2.1 Four panel solution with constant panel spacing-variation of \square
 - 3.3.2.2 Four panel solution with constant panel spacing-variation of $\square\square$
 - 3.3.2.3 Four panel solution with constant panel spacing-variation of f and \square
 - 3.3.2.4 Four panel solution with variable panel spacing
- 3.4 Relative contribution of terms in the SKM for smooth rectangular channels
- 3.5 Recommendations for modelling rectangular channels
- 3.6 Modelling simple trapezoidal channels
- 3.7 Relative contribution of terms in the SKM for smooth trapezoidal channels
- 3.8 Recommendations for modelling trapezoidal channels
- 3.9 Concluding remarks

CHAPTER 4 MODELLING FLOW IN SIMPLE CHANNELS WITH HETEROGENEOUS ROUGHNESS

- 4.1 Introduction
- 4.2 Experimental data
- 4.3 Modelling philosophy
- 4.4 Modelling trapezoidal channels with heterogeneous roughness
- 4.5 Guidance on calibration coefficients used within the model
- 4.6 Relative contribution of terms in the SKM equation for differentially rough trapezoidal channels
- 4.7 Recommendations for modelling differential roughness in trapezoidal channels
- 4.8 Comparison to homogeneously roughened channels
- 4.9 Concluding remarks

...

In some types of postgraduate study (particularly at master's level), a thesis might aim to present and evaluate an analytical approach rather than performing experiments directly and discussing the results. Some theses, for example, are concerned with proposing a framework for use in future research. In other theses, the main objective may be a detailed analytical and critical review of the available literature in order to identify future research needs.

Task 1a

Read the two abstracts for theses below. In which thesis would you expect to find more detailed information about methods? Why?

a) *Coupled superconducting microwave resonators for studies of electro-mechanical interaction*

The motivation behind the work described in this thesis is to study the coupling between a nanobar and a pair of identical, coupled, superconducting microwave resonators, where the splitting frequency at their avoided crossing is close to the nanobar resonant frequency.

The splitting frequency as a function of the coupling between the microwave resonators has been thoroughly investigated by theoretical simulations in COMSOL and AIM Spice, and experimentally verified by low temperature measurements. Deviations of the measured splitting from the theoretical values and reflection measurements showed that

the resonators required to be tuned in order to reach the avoided crossing.

A novel tuning mechanism was devised and implemented in-situ in the experiments. Tuning of resonators was successfully achieved and there was excellent agreement of the measured splitting with the predicted values. A wide frequency tuning range of 50 MHz was obtained, more than required for our experiments, without degrading the high resonator quality factors (~ 105). This enabled the measurement of the inherent splitting of the coupled resonator frequencies at the avoided crossing, and more importantly, paves the way for studies of electro-mechanical interaction.

In the absence of nanobars, an analogous experiment that varied the resonator inductance instead of its capacitance was devised. The resonant frequency of one of the resonators was perturbed using a small amplitude magnetic field using a coil placed underneath the sample, a case that has not been previously explored. The results obtained from these preliminary experiments have shown a good agreement with the theoretical predictions.

b) Depressive symptoms in adolescents with type 1 diabetes

Adolescents with T1D are more vulnerable to developing depressive symptoms than their peers and the presence of depressive symptoms can have a negative influence on the self-management of T1D. It is therefore important to gain an understanding of the processes that underlie depressive symptoms in adolescents with T1D and also to examine the relationship between depressive symptoms and metabolic control. A systematic literature review is presented that synthesized and evaluated evidence on the longitudinal relationship between depressive symptoms and metabolic control in adolescents with Type 1 diabetes. The main focus was on issues of directionality within this relationship over time and identifying factors that may influence identified longitudinal associations. An empirical paper that investigated the role of cognitions proposed by Beck's cognitive theory of depression (1967) and Bandura's social cognitive theory (1997) in depressive symptoms in adolescents with T1D is also presented. Further research exploring depressive symptoms in adolescents with T1D is required.

Task 1b

Can you label the following extracts from an article from a science journalⁱⁱⁱ? Choose from:

<i>Overview</i>	<i>Procedure</i>	<i>Limitations</i>	<i>Statistical analysis</i>
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A. Assay plates (384-well) were prepared by dispensing 0.05 μ l of compound from master plates at 1 mM in each well. Final assay volume was 25 μ l and final compound concentration was 2 μ M. The sixth column was the positive growth control and had 0.05 μ l of DMSO. The eighteenth column had 0.05 μ l of a mixture of 50 μ M chloroquine and 50 μ M artemisinin stock solutions as negative growth control. The parasite inoculum (25 μ l) was dispensed into plates containing compounds using a Multidrop Combi
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dispenser (Thermo Scientific). Plates were shaken for 10 s to ensure mixing and then incubated at 37 °C for 72 h in an atmosphere of 5% CO₂, 5% O₂, 95% N₂.

B. *P. falciparum* strains 3D7 and Dd2 used in this study were obtained from the Malaria Research and Reference Reagent Resource Center (MR4). Accurate descriptions can be obtained at <http://www.mr4.org>. Parasite strains were cultured using standard procedures as described²⁸. An inoculum of parasitized red blood cells (PRBC) at 0.25% parasitaemia and 2% haematocrit in RPMI-1640, 5% AlbuMAX, 2% d-sucrose, 0.3% glutamine and 150 µM hypoxanthine was used for the assay.

C. Given the large number of positives, it was operationally necessary to estimate the concentrations producing 50% inhibition using the LDH assay above and generating dose–response curves with fivefold dilution steps down to 3 nM compound in an interplate design, instead of using the hypoxanthine incorporation assay with twofold dilution intraplate series generally considered the standard method to calculate IC₅₀ for antimalarials³⁴. We denominated this parameter XC₅₀ to indicate that it is an estimation of the usual IC₅₀ values. The lowest concentration tested was 3 nM. Agreement between the two methods was found to be within the expected limits with standard antimalarials (Supplementary Table 3). To eliminate the possibility of retaining inhibitors of the biochemical readout system, one set of the primary hits was assayed against parasite LDH activity under identical screening conditions. Non-specific cytotoxicity was also a concern and we addressed it by assaying the hits at five times the screening concentration against human hepatoma HepG2 cells as below.

D. Molecular frameworks were calculated using an in-house implementation of the algorithm described previously¹². The frameworks were then used to define clusters of compounds that share a particular framework. To minimise the number of frameworks that describe only a small number of molecules (<10 in our standard processing), we attempt to reclassify all such molecules into a smaller framework (that is, the framework describes a smaller proportion of the structure of the reclassified molecule). Therefore there will exist some clusters that share a molecular framework, but that are not as structurally homogenous as would be given by simply grouping together compounds by unique frameworks. Compounds were also classified in chemical families using the Daylight fingerprint methods with a Tanimoto similarity index of 0.85, following the procedures in the Daylight Information Systems manual¹³.

NB The sections would not appear in this order. Which would come first?

Task 2

1. Label the following sections from a thesis^{iv} There are six classifications but you only need to use four of them. Choose from:

*1 Overview & Sample, 2 Sampling Technique, 3 Materials,
4 Limitations, 5 Procedure, 6 Statistical Analysis*

A. Each patient record was studied and the location of all penetrating injuries for each patient was marked on one of four anatomical figures (Figures 27 - 30 below).

Each wound was colour-coded according to severity, these are defined here:

minor - not a threat to life or limb, these were given an average AIS score of 1.

major - wounds that resulted in major blood loss, threat to life, tendon damage, bone involvement, major neurovascular injury or permanent major cosmetic deformity, these were given an average AIS score of 3.

devastating - fatal or near-fatal (patients in the near-fatal category arrived at hospital in cardiac arrest or in a moribund state), these were assigned an average AIS score of 5.

B A computerised, retrospective search was carried out on 500 consecutive patients attending the Accident and Emergency department of Glasgow Royal Infirmary between 2006 and 2009 following penetrating trauma.

C. Patients were identified from their discharge diagnosis. STAG (Scottish Trauma Audit Group) records for penetrating trauma victims were identified for the same period (STAG collates information on patients with major injuries who died, or who were in-patients for more than 72 hours).

D. The total number of wounds in all three categories of severity were plotted on the anatomical figures and are presented.

Figures 27 – 30 are copies of the anatomical charts used to plot the site of the wounds. These charts were designed so that the lines of demarcation correspond to prominent bony landmarks and other clear surface anatomical features. These are described here.

The location of wounds was determined exclusively by clinical notes and sketches.

2. Can you put the 4 sections back in their original order?

B WRITING ABOUT PROCEDURES

Task 3

The following extract has been taken from a thesis^v. Underline words that refer to procedures, and **highlight** or circle words that refer to materials.

3. Experimental Method

3.1. Solders

The solders used in the present work are given below (all compositions weight %):

Solder Name	Nominal Composition	Supplier
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[table continued here]

Table 3.1. Compositions of solders used in the present work

3.2. High-cycle fatigue (HCF) test development

3.2.2. Solder joint construction

The solder joints are constructed by filling with solder the gap between two axially-aligned cylindrical copper rods with a diameter of 2.50 mm. The rods were manufactured by EDM (Electro-Discharge Machining) to ensure maximum trueness; these were found to be far superior to those made by more conventional lathe machining. Testing the actual diameters of the rods showed they have a diameter deviation no more than 0.08 mm from the nominal 2.50 mm. To create the solder joint, two rods are assembled in a stainless steel 316 fixture that aligns them end-to-end and, when the desired gap between the ends has been set, clamps them in place very accurately (Figure 3.1).

[figure here]

Figure 3.1. Stainless steel assembly block holding two halves of Cu rod prior to soldering

The description of the steps you followed in conducting your study should be written so that a reader in your field could accurately replicate your procedure is required. The Procedures section is usually developed along the same time sequence that the researcher followed in setting up the experiment.

Because this time sequence is often the main organising principle of the section, the logical relation of time is not usually expressed overtly but is instead made clear from the sequence of the steps described.

This means that you would rarely write "first", "second", "third", and so on, although "then" is quite commonly used (but not at the beginning of a sentence).

Example^{vi}:

All participants were instructed "to listen or watch for main ideas and to take notes as you would in a regular lecture situation". They were then asked "to explain what the lecturer had said as if you are telling a friend who had missed the lecture but needed the lecture material to prepare for a test". In this task, they were allowed to use their notes and to take as much time as they needed. These immediate recall summaries were tape-recorded and several participants also participated in follow-up interviews. The summaries were

then transcribed and analyzed for completeness and accuracy. In doing the transcriptions, the authors created the orthographic forms of the texts presented later, marking sentence and paragraph boundaries and using a series of 3 periods (...) to indicate a pause in the oral version.

It is sometimes necessary to explain more clearly the relationship in time between certain events. Here is an extract from later in the "Procedure" section of the same article:

Evaluation of each participant's transcript was done qualitatively by the two authors after extensive review of the videotape and a lengthy interview with the lecturer.... Before interviewing Professor Caddell, the two authors did an independent analysis of the structure and content of the lecture....

Task 4

With a neighbour, discuss examples of explicit and non-explicit expression of time in the following section of a PhD in Engineering^{vii}:

A tolerance of ± 20 microns is allowed at this stage due to practicality and the fact that this dimension is not critical to the determination of tensile stresses. The ends of the rods as-manufactured have good orthogonality to their long axes but their surfaces are too rough for acceptable soldering. Therefore before soldering they are faced off with 1200 then 2500 grit abrasive paper using the same alignment fixture as before on a circular grinding wheel. This surface is further prepared just before use by dipping for 5s in a dilute nitric acid solution then rinsing with water to remove any oxide layer or contamination. The final preparation stage before soldering is to coat the rods with polyamide ('Kapton') tape which resists solder (as seen in Figure 3.1). Only the surfaces to be soldered are left exposed. This ensures that when immersed in a solder bath the majority of the rod is not wetted by the solder.

C CHOICE OF ACTIVE AND PASSIVE IN THE METHODS SECTION

Look again at an extract from the thesis. What was used more often - the passive or active voice?

Therefore, before soldering they are faced off with 1200 then 2500 grit abrasive paper using the same alignment fixture as before on a circular grinding wheel. This surface is further prepared just before use by dipping for 5s in a dilute nitric acid solution then rinsing with water to remove any oxide layer or contamination. The final preparation stage before soldering is to coat the rods with polyamide ('Kapton') tape which resists solder (as seen in Figure 3.1). Only the surfaces to be soldered are left exposed. This ensures that when immersed in a solder bath the majority of the rod is not wetted by the solder.

You can use either the *active or passive voice* when you describe the procedure in your thesis.

The passive is used a lot, but there is usually a mixture (see, for example, paragraph B in task 1, and task 2).

Active voice

The two authors	did	an independent analysis	of the structure and content of the lecture
An independent analysis	was done	(by the two authors)	

Passive voice

Your decision on whether to use the active or passive voice in procedural statements should be made keeping the following in mind:

- 1 The passive voice is conventionally used to describe procedure in order to *depersonalise* the information. The passive construction allows you to omit the agent (usually "I" or "we"), placing **emphasis on the procedure** and how it was done.

For example:

*A computerised, retrospective search was carried out on 500 consecutive patients (*by us = implied information that is not given).*

- 2 In addition to questions of style, your choice of the active or passive voice will sometimes be determined by a general principle of English language: *old information* comes near the beginning **of the sentence** and new information (mentioned for the first time) at the end.

Poor example:

One of the main limitations of vibration testing as practised by most soldering researchers is that it involves the testing of PCB assemblies populated with components in order to determine their reliability under **vibratory conditions (information mentioned the first time)**. An individual solder joint *may experience (active)* a variety of specific conditions (*refers back to the 'vibratory conditions' mentioned before*) depending on the type of component it is attaching, its position on the PCB and the vibration loading imposed on it.

Instead, you would follow the known-new information principle, and start the second sentence with the old (=previously mentioned) information. In order to do this, you may need to use a passive.

Good example:

One of the main limitations of vibration testing as practised by most soldering researchers is that it involves the testing of PCB assemblies populated with components in order to

determine their reliability under **vibratory conditions** (new information). The precise *conditions* (old information) experienced by an individual solder joint (passive) vary hugely with the type of component it is attaching, its position on the PCB and the vibration loading imposed on it.

Task 5

Consider the following extract from a PhD thesis^{viii}:

Seven hundred questionnaires were distributed to dentists attending a provincial convention and a total of 298 valid forms were returned. Differences were determined between the samples and between the back pain sufferers and non-sufferers. Of the 465 dentists, 62.2 % (288) had suffered back/neck pain at sometime in their lives and 36.3 % were currently suffering from such a problem.

What do you think was the next sentence? Choose from:

1. Back pain was found to be greatest among dentists aged 30 to 50 years, which ...
2. Dentists aged 30 to 50 years experienced the greatest back pain, which ...

Task 6

Rewrite the following extract from a Methods section^{ix}. Depersonalise and change verbs to the passive voice where necessary, and make any other changes you consider appropriate.

1 Our 3-year study of changes in the ration of serum urea to serum creatinine in Colorado wild bears began in the winter of 2006 and ended in the fall of 2009. **2** We performed the investigation in the Black Mesa-Crystal Creek area in west-central Colorado. **3** The study area has three major vegetation bands: a mountain shrub community at lower elevation (2235 to 2330m), large aspen forests at elevations between 2330 and 3330 m, and mixed forests of Engelmann spruce and fir at higher elevations. **4** We obtained a total of 76 blood samples from 27 female and 21 male bears. **5** We captured bears with Aldrich spring-activated foot and lower leg snares. **6** We immobilized snared bears with a combination of ketamenia hydrochloride and xylazine hydrocholride. **7** To administer the drug, we used a six-foot pole. **8** In winter we located the bears with a radio signal that the bears' collars emitted. **9** We cooled the samples, separated serum from red blood cells, and determined urea and creatinine concentrations. **10** We did our statistical analysis of changes in blood parameters with Scheffe's comparison because we could not consider seasonal values either independent or dependent.

D: GOOD ACADEMIC PRACTICE

An additional hand-out about correct referencing and plagiarism is available on Canvas.

These topics are very important, but we trust that by this stage of your degrees, you are aware of that.

Here is a short exercise to make you think a bit more about these subjects. Discuss your answer with your neighbour(s). If you feel you need extra help, there is plenty of information on the university intranet and/or on Canvas.

Task 7

Compare the originals^x on the left with the paraphrases or quotes on the right.

Are they acceptable? What would you change and why?

<p>1. <i>It is an experimental technique concerned with the development, recording and analysis of myoelectric signals.</i></p> <p>(Note: definition of 'electromyography', taken from Basmajian & DeLuca, 1985, p.121, it refers to)</p>	<p>Electromyography involves recording, analysing and developing myoelectric indicators, and is a previously untried procedure. (Basmajian & DeLuca, 1985)</p>
<p>2. <i>The cell body and dendrites of a motor neuron, the multiple branches of its axon, and the muscle fibres that innervates it.</i></p> <p>(Note: definition of 'motor unit', taken from Enoka, 1994 p.151)</p>	<p>2. The smallest functional unit for the neural control of the muscular contraction process is called a motor unit (Fig. 6-1). It is defined as: "The cell body and dendrites of a motor neuron, the multiple branches of its axon, and the muscle fibres that innervates (sic) it" (Enoka, 1994 p.151)</p>

KEY

Task 1a

A) is likely to have more specific detail regarding methods as the research deals with experiments and a discussion of the results. B) instead is a long analytical and critical literature review intending to point out gaps and indicate the need for further research

Task 1b

- A. Procedure (this would come second)
- B. Overview (this would come first)
- C. Limitations
- D. Statistical analysis

Task 2

1. A. Procedure B. Overview and sample C. Sampling technique D. Statistical Analysis
2. Order: 1B-2C-3A-4D.

Task 3**3. Experimental Method****3.1. Solders**

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[table continued here]

Table 3.1. Compositions of solders used in the present work**3.2. High-cycle fatigue (HCF) test development****3.2.2. Solder joint construction**

The solder joints are constructed by filling with solder the gap between two axially-aligned cylindrical copper rods with a diameter of 2.50 mm. The rods were manufactured by EDM (Electro-Discharge Machining) to ensure maximum trueness; these were found to be far superior to those made by more conventional lathe machining. Testing the actual diameters of the rods showed they have a diameter deviation no more than 0.08 mm from the nominal 2.50 mm. To create the solder joint, two rods are assembled in a stainless steel 316 fixture that aligns them end-to-end and, when the desired gap between the ends has been set, clamps them in place very accurately (Figure 3.1).

[figure here]

Figure 3.1. Stainless steel assembly block holding two halves of Cu rod prior to soldering

Task 4

A tolerance of ± 20 microns is allowed at this stage due to practicality and the fact that this dimension is not critical to the determination of tensile stresses. The ends of the rods as-manufactured have good orthogonality to their long axes but their surfaces are too rough for acceptable soldering. Therefore before soldering they are faced off with 1200 then 2500 grit abrasive paper using the same alignment fixture as before on a circular grinding wheel. This surface is further prepared just before use by dipping for 5s in a dilute nitric acid solution then rinsing with water to remove any oxide layer or contamination. The final preparation stage before soldering is to coat the rods with polyamide ('Kapton') tape which resists solder (as seen in Figure 3.1). Only the surfaces to be soldered are left exposed. This ensures that when immersed in a solder bath the majority of the rod is not wetted by the solder.

Task 5

Both sentences are possible, depending on the focus of the next part of the text. In the original text, the author chose sentence 1 (*Back pain was found to be greatest among dentists aged 30 to 50 years, which ...*), probably because she wanted to pick up the previously mentioned issue of back pain, which (as old info) is put at the beginning of the sentence. This then leads to the use of the passive.

Task 6

1 Our 3-year study of changes in the ration of serum urea to serum creatinine in Colorado wild bears began in the winter of 2006 and ended in the fall of 2009. **2** The investigation was performed in the Black Mesa-Crystal Creek area in west-central Colorado. **3** The study area has three major vegetation bands: a mountain shrub community at lower elevation (2235 to 2330m), large aspen forests at elevations between 2330 and 3330 m, and mixed forests of Engelmann spruce and fir at higher elevations. **4** A total of 76 blood samples were obtained from 27 female and 21 male bears. **5** Bears were captured with Aldrich spring-activated foot and lower leg snares. **6** Snared bears were immobilized with a combination of ketamenia hydrochloride and xylazine hydrocholride. **7** In winter the bears were located with a radio signal emitted by the bears' collars. **8** The samples were cooled, serum was separated from red blood cells, and urea and creatinine concentrations were determined. **9** Statistical analysis of changes in blood parameters was done with Scheffe's comparison because seasonal values could not be considered either independent or dependent.

Note: sentences 4-10 are now all in the passive, which might be too much of a repetitive pattern for the reader. The writer might consider re-organising this section, or adding some information to remedy this. (e.g. sentence 7 could go before 5, and 4 could be moved before sentence 8, and changed to 'These methods led to (active) the capture of 27 female and 21 male bears, from whom a total of 76 blood samples were obtained.')

Task 7

Electromyography involves recording, analysing and developing myoelectric indicators, and is a previously untried procedure. (Basmajian & DeLuca, 1985)	Not acceptable: the writer is simply playing with words, and not demonstrating their understanding in the paraphrase. A quote would be better here.
The smallest functional unit for the neural control of the muscular contraction process is called a motor unit (Fig. 6-1). It is defined as: "The cell body and dendrites of a motor neuron, the multiple branches of its axon, and the muscle fibres that innervates (sic) it" (Enoka, 1994 p.151)	Acceptable: it was a good decision to quote here, as it is a precise definition. The reference is given correctly, and the addition of (sic) shows that it is the original author who made a mistake, not a misquote from the writer (-the verb should be the plural form 'innervate' here, as the head word of the corresponding subject is fibres).

ⁱ Adapted from Weissberg and Buker, 1990: 92

ⁱⁱ <http://etheses.bham.ac.uk/688/1/Chlebek09PhD.pdf>

ⁱⁱⁱ <http://www.nature.com/nature/journal/v465/n7296/full/nature09107.html>

^{iv} http://etheses.bham.ac.uk/692/1/Bleetman00PhD_A1a.pdf

^v <http://etheses.bham.ac.uk/198/1/Barry08EngD.pdf>

^{vi} Olsen, L A and Huckin. T N (1990) Point-driven understanding in engineering lecture comprehension English for Specific Purposes. 9, page 36

^{vii} <http://etheses.bham.ac.uk/198/1/Barry08EngD.pdf>

^{viii} <http://etheses.bham.ac.uk/216/1/Gandavadi08PhD.pdf>

^{ix} Example from Weissberg and Buker, 1990:93

^x <http://etheses.bham.ac.uk/216/1/Gandavadi08PhD.pdf>