ECSE Capstone Project

Coursebook 2023

Department of Electrical, Computer, and Software Engineering

ENGINEERING
DEPARTMENT OF ELECTRICAL,
COMPUTER, AND SOFTWARE ENGINEERING

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Outline of Course Schedule

Week	Date	Proposed Lectures *Tuesdays, 10-11 am*	Tutorials *Thursdays, 10 am-12 pm or 3-5 pm*	Major Assignments[†]
1	27 Feb-3 Mar	Welcome to the Project	Team Formation	
2	6-10 Mar	Risk Analysis[‡]	Risk Analysis EEE Technical Refresh: Strain Gauges	**Risk Analysis** [5%]
3	13-17 Mar	Sustainability: The Why	Self-directed[*] EEE Technical Refresh: Amplifier Design	
4	20-24 Mar	Sustainability: The How	Self-directed[*] EEE Technical Refresh: PCB Design	
5	27-31 Mar	Peer Reviewing	Self-directed[*]	**Project Proposal** [10%]
6	3 - 7 Apr	*No lecture*	Self-directed[*]	**Project Proposal Feedback** [10%] PCB Design Bill of Materials
	10-21 Apr		Mid-Semester Break	
7	24-28 Apr	*No lecture - ANZAC Day*	Self-directed[*]	
8	1-5 May	Māori and Data Sovereignty[‡]	Self-directed[*]	
9	8-12 May	Te Tiriti o Waitangi	Self-directed[*]	
10	15-19 May	Privacy[‡]	Self-directed[*]	
11	22-25 May	*No lecture*	Demonstrations	**Demonstration and Interviews** [15%]
12	29 May-2 Jun	Course Wrap-up	*None*	**Final Report** [35%] **Course Reflection** [5%]

Notes:

[†] In addition to the major assignments, you will have weekly **Mentor Engagement** sessions and fortnightly **Status Reports** in weeks one to ten.
[*] Self-directed tutorials are a time for your team to work together on the project.
[‡] Denotes a guest lecture.

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1. Introduction

Welcome to your capstone project. In this course, you will apply many of the technical skills and knowledge you have learned over the past few years of your degree. This combined course contains ELECTENG 770, COMPSYS 770, and SOFTENG 770. You will work together in mixed specialisation teams to design and build a prototype system to write a business case.

1.1 What is a Capstone Project?

A capstone project is a final, culminating project completed by students near the end of their studies. The term capstone is an architectural feature. It refers to the last stone placed at the top of a building or wall, usually at the highest point, to show that the structure is complete. It is the culmination of the whole construction project, like a crowning jewel.

To quote Hoffman[9]:

> "An engineering capstone course integrates the skills and competencies that students have learned in their engineering program. It attempts to balance technical, business, and interpersonal skills that will help students to immediately contribute to team efforts in today's fast-paced business and technical environment. The engineering capstone course simulates as close as academically possible the activities in which an engineer is involved. The course challenges the student's personal and professional skills. The nature of the course forces us to accept dimensions of professional practice that go beyond technology by also including societal considerations."

Or, to paraphrase, the purpose of a capstone project is to provide you with an opportunity to integrate and apply what you have learned throughout your studies in a real-world setting. You will use your acquired knowledge and skills to solve a challenging problem in a simulated industry setting. It gives you a chance to demonstrate your expertise in your specialisation.

Throughout this project, you will be:

- Working together in a small multi-disciplinary team (electrical, computer systems, and software engineering).
- Developing and presenting a business plan.
- Designing a prototype solution for a specified problem (see the Project Brief).
- Presenting your prototype to a panel of experts, both technical and non-technical.

The project will take your team approximately ten weeks to design and implement, with two weeks for presentations and report writing.

Why do you have to do a capstone project? There are several reasons why:

- **Hones skills:** you've spent the past few years learning technical and soft skills that will help you in your post-study career. The capstone project is a safe, guided space to allow you to apply these skills in a broader context. Along the way, you'll see what you don't know yet and be able to ask questions to fill in these knowledge gaps before you enter the professional world.
- **Demonstrates learning and knowledge:** while you have taken several years of classes, it doesn't mean you've learnt what was taught. When asked a question, you will often remember you learnt it in class, but you can't remember what it was. The capstone allows you to apply the knowledge in a project, helping you to refresh and establish the ability to answer these tough questions.
- **Increase confidence:** your capstone will help you see how much you are capable of. This challenging project will push you and demonstrate what you can do in a short time period.
- **Increases the rigor of your final year:** the capstone increases the stakes of what you are doing, helping you to focus your energy on a life-like project and the continuation of your learning.

1.2 Intended Learning Outcomes

By the end of this course, you should be able to:

1. Demonstrate the ability to apply the knowledge and skills learnt in previous courses to a concrete, real-world problem.
2. Formulate a business plan justifying the development and marketing of an engineering solution.
3. Demonstrate the ability to communicate effectively through oral, written, and visual presentations.
4. Evaluate the legal and ethical issues in developing a real-world solution, including sustainability, data sovereignty, health and safety, and social. Incorporate diverse viewpoints, especially respecting Te Tiriti o Waitangi.
5. Further develop the ability to collaborate and work successfully in a diverse team.

1.3 How does Capstone Differ from 'Part IV' Projects?

The 'Part IV' project (COMPSYS/ELECTENG/SOFTENG 700) is a research project. In these projects, you work in pairs to explore new directions and expand humanity's knowledge. These are intended to teach you how to perform research, including searching for background knowledge, designing prototypes, running evaluation studies, and reporting your results.

In contrast, a capstone project is a design and build project. It builds on the skills you have learnt over your whole engineering programme and helps you consolidate your knowledge. You will learn skills related to completing the project, not new technical skills or background. While you will write a report at the end of the project, this report is focused on developing a business case based on your prototype rather than adding new knowledge.

Thus, the capstone is similar to the design courses you took in Parts II and III, while the 'Part IV' projects differ from what you previously worked on. Capstone projects are designed to mirror working in an industry-based job, while 'Part IV' projects are training you to be a researcher.

Some other (minor) differences:

- Capstone project teams have more members (seven to nine students),
- Capstone projects are a single semester,
- Everyone in capstone works on the same project.

1.4 Teaching Staff

Here are the key contacts for the course:

1.4.1 Course Coordinator

The course coordinator is responsible for managing and organising this course. You should contact the course coordinator if you have any questions or issues about your personal circumstances or marks.

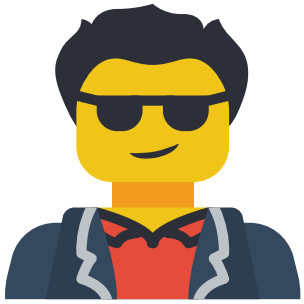
Dr Craig Sutherland
Email: cj.sutherland@auckland.ac.nz
Phone: +64 9 923 2514 or extension 82514
Room: 405-665

1.4.2 Technical Leads

If you have any technical questions, you should raise these via the Microsoft Teams channel. We have staff who will triage these questions and reply where possible. However, you may receive a message from one of the technical leads if the triage staff cannot answer your questions.

Note: do not contact the technical leads directly. This information is here in case they need to contact you for further information.

Dr Duleepa Thrimawithana
Area: Electrical and Electronic Engineering
Email: d.thrimawithana@auckland.ac.nz



Associate Professor Kevin Wang
Area: Computer Systems Engineering
Email: kevin.wang@auckland.ac.nz

Dr Nasser Giacaman
Area: Software Engineering
Email: n.giacaman@auckland.ac.nz

Dr Andrew Meads
Area: Software Engineering
Email: andrew.meads@auckland.ac.nz

1.4.3 Mentors

Each team will have a mentor to support them. Their role is to help your team with any non-technical questions or issues. You will need to meet with them once a week to provide a status update.

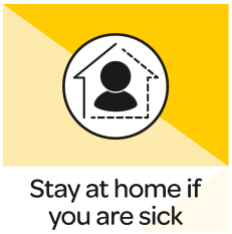
In addition, your mentor is your first contact point if there are any urgent issues with your team. They will escalate any critical issues to the course coordinator.

1.5 Commitment to Teaching and Learning Continuity

The University of Auckland undertakes to maintain the continuity and standard of teaching and learning in all your courses throughout the year. If there are unexpected disruptions, the University has contingency plans to ensure that access to your course continues and that your assignment is fair and not compromised. Some adjustments may need to be made in emergencies. You will be kept fully informed by your Course Coordinator, and if a disruption occurs, you should refer to the University Website (`https://www.auckland.ac.nz/`) for information about how to proceed.

1.6 Stay Home If You Are Unwell

If you have cold, flu or COVID-19 symptoms, stay home and call your doctor or Healthline on **0800 358 5453** for advice about getting tested. If you're waiting for COVID-19 test results and have been told to self-isolate, you must legally do so. Self-isolation means staying at home and taking common sense precautions to avoid close contact with those you live with.



You must stay away from campus until you have been cleared by Healthline or another healthcare professional to attend in person or have received a confirmed negative COVID test result.

If your ability to attend a tutorial or complete an assignment is affected by illness or other misfortune (compassionate consideration), contact the course coordinator (*Dr Craig Sutherland*).

Additional information about The University of Auckland's policies and procedures related to COVID-19 are available online (https://www.auckland.ac.nz/en/news/notices/2022/covid-19.html).

1.7 Assessment

This course is a practical project course - there is no theory components (tests or exams.) To pass the course, you need to achieve 50% overall.

1.8 Course Components

This course has three components: lectures, tutorials, and drop-in sessions.

1.8.1 Lectures

We will cover additional content in lectures to help you with your projects. This content is non-technical and builds on what you have learnt in the Systems Courses (ENGGEN 204 and 303). You are expected to do additional reading and **practise exercises** outside the formal contact hours. Lectures are on Tuesdays from 10:05 to 10:55 am, in OGGB4260-073.

Please be on time for lectures, and if you are late, enter unobtrusively to avoid disturbing other students. Be considerate of noise while the classes are in progress, and silence your cell phone before entering.

Video recordings of lectures will be made available online. You may find these helpful for revisiting the more challenging concepts. Be aware that capturing all the activities in a class is impossible. Sometimes technical issues prevent entire lectures from being recorded; there's nothing like being there in person.

1.8.2 Tutorials

The tutorials are small group sessions where you can work together in your teams. Most of these tutorials are a time for you to work on your project in your group. However, there are scheduled tutorials in the following weeks:

Week 1: Team formation,
Week 2: Risk analysis plus a technical refresher session for EEE students.
Week 3: Technical refresher session for EEE students (one hour only).
Week 4: Technical refresher session for EEE students (one hour only).
Week 11: **Demonstration and Interviews**.

Tutorials are on Thursdays from either 10:05 to 11:55 am or 3:05 to 4:55 pm. Please check your enrolment schedule to find which tutorial you should attend. We may allocate you to a different room based on your team. Please check your team allocation details for which room your group will meet.

The morning tutorials are in rooms 402-220, 402-221, 405-336, 405-344.

The afternoon tutorials are in rooms 405-222, 405-236, 405-240, 405-336, 405-344.

Note: it is not possible to change your tutorial time slot.

1.8.3 Drop-in Sessions

In addition to the tutorial sessions, we have organised the following drop-in clinics in the MDLS labs.

- **405-521**
  - Thursdays, 2-4 pm
  - Fridays, 3-5 pm
- **405-522**
  - Tuesdays, 12-6 pm
- **405-536**
  - Wednesdays, 11 am-2 pm
- **405-541**
  - Wednesdays, 12-2 pm
  - Thursdays, 12-6 pm
  - Fridays, 10 am-2 pm

You are welcome to use the labs during any of these times: we have booked the labs to ensure there is some time available for you. However, they are optional sessions: we will not be providing support during most of these times.

There will be technical support available on Tuesdays between 12-2 pm in **405-522**.

1.9 Microsoft Teams

We will be using Microsoft Teams as a communications forum for this course. Microsoft Teams is a collaboration and communications workspace that you can use for meetings, messaging, and file sharing.

We will be using the following channels in Microsoft Teams:

Common Room This channel is for general communications across all students and staff.

Tech Support This channel is for technical support. Use it if you want to connect with the teaching staff to ask for help with your projects. This channel is public, so do not discuss specifics for your prototype.

Assignment Questions This channel is for general questions about the assignments. Use it if there are questions about the assignment details, deadlines, requirements, marking rubrics, etc. If you have questions about your individual or team marks, please contact the course coordinator (*Dr Craig Sutherland*.)

Team This is a private channel that is just for each team. Use it for communications with your team mates and mentor[1].

There are two ways to use Microsoft Teams:

- Desktop, iOS, and Android application: these can be downloaded from `https://www.microsoft.com/en-us/microsoft-teams/download-app`.
- On the web: this can be access via `https://teams.microsoft.com/`.

1.10 Online Resources

These are some generic resources to help you in this course.

1.10.1 Canvas

`https://canvas.auckland.ac.nz/courses/91591`

Canvas, the University's learning management system, will contain all online resources for the course. Here you will find:

[1] The teaching team can also access this channel.

1. An electronic copy of this Coursebook
2. A record of all e-mail announcements
3. Your assignment marks
4. Answers to Frequently Asked Questions (FAQs)
5. Links to useful websites, lecture recordings, and online tools
6. Submission dropboxes

1.10.2 Library and Learning Services

https://www.library.auckland.ac.nz https://www.library.auckland.ac.nz/services/student-learning/undergraduate

The library website provides a number of resources to help you with your study. As well as containing a wide range of books, magazines, and other physical material, the library also provides workshops and resources to help students with their studies.

1.11 Approaches to Study

University is very different from high school in many ways. As a university student, you are expected to play a key role in managing your own learning. In this section, we have included some tips to help with your learning.

1.11.1 Expectation of self-directed study in this course

Generic guidelines state that a student enrolled in a 15-point course should expect to spend **10 hours a week** on the course, which includes class hours and personal study time. Unfortunately, these guidelines do not consider diverse student ability and prior discipline knowledge, specify the level of attainment likely to be achieved with this level of time investment, or differentiate between cognitively passive or cognitively active learning behaviour ('studying hard' vs. 'studying smart').

1.11.2 Time Management

Time management is a crucial skill to support your study, but not always the easiest skill to apply. Setting the right balance between your study time and time for other tasks is important to help you succeed. Some tips for effectively using your time are:

Write a schedule: at the start of each week, plan what you will be doing when. Start by including your lectures, labs, tutorials, etc., then plan time for any tasks you need to complete that week (e.g. any assignments, pre-reading, etc.) Don't forget to include time for yourself, especially during intense times (e.g. preparing for exams or tests.)

Allow extra time: it often takes more time than expected to complete assignments and other tasks. So when planning, build in a buffer to allow for these overruns. If you do finish the activity sooner, use the time to take a "me" break and reward yourself for finishing early!

Get rid of distractions: when you are studying, turn off phones and other devices that could distract you. Ideally, try to find a place where you can focus. Remember, different locations work for different people, so experiment and find a good place for you.

Take down time: we need time to change between different activities. This time helps to clear your mind and allows you to focus on the next topic. Exercise is often a great way to help clear your mind: don't underestimate the link between your physical and mental abilities.

More information is available online at https://learningessentials.auckland.ac.nz/key-study-skills/time-management/.

1.11.3 Note Taking

A good set of notes can make a difference to what you learn. Taking notes during lectures and other face-to-face activities can help you to remember what was taught. Reviewing these notes later will help to consolidate your learning.

Research has indicated a link between orderliness and high grades. So take the time to revisit and order your notes after initially writing. Ideally, you should spend some time every week organising and revising your notes:

1. Are things ordered in a way that you can find things?
2. Do your notes make sense?
3. Are their items that are missing?
4. Could parts be rewritten to improve your understanding?

You don't need to spend long, but the time you spend will repay itself by the end of the semester.

More information is available online at https://learningessentials.auckland.ac.nz/key-study-skills/note-taking/.

1.11.4 Where to Find Additional Help

There are a number of online resources that can support your learning. These are available at https://learningessentials.auckland.ac.nz/.

In addition, Libraries and Learning Services provides a range of workshops to help you develop academic skills. These are advertised at https://www.library.auckland.ac.nz/workshops/.

1.12 Course History

Year	Description
2023	First offering of the course

1.13 Errata

If you find any errors in this course book, please contact the course coordinator (*Dr Craig Sutherland*).

We will publish all mistakes and corrections online on Canvas (https://canvas.auckland.ac.nz/courses/91591/pages/course-book).

2. Project Brief

You have been hired at an engineering firm to answer a Request for Proposals by the Royal New Zealand Society for the Prevention of Cruelty to Animals (SPCA). SPCA want to build an intelligent scale system for weighing dogs at their rescue centres. The system is needed so SPCA can help improve the health and well-being of the animals under their care. This system should provide real-time data on the weight and growth of the animals, enabling staff to identify any issues and take appropriate action quickly. The system should use a combination of sensors and digital technology, such as load cells and wireless connectivity, to monitor the health of the animals in SPCA's care and assist staff in their day-to-day jobs.

Note: You are not allowed to contact SPCA at all. You may use any public resources they make available (including their website: `https://www.spca.nz/`). But you cannot call their staff, visit their centres, or make any other attempt to contact them.

2.1 Background

SPCA is a major New Zealand organisation with 31 centres and six community partnerships. Their 600 staff care for over 31,000 animals every year. Moreover, the number of animals needing rescue and care is increasing every year, which means SPCA needs to change how they work to handle the changes.

One crucial task carried out by carers is the regular weighing of animals. Staff use changes in weight to get an idea of their physical health, as animals cannot talk. However, weighing animals is a challenging task. This task can cause animal stress, making it more difficult to weigh them. As a result, staff tend to focus on the animals and sometimes lose the recorded data, which means the animals need to be weighed again. This process can become an ongoing cycle, adding to the stress on animals and staff.

Therefore, SPCA has decided to automate part of the weighing process. They want the staff to focus on the animals rather than the technical details of measuring and recording weights. They have issued a Request for Proposals (RFP) for an intelligent scale system that can weigh animals and automatically track changes in their weight. As animals have a wide range of weights, they have decided to focus on one of their more common animals: small and medium dogs. While dogs

have a wide variety in their weights, they want to focus on dogs weighing between 5 and 25 kg (dogs outside these weights will be covered in a future project.)

2.2 Requirements

The requested system has two important components:

- The system should accurately measure and record an animal's weight,
- And the system should expose the data to staff as part of their job.

Each of their centres will have at least one scale for recording animal weights.

The new system should be simple and easy to use. While they can train their staff to use the system, they have many volunteers who support them, and it would not be easy to ensure all volunteers are trained.

2.2.1 Hardware

The hardware aspect will focus on developing the electronics circuitry to convert the weight to an analog voltage signal that the ADC of a Raspberry Pico W can read. The hardware should be designed to help with accurate measurement of the weight of the animal. Though it is not required to have a text display, the hardware should have some mechanism to indicate that a stable weight measurement has been recorded. This could be, for example, an indicator LED or a beeper. You may also need a tare button (physical or virtual) to zero the scale and some form of an indicator (e.g., an LED indicator or a beeper) to inform the user that the scale has been reset to zero. You may also need to consider a mechanism for identifying which animal is being weighed. However, this could be purely a software feature, where the user setup the details of the dog before weighing on a mobile app. Note that to achieve some of the above functionality, the hardware subsystem needs to work together with the embedded subsystem and possibly the software subsystem. The proceeding sections will present details of the embedded and software subsystems.

To help develop your hardware subsystem, we will provide four load cells attached to a weighing platform. Unfortunately, for obvious practical reasons, we cannot give you a weighing platform suitable for a dog. Instead, we will provide you with the weighing platform used in a standard bathroom scale, with four load cells, one attached to each corner of the platform. Each of these load cells has two strain gauges inside them. One strain gauge is configured to stretch under weight, while the other is configured to compress. The two strain gauges inside each load cell are connected in series, and you have access to each end and the midpoint of the two series of connected load cells. The 12 connections to the eight strain gauges are exposed to you via a 12-pin header. Your hardware must connect to this 12-pin header (schematic provided in the Appendix) to interface with the four load cells fitted to the weighing platform.

The electronics circuitry you develop should include an amplifier circuit to combine and amplify the signal from the four load cells. The change in resistance of the strain gauges is in micro-ohms. So you need to develop a suitable circuit to combine and amplify the signals from the load cells so that the ADC of the Pico W can read the output of the amplifier to determine the weight accurately. You may need to consider common and differential mode filtering of the signals to reduce the susceptibility of the measurement to noise. In addition to the amplifier circuitry, you will also need a regulator (e.g. a linear regulator IC) to derive a regulated voltage for supplying your hardware from a battery pack of 4 AA batteries. Your design should consider power consumption. So, for example, you may want to turn off or disable the output of the regulator when there is no dog on the scale, saving energy and prolonging the battery life. The cost of your hardware is also a primary concern. You will need to select appropriate components to keep the cost minimum, and any extra features should be justified.

Once you have decided on the hardware design, you should verify it using theory and simulations. Then you will need to develop a PCB to assemble and test your hardware design. This PCB should interface with the load cells via a 12-pin header (2x6 header). It also should interface with the Pico W. However, as this is a prototype, you may decide to power the Pico W independently via its USB port instead of powering it using the onboard battery pack.

In addition to the above general requirements, you have to meet the minimum hardware requirements listed below:

Parameter	Value
Supply Voltage	4 x AAA Batteries
Weight Range	0 to 25kg
Weight Accuracy	0.5kg
Output Voltage Range	0 to 3V
Operating Temperature	0 to 40°C
Display	Measure Success - LED Indicator (note #1)
Compliance	RoHS and WEEE (AS/NZS 5377) (note #2)

Notes:

1. A text display has not been included in the minimum requirements. You may include one if you want but you to need to justify its inclusion (e.g. benefits vs. technical complexity and cost.)
2. These standards can be accessed via the University of Auckland library. We expect you to have read these and mention the compliance level in your **Final Report**.

2.2.2 Embedded Software

The embedded microcontroller (Raspberry Pi Pico W) will be the interface between reading the analog weight values from the electronics circuit and relaying that to the software backend. The embedded system should be capable of doing:

1. Considering the animal is constantly moving, the measured weight might be fluctuating. The embedded system should aim to provide the best possible accuracy and precision. This would require calibration and auto zero offset to provide a stable measured weight. This requires efforts from both the electronics and the embedded software side.
2. The recorded value will be sent to the backend software via HTTP.
3. Since it is a battery-powered system, power optimisation of the overall embedded system operations (e.g. Wi-Fi module, weight measuring module, processor power states etc.) will involve careful software design and control and is key in designing a practical system.
4. Optional feature 1: Secure web implementation (i.e. HTTPS). You will need to look into Mbed-TLS for SSL implementation along with the C-SDK library.
5. Optional feature 2: Authorisation using API key .

Parameter	Value
Programming language	C
SDK	RPi provided C-SDK for the Raspberry Pi Pico W (note #1), optional: Mbed-TLS for SSL implementation

Parameter	Value
Compliance	C-Tick RSM and local regulations: https://www.rsm.govt.nz/business-individuals/supplier-compliance/

Notes:

1. Use of Arduino, micropython, circuit python and other development frameworks is not permitted, to ensure uniformity.

2.2.3 Software

The software side will require backend and frontend components:

Backend will involve developing data management that stores information about animals and their weights. Data privacy and security is an essential element that needs to be taken into consideration, to minimise data being accessed by unauthorised users. This includes both authentication and authorisation, so taking into account roles of different users (at least admin, vets, and volunteers). The backend needs to expose endpoints that allow the hardware components to send and receive data. Ensure that these endpoints are protected to minimise abuse.

Frontend will involve developing interfaces for SPCA staff to see and manage the data in the backend. There should be two frontend platforms developed (web, desktop app, and mobile apps). You can decide on the platform variants supported[1]. For example, for mobile devices, it could be either Android or iOS if you developed natively, or both if you use cross-platform technologies.

All frontends should allow for user login. Users should have different views depending on the user's role. There will need to be a way for an admin to manage user access in the system (e.g., to define a new user as a "vet" or "volunteer"). Think about how data is portrayed, using visual elements (such as charts) that can help the staff keep informed.

You must implement authentication on the frontends (e.g., logging into the website, mobile app, etc.). However, given the added complexity of implementing it on the hardware to software endpoints, you do not need to secure this connection. You can still protect the endpoints, for example, by having a "password" added to the request body, but you do not need to implement bearer authentication on the hardware side.

There should be in-app communication mechanisms for volunteers to send questions to vets and for the vets to reply. This does not need to be real time communication, but it should have some notification mechanism (e.g., email, text, or in-app notifications) when a new message is received. The messages should persist, and be visible across both platforms that you implement.

The software side has the following minimum requirements:

Parameter	Value
Operating System	Windows 10 (note #1)
Number of Concurrent Connections	
• Scales	40

[1] Android and iOS does not count as two platforms: it is still one ("mobile"). Similarly, a cross-platform desktop app (that runs on Windows, MacOS, and Linux) still counts as one ("desktop".)

Parameter	Value
• Client Applications	100
Security	HTTPS between client application in Web API (note #2) Centre staff should only be able to access data within their centre. Some central staff should be able to access aggregated data across all centres.
Data Storage	All data must be kept for a minimum of three months. A user should be able to find any record within this time period. A centre can have up to 200 dogs at any single time. There can be up to 100 staff and volunteers working at each centre.

Notes:

1. This is the basic requirement, you can target additional systems if desired. Any additional systems need to be justified for their inclusion (see hardware above). If building a web-based application, you can target any Windows-based browser.
2. A secure connection from the scales to the Web API is not required.

2.2.4 Non-technical

In addition to the technical requirements, the Royal New Zealand Society for the Prevention of Cruelty to Animals is interested in sustainability and privacy, as well as meeting their Treaty obligations.

They want to ensure the development product (including backend components) is sustainable over the long-term, both for the current generation and future generations. As such, they want to recycle, reuse, and reduce waste where possible. You should also consider how the system will be manufactured and disposed of at the end of its useful lifetime[2].

For data privacy, SPCA needs to consider how the system will be used internally and externally. As SPCA has many volunteers, there is the potential that data could be leaked, so they want to minimise data access where possible. While many animals are strays, many animals have come from owners, and this information is both needed and confidential. Finally, SPCA has responsibilities under the Privacy Act. While the final system does not need to cover all of them, it should be designed to allow SPCA to meet these responsibilities.

Finally, SPCA is aware that New Zealand is a multi-cultural society. Like many organisations, they try to include their cultural awareness to ensure everyone is welcome. While the general public may not use the system, it will still be used by various staff.

2.3 Considerations

The requirements state what is needed for a Minimum Viable Product (MVP). At a bare minimum, your team should meet these requirements. However, these requirements prove that your prototype "works": they don't provide a product that is necessarily useable by the end users. You should aim to extend the requirements to produce a product that will benefit the end users.

There are no right or wrong directions for these considerations. Think about what could be added to your prototype to expand beyond the base requirements. Unlike the requirements, these features

[2] Some details on the length of a useful lifetime would also be helpful, but not required.

will need to grow across all three specialisations, so you must work with your teams to decide what you want to build and how. The **Project Proposal** is an opportunity for you to outline your ideas and get feedback from other teams, your mentor and the marking staff.

We have included two personas of potential end users to assist with this process. These are not real people, but they give you an idea of what people want to do with your project.

2.3.1 Persona 1: Michelle

Michelle is an animal care officer in the largest centre in New Zealand (in Auckland). She really loves animals and wants the best for all the animals in her care. Her job is to tend to the needs of animals in her centre. Most of her day is spent performing basic care tasks, such as feeding, watering, and cleaning, for various animals in the centre. She is also responsible for tracking the health of the animals in her care. One important monitoring job is recording the weights of the animals in her care.

Every week, her centre needs to track and manage over 100 animals, although the frequency of weighing varies depending on the needs of the animals. Healthy animals are only weighed once a week, with the weighing times being staggered over the week. Sick animals can be weighed once per day, depending on the vet's requirements.

While Michelle loves animals, she's not fond of computers. She likes her technology to 'work' without forcing her to think about it. She uses a Windows computer mainly because she has to, but only does the minimum. She also has an iPhone, which she uses for all her communications (e.g. email, TXTs, and messenger). When she is weighing animals, she tends to write down the name of the animal and its weight at the time. When she has free time later in the day, she will enter all the animals' weights into an Excel spreadsheet in OneDrive. At the start of each week, Michelle will go and check the weight history of the animals. This involves opening the spreadsheet and reviewing the latest weights of each animal. She emails the centre vet if any weights have changed beyond an average amount. The email includes the animal's name, where it is currently housed, and how much the weight has changed. She doesn't like doing this part of her job and sometimes "forgets" to do it.

2.3.2 Persona 2: Rawiri

Rawiri (ngati haroua) is the animal welfare administrator for the upper North Island. He is not an animal lover ("they're ok, but I just don't want one"), but he doesn't like to see animals suffer. An essential part of his job is ensuring the animals at centres in the upper North Island are ok and getting the care they need. His career is partially based in Auckland: he spends three days a week in his office and the other two days travelling around the country. He aims to visit each centre at least once a month, although he visits some centres more often (e.g. if they are having any issues.)

Rawiri uses a work-issued laptop and cell phone for his job. Where possible, he uses the wi-fi

network at his office and each centre and cellular data when travelling on the road. He doesn't mind computers; they are essential to his job. However, he would prefer to minimise his time on a screen so he can focus more on helping centres with their animals.

Rawiri doesn't deal directly with animals but does not need to track what is happening to them. As such, he often reviews the data entered by the staff across multiple centres. Rawiri is looking for patterns and trends rather than single data points. For example, he checks every centre once a week to ensure that all animals have been weighed, so he can follow up if some animals are getting missed. Another example is looking for trends across animals in a centre. If the weights of the animals are declining on average, he knows there is an issue. A final example: he goes through each centre and red-flags any animals whose weight has been decreasing over time (either consistently across several weeks or drastic drops over a couple of weeks.)

In addition to supporting the centres, Rawiri needs to generate monthly and yearly reports for management. These reports help management understand what is happening across the different centres. They are interested in what is happening across the organisation. Rawiri has to work with the other animal welfare administrators in the country to produce these reports.

Most of Rawiri's data analyses are manual. He copies and pastes data from each centre's Excel spreadsheet into a custom spreadsheet he has produced. While this reduces some of the work, it is still a manual process, as he needs to clean the data (especially as each centre enters weights in a slightly different format.) He would like a system that automatically standardises all the data and produces trends and statistical data for him. However, he would still need to download data, as he might have custom queries or analyses that he wants to generate.

3. Project Artifacts

As part of your project, you will generate various artifacts including documentation, circuit boards, components, and software. In addition, we have provided some tools for helping you manage these artifacts: a GitHub repository that will hold all your work.

3.1 Documentation

An important part of any project is documentation. Documentation explains what is happening and provides a window on the project for external parties[1]. You will need to generate the following documentation.

3.1.1 Team Charter

The team charter defines your goals and explains what abilities each person brings to the team. It helps defines the different roles and responsibilities in your team, and helps sets a common ground for everyone involved.

You will complete your team charter in your first tutorial (Week One for most people.) The charter is exactly the same as the team charter from ENGGEN 303: you can download the template from https://canvas.auckland.ac.nz/courses/91591/assignments/320500. Once you have completed your team charter, upload it to the same page.

3.1.2 Risk Analysis

A risk analysis helps your team identify any potential issues before they occur and plan for them. This process helps your project run smoother and achieve your desired objectives.

This document is an assessed activity. Full details are available under the **Risk Analysis** assignment and in the chapter on Risk.

3.1.3 Issues Log

An issues log is a list of all the issues that have occurred for the project. By tracking issues, you know what is potentially preventing your project from succeeding. It also allowed external parties to see what problems your team is having.

You should raise any issues in your team's GitHub repository (see below.) In addition, you should

[1] For example, the teaching and marking teams.

track what is happening for each issue, including whether it has been resolved. This way, both your mentor and the teaching team can see what you have been doing to resolve the issue.

3.1.4 Bill of Materials

You will need to complete a bill of materials if your team needs to order any components. See section 4.1.2 for more details.

3.1.5 PCB Design

Each team will need to design a PCB for the electronic components. See section 4.1.2 for more details.

3.1.6 Project Proposal

The Project Proposal explains what your team plans to achieve. This document is different from the project brief you received from your client. It explains how you plan to implement their requirements and what is unique about your implementation.

This document is an assessed activity. Full details are available under the **Project Proposal** assignment.

3.1.7 Business Case

The Business Case is the end objective of this course: everything you are doing is building towards this document. You have already learnt how to write a business case in ENGGEN 303. You are expected to apply what you learnt from ENGGEN 303 to your capstone project (i.e., we are not going to teach you how to write a business case.)

The practical, technical component of this course is to prove the viability of your proposal. Effectively, you are building a prototype to show how your proposal (see above) actually works and what could be changed to improve it. In addition, there are certain technical requirements that SPCA has specified: the prototype will show how you meet these requirements. Finally, unlike ENGGEN 303, you are expected to know how to implement your project: we will not be teaching any new technical skills during this course.

This document is an assessed activity. Full details are available under the **Final Report** assignment.

3.2 GitHub Repository

Each team will have a GitHub repository for storing their work. Appendix B has details on using Git and GitHub.

Note: all team members can see all files in your repository. Do not include anything private in here. This include individual assignments like the status reports, peer reviews, and course reflections.

3.2.1 Folders

The repository contains the following folders:

3.2.1.1 project

This folder will hold all the artifacts for your project. These include any diagrams and schema you produce, lists of materials, source code, etc. This repository should also hold your issues log.

3.2.1.2 risk-analysis

This folder should hold the details for your **Risk Analysis**. The repository includes the base template, plus tools and instructions for how to generate a PDF from the Latex.

We will automatically generate the submission from your repository and submit it to your Canvas submissions dropbox.

3.2.1.3 proposal

This folder should hold all the documentation for your **Project Proposal**. The proposal must be written in Latex: Appendix C has details on how to use Latex.

By using the GitHub repository for your proposal, we are able to automatically generate both the proposal for your team, plus any documents we need for marking. It also allows us to see how has contributed to the project and can help resolve issues later about project engagement.

3.2.1.4 final-report

This folder should hold all the documentation for your **Final Report**. Like the proposal, this must be written in Latex. The repository contains the template, tools, and documentation. And again, we will be using automated tools to generate the final report for marking.

3.2.1.5 images

In addition, there is an images folder. This folder should hold all the images for your reports.

By default, this folder contains the title page image, plus some logos for SPCA. Do not delete the title page image, as it will break the build process. You may use the logos for SPCA in your reports or your application if desired. However, you must not share these logos in the public domain (e.g. outside of this course.)

3.2.2 Actions

The repository also contains some GitHub actions. These actions will automatically build and package your reports whenever someone pushes changes to the relevant folders in your repository. These actions allow you to check that your reports are being correctly generated.

The actions are:

Name	Folder	Output
Build Project Final Report	final-report	final-report.zip
Build Project Proposal	proposal	proposal.zip
Build Risk Analysis Report	risk-analysis	risk-analysis.zip

Each output file contains the generated PDF files (if succesful) and the log files. If the build was not successful, check the log files to see if there are any error messages explaining why.

4. Equipment

Like most engineering projects, there will be equipment for you to use and to modify. This chapter provides some information on the equipment, plus where to use it.

4.1 Equipment List

Each team will receive the following items:

- Raspberry Pi Pico W
- USB cable
- A weighing platform with 4 load cells and attachments

In addition, there will be weights that can be used across teams.

To build your hardware, you have access to the components available through the component store (a list will be posted on Canvas). If you wish to purchase any additional parts, these should be included in the Bill of Materials submitted during Week 6 of the semester. At least two of the preferred component distributors (Digikey, Mouser, Element14 or RS) should have sufficient stock of any parts to be ordered. You will need to allow three weeks lead time and these additional costs need to be justified in your report.

4.1.1 Collecting Your Equipment

Each team can come and collect their equipment from the ECSE storeroom from the Tuesday of Week Three (14 March). One person in the team will need to check they have collected all the required items and sign them off.

4.1.2 Ordering Additional Equipment

There is also a budget of NZ$40 per team that you can use for ordering additional equipment. You will need to put together a bill of materials and submit these online on or before 6th April. The submission link is https://canvas.auckland.ac.nz/courses/91591/assignments/321558.

Each team will also need to design a PCB for their system. This is also due on or before 6th April. We will collect all the PCB designs and send them for printing over the mid-semester break. The submission link is https://canvas.auckland.ac.nz/courses/91591/assignments/321559.

Submit only **ONE** bill of materials and **ONE** PCB design per team. If you submit multiple, we will only use the last submission.

4.1.3 Datasheets and Documentation

The documentation for the Raspberry Pi Pico is available at https://www.raspberrypi.com/documentation/microcontrollers/raspberry-pi-pico.html.

4.2 Lockers

Each team will be provided a locker to hold their prototype and equipment. These lockers are located on levels four and five of building 405 (many of you will have used these lockers in Parts II and III.)

You will need to apply for a locker once your groups have been assigned. We will send you the details of how to sign up for a locker in a communication during the first week of semester. One person in your team will need to sign up for the locker: they will receive an email containing the location of the locker and how to open it.

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5. Overview

This course contains a mixture of personal (individual) and group-work assignments. The following table contains a summary of the assignments over the project:

Assignment	Weighting	Due
Mentor Engagement	10%	Weeks one to ten
Status Reports	10%	Weeks two, four, six, eight, and ten
Risk Analysis	5%	Week two
Project Proposal	10%	Week five
Project Proposal Feedback	10%	Week six
Demonstration and Interviews	15%	Week eleven
Final Report	35%	Week twelve
Course Reflection	5%	Week twelve

The following assignments are individual assignments:

- **Mentor Engagement**,
- **Status Reports**,
- **Project Proposal Feedback**,
- **Course Reflection**.

The following assignments are group assignments:

- **Risk Analysis**,
- **Project Proposal**,
- **Final Report**.

In addition, there is one assignment that has both group and individual components: the **Demonstration and Interviews**.

6. Mentor Engagement

An important part of this project is engaging with your mentor and teammates. Every week, you will need to meet with your mentor and explain what you have been doing over the week.

This assignment is an **individual** assignment. You and your team will need to talk with your mentor each week during weeks one to ten[1]. Attending each weekly meeting is worth **1%** of your final grade, for a total of **10%** overall.

Each weekly meeting should be short: no more than fifteen minutes. Before each meeting your team should collate a short summary of the following:

1. What has your team achieved in the past week?
2. What are you planning to achieve next week?
3. What issues have you encountered?

Allow some time within the fifteen minutes to receive feedback from your mentor.

6.1 Marking Criteria

Criteria	Marks	
Attendence **[2 marks]**	1 mark	Attended meeting on time and being professional.
	1 mark	Engaged with mentor and provided input to the meeting.

[1] Please talk to the course coordinator (*Dr Craig Sutherland*) if you join the course after week one.

7. Status Reports

As part of this course, you are expected to reflect on what you have been doing and how you could improve. Every fortnight, you will need to write a **Status Report** on your progress.

This assignment is an **individual** assignment. You will need to submit a status report at the end of every **second week**[1]. Each status report is worth **2%** of your final grade, for a total of **10%** overall.

These reports should be similar to what you talk with your mentor about, but in more detail and focused on your personal details. It should have:

1. What have you achieved in the past two weeks?
2. What are you planning to do in the next two weeks?
3. What issues have you encountered? Include any errors that you might need help with.

7.1 Deliverables

The report should be written in Latex using the supplied template (statusReport.tex). Do not include any images or tables. Each report must be a maximum of **ONE** page. Do not change the font size or margins.

Your report must be submitted by **1 pm on Friday** of Weeks Two, Four, Six[2], Eight, and Ten. Each report must be submitted to the relevant Canvas assignment page.

7.2 Marking Criteria

Criteria	**Marks**	
Content **[3 marks]**	1 mark	Covered achievements from the past fortnight.
	1 mark	Included plans for the coming fortnight.
	1 mark	Listed issues and any needed support.

[1] Please talk to the course coordinator (*Dr Craig Sutherland*) if you join the course after week two.
[2] This report is due on Thursday, as the Friday is a public holiday (Good Friday).

Criteria	Marks	
Spelling and Grammar **[1 mark]**	1 mark	No spelling or grammar mistakes, within page limit.

7.3 Notes

- The reports are individual and will only be shared with the marking team and your mentor. The rest of your team will not see your status reports.
- The final version of your status report will be automatically generated from the Latex file.
- The issues in these reports are different from the issues in your team's Issues Log. The team's Issues Log will focus on issues relating to your team's ability to complete the project. The issues in these reports should be specific to you, although we realise there may be some overlap.

7.4 Submission Links

Week Two (10 March, 2023): https://canvas.auckland.ac.nz/courses/91591/assignments/315378

Week Four (24 March, 2023): https://canvas.auckland.ac.nz/courses/91591/assignments/315382

Week Six (6 April, 2023): https://canvas.auckland.ac.nz/courses/91591/assignments/315381

Week Eight (5 May, 2023): https://canvas.auckland.ac.nz/courses/91591/assignments/315380

Week Ten (19 May, 2023): https://canvas.auckland.ac.nz/courses/91591/assignments/315379

8. Risk Analysis

The first task your team needs to perform is a **Risk Analysis**.

This assignment is a **group** assignment. Your team will need to submit it at the end of **Week Two**. The analysis is worth **5%** of your final grade.

8.1 Deliverables

The report should be written in Latex using your GitHub repository. Do not include any images or tables. The report must be a maximum of **FIVE** pages. Do not change the font size or margins.

Your proposal will be automatically generated in the afternoon of the Friday of Week Two. All changes must be submitted by **1 pm on Friday 10 March**.

8.2 Marking Criteria

Criteria	**Marks**	
Risk Identification **[4 marks]**	2 marks	Identified potential risks.
	2 marks	Provided examples for each risk.
Risk Mitigation **[5 marks]**	2 marks	Each risk has a potential mitigation.
	2 marks	Mitigations have examples of how they would be applied.
	1 mark	Monitoring plan included.
Spelling and Grammar **[1 mark]**	1 mark	No spelling or grammar mistakes, within page limit.

8.3 Notes

- The final version of your risk analysis will be automatically generated from your GitHub repository. This document will be uploaded to Canvas after generation.

- A PDF version of the risk analysis and plan will be made available to the whole team, as well as your team mentor.
- The GitHub repository contains a trigger to automatically generate a version of your analysis. **Important:** check the output after every commit to ensure it is valid!
- The page limit does not include the title page or list of team members.

9. Project Proposal

While SPCA has provided an overall design brief, it is up to your team to provide a more detailed project proposal. For this assignment, your team will write a **Project Proposal** to explain what your team intends to build and how it will meet the design brief.

This assignment is a **group** assignment. It will be automatically generated from your GitHub at the end of **Week Five**. The proposal is worth **10%** of your final grade. Your group will receive an overall mark for the report: your individual mark may be adjusted based on feedback from your teammates.

9.1 Deliverables

The report should be written in Latex using your GitHub repository. You can include tables and images, but ensure your document compiles before the deadline. The full report must be a maximum of **TWELVE** pages. Do not change the font size or margins.

The proposal should be targetted for both a general and a technical audience but not specialists in your discipline. The business proposal will be read by people with little technical knowledge: this means you should avoid all technical jargon in these parts of the report and write in plain English. The technical elements will be read by engineers. However, as the report will be read by multiple engineers, you should assume they do not know the technical details of your specific discipline. If in doubt, check with other people in your team in a different discipline. If they do not understand your terminology, then the target audience will not.

This report will be anonymously reviewed by your peers. Do not include any identifying information in the report, except for `team.tex` (the documentation generation process will automatically remove these details). Identifying details include the names of your team and team members, student IDs, and emails.

The `proposal/parts` folder has a file called `feedback.tex`: this is an optional file that you can complete if you want specific feedback from your peer reveiws (see Before the Review in Chapter 16). If you do not want to ask for any specific feedback, delete the content in this file. We will not mark any content from this file (it will only be included in the peer-review version of the proposal.)

Your proposal will be automatically generated in the afternoon of the Friday of Week Five. All

changes must be submitted by **1 pm on Friday 31 March**.

9.2 Marking Criteria

Criteria	Marks	
Content **[15 marks]**	3 marks	Clearly explains how the overall proposed solution will achieve SPCA's objectives for the projects. Explains how the parts will work together.
	4 marks	Hardware criteria (see below).
	4 marks	Software criteria (see below).
	4 marks	Non-technical criteria (see below).
Organisation and Structure **[4 marks]**	1 mark	Introduction and conclusion are included.
	1 mark	The report is well structured and easy to follow.
	2 marks	All images and tables contribute to the overall proposal. All images and tables are referenced in the text.
Spelling and Grammar **[1 mark]**	1 mark	No spelling or grammar mistakes, within page limit.

9.2.1 Hardware Criteria

The hardware design section of the project proposal should include the following sub-sections:

Prior Art: Include details of existing products, their technical specifications and functional specifications.

Operating Principles: Includes details of how the load cell(s) will work and how load cells can be connected together in a scale with multiple load cells. Include details of different methods of conditioning the signal from load cell(s) so that it is in a suitable form to be interfaced with an MCU.

The Proposed Design: With the aid of diagrams and initial simulation results detail your proposed design. Include expected bill of materials and component costs. List technical and functional specifications of your design.

9.2.2 Software Criteria

The software design section of the project proposal should include the following sub-sections:

Prior Art: Include details of existing products, their technical specifications and functional specifications.

Embedded: Explain the software components for retrieving a stable correct weight measurement from the sensing electronics via ADC. Include details on the communication channel with the remote backend software.

Backend: Explain what data the backend will track and how. List the endpoints that you will expose and explain what components use them. Include details on how you will secure the endpoints.

Frontends: List the frontends you will support and the functionality they will supply. Include some preliminary designs of views for the users and the 'flow' through the applications. Identify how different users will use the apps to achieve their work requirements.

9.2.3 Non-technical Criteria

The non-technical section of the project proposal should include the following sub-sections:

Project Plan: Details of work division and draft project plan.

Sustainability: Include details of the sustainability issues you have considered and how you will approach them. Include potential areas to investigate.

Data Privacy: List the main areas where you will consider data privacy and why. Include any assumptions you are making and why they are relevant.

Te Tiriti Obligations: Explain how you will approach Treaty obligations and ensure the system is usable by different cultures. Include details of what is considered within the scope of your project and what you will exclude, with some justifications of why.

9.3 Notes

- The final version of your project proposal will be automatically generated from your GitHub repository. This document will be uploaded to Canvas after generation.
- All work for the project proposal must be contained in the GitHub repository. The commits to the repository may be used as an indication of workload towards this assignment.
- The GitHub repository contains a trigger to automatically generate a version of your proposal. **Important:** check the output after every commit to ensure it is valid!
- The page limit does not include the title pages, blank pages, list of team members, table of contents, executive summary, or appendices.

10. Project Proposal Feedback

For this assignment you will need to read the **Project Proposals** from two other teams and provide **Feedback** on their proposal.

This assignment is an **individual** assignment. You will need to submit both reviews by the end of **Week Six**. The reviews are worth **10%** of your final grade.

10.1 Deliverables

The reviews must be submitted via Canvas. You will need to review the proposals using the **Project Proposal** assignment (`https://canvas.auckland.ac.nz/courses/91591/assignments/315398`).

10.2 Marking Criteria

Criteria	Marks	
Reviews **[8 marks]**	4 marks	Review one provides clear and easily understood feedback on the draft; gives guidelines for future improvements; uses a constructive and helpful style of writing.
	4 marks	Review two provides clear and easily understood feedback on the draft; gives guidelines for future improvements; uses a constructive and helpful style of writing.
Spelling and Grammar **[2 marks]**	2 marks	No spelling or grammar mistakes in either review.

10.3 Notes

- All reviews must be submitted in Canvas: you can use any of the submission methods (in-document annotations, plain text comment, uploaded document.)

11. Demonstration and Interviews

You have nearly reached the end of your project. Now it is time for you to provide a **Demonstration** of what your team has achieved over the semester. In addition, each team member will need to attend a short **Interview** and answer some questions related to their role in the project.

This assignment contains **individual** and **team** elements. You will do your demonstration and interview during **Week Eleven**. The demonstration and interview is worth **15%** of your final grade.

11.1 Deliverables

Each group will have a one-hour session to prepare their demo, show it to the markers, and sit the interviews. The first thirty minutes is time for you to prepare your demo and ensure it works. During this time, there will be technical support available to help with any onsite issues. By the end of the thirty minutes you should be ready to demonstrate your prototype. The first half-hour is not assessed.

In the second half hour, you will have five minutes for the demonstration, and the remainder of the time for individual interviews. For the demonstration, you will have exactly five minutes to show your prototype. After the demonstration, each team member will then need to answer two or three questions about their involvement in the project. The questions will require a mix of technical and non-technical answers.

11.2 Marking Criteria

Criteria	**Marks**	
Demonstration **[10 marks]**	2 marks	Preparation is obvious in the demonstration: runs to time, not reading notes, speaker transitons flow well.
	4 marks	Content is relevant and explains the project, relevant supporting material where necessary.
	2 marks	Delivery engages and connects with the audience.
	2 marks	Purpose is achieved and makes the audience interested in the project. Provides a clear take-home message.

Criteria	Marks	
Interview **[20 marks]**	20 marks	Questions are answered knowledgeably. Answers are related to the project and content presented.

11.3 Notes

- We will publish the demo and interview timetable in **Week Ten**.
- The setup time is to ensure it works on-site: you should test your prototype at least a day before the demo to ensure it works in general.
- You will have exactly five minutes for the demonstration. If you do not complete within the five minutes, we will stop you.
- There will not be any questions during the demonstration.

12. Final Report

The **Final Report** is your last team-based assignment. In the **Final Report**, you will pull together all of the pieces of your project and explain how you have meet the design specifications. The report needs to include two main parts: the business case to present to the Royal New Zealand Society for the Prevention of Cruelty to Animals and a technical summary of your work.

This assignment is a **group** assignment. It will be automatically generated from your GitHub at the end of **Week Twelve**. The **Final Report** is worth **35%** of your final grade. Your group will receive an overall mark for the report: your individual mark may be adjusted based on feedback from your teammates.

12.1 Deliverables

The report should be written in Latex using your GitHub repository. You can include tables and images, but ensure your document compiles before the deadline. The full report must be a maximum of **TWENTY FIVE** pages. Do not change the font size or margins.

The final report should be targetted for both a general and a technical audience but not specialists in your discipline. The business case section will be read by people with little technical knowledge: this means you should avoid all technical jargon in these parts of the report and write in plain English. The technical summary section will be read by engineers. However, as the report will be read by multiple engineers, you should assume they do not know the technical details of your specific discipline. If in doubt, check with other people in your team in a different discipline. If they do not understand your terminology, then the target audience will not.

Your proposal will be automatically generated in the afternoon of the Friday of Week Twelve. All changes must be submitted by **10 am on Friday 2 June**.

12.2 Marking Criteria

Criteria	Marks	
Executive Summary **[5 marks]**	2 marks	Summarises all the essential information from the report.
	2 marks	Clear recommendations.

Criteria	Marks	
	1 mark	Section is stand-alone and provides the reader with sufficient information to make a decision.
Introduction **[5 marks]**	2 marks	Context for the project is clear, provides essential background for the reader.
	2 marks	Clearly describes the aim of the report.
	1 mark	Briefly summaries the methodolgy of the report with the main sections.
Problem Definition **[10 marks]**	4 marks	Clear specific problem statement, provides an idea of how the problem evolved from a broad conception to the specific statement.
	3 marks	Clear identification of specific users/customer segments, existing products/services targeting the problem and problems they have.
	3 marks	Identifies appropriate requirements and their importance; provides evidence of how the requirements were selected.
Implementation Plan **[10 marks]**	2 marks	Appropriate starting point from project approval and does not contain the work in the prototype.
	3 marks	Identifies all key stakeholders with a brief description.
	3 marks	Scope is clearly defined and connects to the goals established in the previous sections.
	2 marks	Assumptions are all clearly defined and reasonable.
Considerations **[10 marks]**	5 marks	Included the ethical, legal, Te Tiriti, and data soverignity issues of the project.
	5 marks	Included the compliance and sustainability issues of the project.
Technical **[20 marks]**	4 marks	The technical sections have an overview that explains how all the parts work together and explains the overall technical implementation.
	8 marks	Hardware criteria (see below).
	8 marks	Software criteria (see below).
Conclusions **[5 marks]**	2 marks	Main points from the report are clearly summarised.
	3 marks	Outlines the resources needed for an actual implementation of the project, including time, money, and people.
Reporting **[5 marks]**	2 marks	No spelling or grammar mistakes, within page limit.
	2 marks	Organised into logical sections and paragraphs that flow well and are easy to read.
	1 mark	Clear formatting and use of figures and tables, including captions.

12.2.1 Hardware Criteria

The hardware design section of the final report should include the following sub-sections

Final Design: With the aid of schematics, CAD diagrams, etc. present your final design.

Hardware Validation: Provide experimental and simulation data to validate the hardware design and confirm it meets the specifications. You should consider component availability and impact of component tolerances on the performance.

Standard Compliance: Discuss how the production design will be made to comply with standards such as ROHS and WEEE (AS/NZS 5377). Details of steps taken to improved serviceability, reduction of e-waste, design for recycling and end-of-life, reduction of carbon footprint, etc.

12.2.2 Software Criteria

The software design section of the final report should include the following sub-sections

Embedded : With the aid of diagrams (and experimental results), explain the final implementation of your embedded system. Explain the approach (and implementation) you used to retrieve a stable ADC reading that reflects a measured weight; to perform power saving for your embedded system; and to communicate with the backend software system via embedded TCP/IP (and HTTP) stack.

Backend: With the aid of diagrams, show the design and final implementation of your backend system. Include the database schema and relevant dataflows. Include details of the security scheme, including any authentication and authorisation.

Frontend: For each frontend, provide an overview of how the frontend works and the functionality they make available to the users. Include relevant dataflows to demonstrate how the frontend interacts with the backend, and what data is stored in each application.

Requirements Compliance: Discuss how you tested and evaluated your implementation to show your system complies with the concurrent connections and data storage requirements.

12.3 Notes

- The final version of your project report will be automatically generated from your GitHub repository. This document will be uploaded to Canvas after generation.
- All work for the project report must be contained in the GitHub repository. The commits to the repository may be used as an indication of workload towards this assignment.
- The GitHub repository contains a trigger to automatically generate a version of your report. **Important:** check the output after every commit to ensure it is valid!
- The page limit does not include the title pages, blank pages, list of team members, table of contents, executive summary, or appendices.

13. Course Reflection

The final assignment for the course is a **Course Reflection**. In this assignment, you will reflect back on what you have learnt over the project.

This assignment is an **individual** assignment. You will need to submit it by the end of **Week Twelve**. The feedback is worth **5%** of your final grade.

There are two aspects you should reflect on:

1. How well did you learn over the course of the project? What helped you to learn and what hindered your learning? If you could do the course again, what would you change, and what would you like changed in the course to help your learning?
2. What benefits did the risk analysis provide? Was the planning stage helpful and did you use any of the plans you developed? If you were to do the exercise again, what would you change to make the process easier and more benefical to you?

This assignment is not about how well you met the project outcomes but your thoughts on your progress. The reflection aims to help you be a better learner. By reflecting on what does and doesn't work, you can think about what you can change in the future.

You can also include things that you think can be changed in the course. We are interested in your feedback on what has and hasn't worked. But remember, the reflection should focus on **you** learning. A learning experience is a partnership (the concept of ako), so we're looking for how both parties can improve.

13.1 Deliverables

The report should be written in Latex using the supplied template (reflection.tex). Do not include any images or tables. Each report must be a maximum of **THREE** pages. Do not change the font size or margins.

Your reflection must be submitted by **10 pm on Friday** of Week Twelve. The file must be submitted to the Canvas assignment page (`https://canvas.auckland.ac.nz/courses/91591/assignments/315401`).

13.2 Marking Criteria

Criteria	Marks	
Course Reflection **[5 marks]**	3 marks	Conscious and thorough understanding of what the course was trying to achieve and how well you personally achieved the learning objectives.
	2 marks	Reflection considers what worked well and what didn't, includes some thoughts on what could be changed in future to improve learning.
Risk Reflection **[4 marks]**	2 marks	Clear reflection on value of the risk analysis and whether it helped with the project or not.
	2 marks	Clear reflection on how well the team applied the risk analysis framework and what could be changed to help the implementation in future.
Spelling and Grammar **[1 mark]**	1 mark	No spelling or grammar mistakes.

13.3 Notes

- This reflection is an individual task and will only be shared with the marking team. The rest of your team will not see your reflection.
- The final version of your course reflection will be automatically generated from the Latex file.

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14. Risk

When you are involved in the group project, you want the project to run smoothly, with the best possible outcomes. Unfortunately, many things can go wrong and these can mean that the success of your project is compromised. The good news is that most of the common problems can be managed, either by thoughtful up-front planning or by deciding at the beginning of the project what you will do if the unwanted situation occurs.

14.1 Introduction

A *risk* is something that describes situations that may result in *issues* that negatively affect project outcomes. Once an issue occurs, it is too late. The recommended approach is to identify risk situations at project commencement and put in place processes that will minimise the likelihood or effects of issues occurring.

14.1.1 Key Terms

Planning: Many of the problems that occur in group projects can be avoided by planning at the beginning of the project. For example, if some of your team are in a different country, you should plan how and when you will communicate. If you know a team member is going on holiday, you should plan how you will schedule tasks around this. Your plans should be specific, for example, "We will meet every Thursday at 11a.m. by zoom. Martha will manage the zoom meetings."

Monitoring: Making a plan at the beginning of a project will be ineffective unless you continue throughout to check that the plan is being followed. This is the process of monitoring. You should assign a project role that has responsibility for ensuring monitoring takes place.

Risk: Many problems occur during projects that can't be known in advance, for example, a team member might be unavailable due to illness. These are risks, i.e. situations that might happen and will impact the success of your project. Although uncertain, you should still think about what you will do to reduce the impact of unwanted situations on your project (see Risk Management).

Risk Management: You can avoid many risk situations from becoming issues by planning in advance what you will do if the situation eventuates. Risk management includes identifying potential risks and putting plans in place to mitigate them. For example, if you think you might have problems with merging code modules, you might focus on designing the interfaces between modules to avoid conflicts.

Likelihood and Impact: When you're thinking about risk situations at the start of your project, you should identify situations that are most likely to occur and those that will have the greatest impact on your project. For example, a risk with working with a new technology is that it is incompatible with the systems you are using. This has low likelihood but would have a large impact. A possible mitigation might be to test for compatibility during the first week, before you decide to use it.

Issues: These are things that have gone wrong in your project and compromise your project's success. They happen when you have not tidentified risks in advance or been thorough with following though on mitigation strategies.

14.2 A Framework

Figure 14.1 shows the framework for handling problems and potential issues in your team.

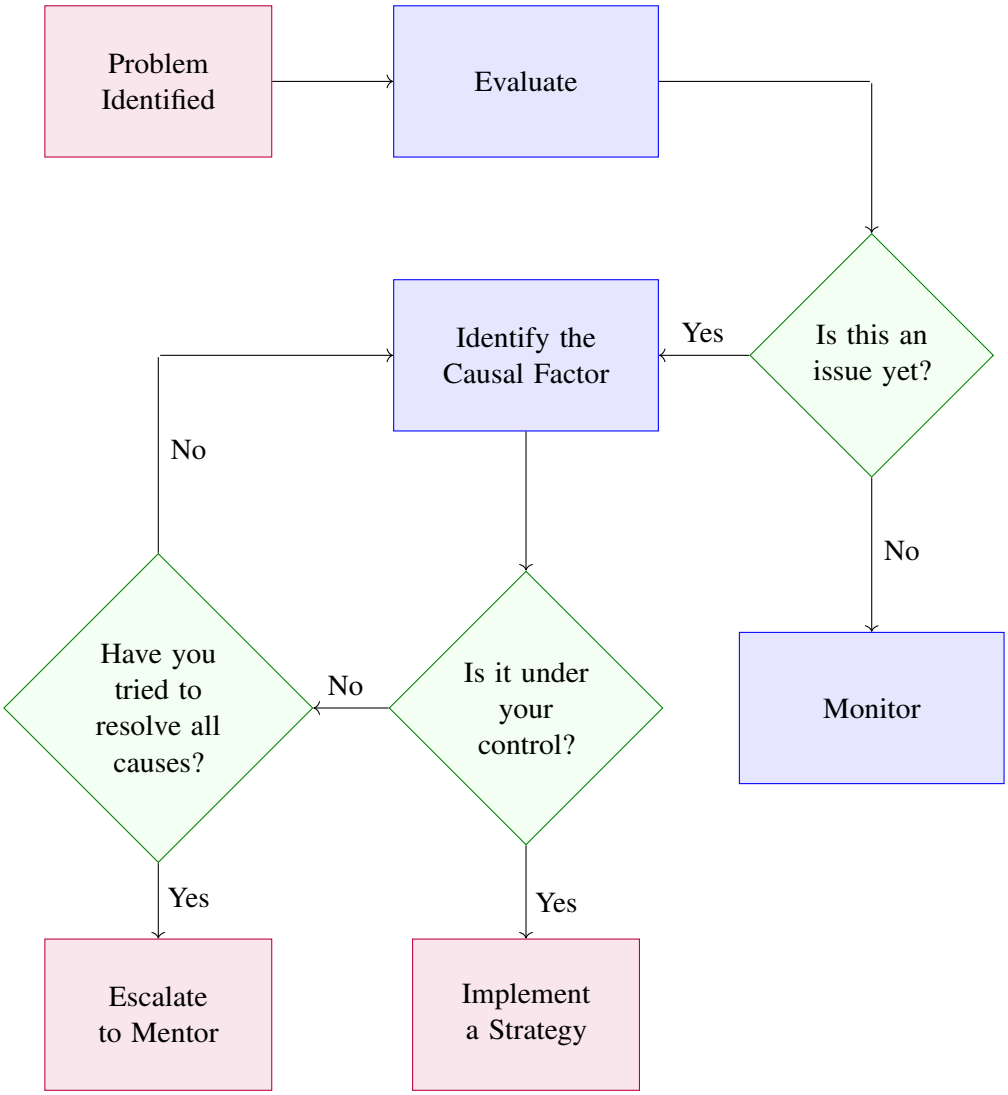

Figure 14.1: The risk management process

Some key points:

- Identifying a problem is a judgement call: do you think the problem will impact the project? For example, is it an issue if a student misses one meeting? What about two? You will need

to decide what is the trigger level for identifying if something is a risk.
- Monitoring involves putting your monitoring plan into action (see the **Risk Analysis** assignment). The plan should include who will do the monitoring and how often.
- Try to identify all potential factors when identifying causal factors. Then select the most likely factor that is causing the risk.
- When implementing a strategy, include who will implement it and when, as well as who will monitor the strategy.
- Try not to escalate the problem too soon. If you escalate too soon, your mentor will ask you to resolve it within your team. However, don't leave it too late to escalate. If it is starting to effect your team and you have tried everything then talk to your mentor. Remember, your mentor is there to provide support and advice.

14.2.1 Example

A common risk for projects is a student may miss multiple meetings. A possible risk analysis might be:

Risk: student misses multiple meetings.
Becomes an issue when: student misses two meetings in a row or half the meetings over a two week period.
Monitoring plan: team leader will track who attends every meeting and will raise the issue if a member triggers the criteria.
Impacts: project is delayed, reduced scope of the project, key documentation not written.

After a student triggers the criteria, the next step is to identify what is causing the risk. In the case above, the causal factor may be the student is sick. In this case, the team may implement a strategy to reallocate the work to focus on the required components and remove some optional components. The person monitoring the strategy would be the technical lead for the area. If the required work is completed on time (e.g. due to the sick member returning), then the team will look at some optional components. Otherwise, the team will escalate the issue to their mentor.

14.3 Common Risks

There are five main categories of risk in student projects (derived from [4]).

14.3.1 Student Contribution

Risk factors affecting how well students are able to contribute to the project.

Engagement	Commitment to a project as a result of mental state, for example, interest, conscientiousness, motivation.
Expertise	Ability to execute tasks. Aspects include knowledge, experience, familiarity with technology.
Personality	Personality attributes that contribute towards team dysfunction or ineffective project participation. Examples are team members who prefer to work in isolation, are too shy to speak in meetings, are assertive or are resistant to complying with decisions.
Availability	Degree to which a student is available to the project as a result of external factors. Examples are students taking several courses, leaving less time for the project, time differences, illness or death in the family causing student to be unable to inability to contribute or communicate.

14.3.2 Team Self-Management

Risk factors affecting the ability of the team to self-manage effectively.

Communication	Extent to which the team members succeed in communicating with each other. Example issues are student leaving without informing anyone, or team members trying to communicate in different ways.
Co-ordination	Success in co-ordinating project tasks. Dimensions include product (for example, merging student code), process (for example, tasks), students (for example, meeting times).
Process	Success of execution of planned project tasks. Issues include uneven distribution of workload and individuals not completing agreed tasks on time.
Clarity	Degree to which students are clear about aspects of the project. Examples include clearly defining activities and expectations for documentation, ensuring product requirements are understood, being clear about the role of the lecturer.
Wellbeing	Student health issues that affect their contribution.

14.3.3 Resources

Risk factors relating to failures with required resources.

Hardware	Likelihood of failures with, or not having access to, needed equipment, for example, hard disks, laptops, USB sticks, network connections.
Software	Likelihood of not having access to required data. Unanticipated problems with third party software.
Technology	Likelihood of technology challenges, for example, technology changing too fast.

14.3.4 Teaching Staff Contribution

Risk factors affecting how well the teaching staff are able to support the project.

Engagement	Willingness of teaching staff to commit to the project, for example, interest, conscientiousness, motivation.
Expectations	Teaching staff expectations of the project, for example, lecturers setting difficult delivery dates.
Expertise	Teaching staff capability with respect to the software being developed. Aspects include knowledge, experience, familiarity with technology.
Availability	Degree to which teaching staff are available to the project, for example, as a result of other commitments or illness.

14.3.5 Client Contribution

Risk factors affecting how well clients are able to support the project.

Engagement	Willingness of clients to commit to the project, for example, interest, conscientiousness, motivation.

Expectations	Client expectations of the project, for example, clients changing requirements or assuming few meetings.
Expertise	Client capability with respect to the software being developed. Aspects include knowledge, experience, familiarity with technology.
Availability	Degree to which clients are available to the project, for example, as a result of other commitments or illness.

14.4 Process

In your group, brainstorm potential risks for your project. These can include the common risks mentioned above, plus other risks that are specific to your project. For each situation you think of:

1. Write up an example of the risk and how it might occur.
2. Identidy some of the root causes of the risk.
3. Brainstorm what plans you might put in place to minimise the effect of the situation (planning.)
4. Discuss how you will make sure your plan is being followed (monitoring.)
5. Decide at what point you would inform the teaching team that there is a problem (escalation.)

Example: a team member is not contributing. This risk could result in the student failing to attend meetings and not carrying out tasks. As a result, progress on the project would be held up. While there are multiple causes, two common causes might be the student is sick or the student is prioritising other courses. If the student is sick, there is not much the team can do, other than re-allocating the work or shifting some tasks to when the student recovers. If the student is prioritising other courses, you could talk with the student about the issue and try to find ways to resolve it (perhaps the student is focusing on an important assignment and will be available later.) If the student doesn't respond, you could then escalate it and notify the teaching staff. If the student still fails to respond, you could ask for them to be removed from the team[1].

14.5 Resources

- There are lots of resources online for handling risk. For example, Asana, a project management tool, provides this resource https://asana.com/resources/project-risks, while Coursera provides this https://www.coursera.org/articles/how-to-manage-project-risk.
- There are also student specific resources. For example, from the University of Auckland () and the University of Queensland (https://my.uq.edu.au/information-and-services/student-support/study-skills/group-work/resolving-group-work-issues).

[1] This step is very drastic and would only occur in extreme cases!

15. Sustainability

Before we can answer why sustainability is important, we first need to understand what sustainability is. According to the United Nations Brundtland Commission, sustainability is "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [13]. Leslie Thiele explains sustainability as "satisfying current needs without sacrificing future well-being through the balanced pursuit of ecological health, economic welfare, social empowerment, and cultural creativity" [11, p. 4, 5].

Thus, from an engineering perspective, sustainability is about looking at the "bigger" picture: how do our products help with our present needs without adversing impacting the future. It is about changing the way we do things to ensure that the products we develop are beneficial now, without negatively impacting future generations. This viewpoint includes looking at how are our products manufactured, how are they used, and what happens when they are no longer needed?

In this chapter, we will introduce some of the key aspects of sustainability. Then we will look at how to do a Life Cycle Assessment to analysis what happens with our products.

15.1 Introduction

The definitions of sustainability are deliberately broad and cover a wide range of topics. However, at its heart, sustainability is about ensuring we use our available resources in the best possible manner. The basic premise is we do not have an infinite supply of resources and that they will run out at somepoint [10]. Rather than waiting for the resources to run out, we should take pre-emptive action to ensure any irreplaceable resources are conversed for as long as possible.

Sustainability is often built on the three 'E"s: Environment (or ecological), Economy, and Equity (or social) [13, 10] (see Figure 15.1). Together, these three areas are referred to as the pillars of sustainability: you can't impact trade off one against the other. To be sustainable, a solution needs to benefit all three areas.

Economic sustainability refers to the ability of an economy to sustain long term economic growth. This growth needs to consider not just the current needs of an organisation, but how these needs may change over time. An economy can be defined as "a system of relationships focused on the production, distribution, exchange, and consumption of goods and services" [11, p. 142]. Each of these relationships can generate resources and waste, which in turn can influence other relationships. Economic sustainability thus focused on developing and maintaining conditions that enable economic stability and growth over time.

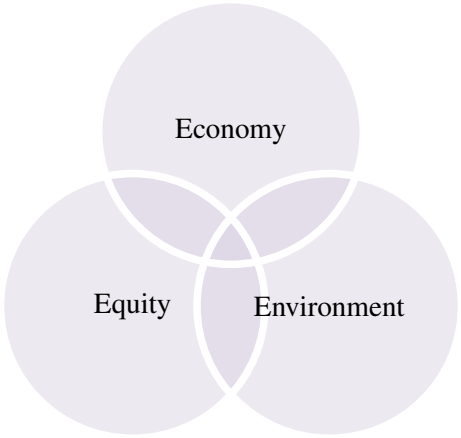

Figure 15.1: The three 'S"s of sustainability (from [10]).

Ecological sustainability is about the ability of the environment and ecosystems to remain productive over time. Human activities often deplete resources in natural ecosystems, causing them to become unbalanced and unstable. For example, humanity has been consuming huge amounts of fossil fuels, which has led to increases in CO_2 in the atmosphere and global warming. Ecological sustainability looks at understanding the complex relationships between human activities and natural ecosystems, to reduce the negative impacts and support longterm conversation.

Finally, social (or equity) sustainability is about meeting the needs of current and future generations in a fair and equitable manner. We should be thinking about future generations, not consuming everything now and leaving nothing for them. It also involves elements of valuing cultural and social aspects, treating different groups with the same respect. It also involves promoting social cohesion, cultural diversity, and the empowerment of marginalized communities. This can often involve exploring and addressing root causes of social inequality, such as historical and economic causes. Social sustainability is about providing a fair and equal society for all people, both now and in the future.

Far from being a buzzword, sustainability is becoming an important part of our societies. While sustainability as a topic is becoming more common, the underlying concepts have been around for a long time, arguably back to ancient times [11]. However, sustability is becoming more of a concern. Humanity has explored all of our planet and know that we live in a contained ecosystem[1]. Sustainability has become increasingly important since the 1980's [13]. For example, in 2015, the United Nations launched the 17 Sustainable Development Goals (or SGDs) [14]. Figure 15.2 shows these goals. The University of Auckland is currently number six in the world for sustainability impact rankings: https://www.timeshighereducation.com/impactrankings#!/page/0/length/25/name/university%20of%20auckland/sort_by/rank/sort_order/asc/cols/undefined.

At this point, you may be thinking that sustainability sounds huge, and what impact could you possibly have? Sustainability is about change [11], and change starts with individuals. As electrical, electronic, computer, or software engineers, you will be changing the future. The products and services that you design and build are the systems that will influence sustainability in the coming years, decades, and centuries. Some fore thought up-front can prevent or minimize future calamities. And one way to think about our products is to consider their whole life cycle.

[1] Yes, we're excluding exploration beyond our planet. Given we have only just started space exploration, it is unlikely it will have any immediate impact on sustainability.

Figure 15.2: The 17 Sustainable Development Goals [14].

The product life cycle, or "gradle-to-the-grave" perspective, refers to the entire process of its manufacture, use, and disposal. It is a holistic viewpoint that considers every stage of the product and its impacts. It includes the following stages (see Figure 15.3):

1. Raw materials extraction
2. Processing
3. Distribution and marketing
4. Use and consumption
5. Disposal and waste management

Figure 15.3: The stages in the product life cycle [12].

Often, engineers focus on the third stage, how people use their products. But a full consideration would cover all the stages, as each stage consumes materials and produces wastes. A full life cycle assessment can identify areas of improvement that may have a greater impact than just improving the usability. For example, the final stage, disposal, is often considered to have the highest potential for waste generation. By looking at the question "what happens to the product when we have

finished with it?", we could change the design of a product so it could be re-used or recycled. For example, can we make the product so it can be repaired to extend its lifetime.

15.2 Life Cycle Assessment

One of the tools that we can use to understand the sustainability of our products is the Life Cycle Assessment (LCA). An LCA is a tool to explore the environmental impact of a product over its entire life cycle: from cradle to the grave. It is a standard that has been ratified by the International Organization for Standardization: ISO 14040:2006 [17]. In this standard, an LCA is defined as "...a technique for assessing the environmental aspects and potential impacts associated with a product...".

An LCA has four phases:

Goal and Scope Definition: Define the goal of the LCA study and what is considered in scope for the study. This phase helps to provide clarity about what the LCA is attempting to achieve.

Inventory Analysis: Collect the data relating to each syage of the cycle and calculate the impacts. This phase typically involves looking at the inputs of each stage and determining what the outputs will be.

Impact Assessment: Assess the impacts of the inventory analysis and convert them into environmental impacts (e.g. global warming, depletion of resources, waste production, etc.). This phase aims to elucidate the significance of potential environmental impacts.

Interpretation: Finally, draw conclusions and recommendations from the analysis. This phase helps decision makers understand what the impacts are and how they compare to other products.

While the standard presents a LCA as a series of phases, it is often implemented as an iterative process (see Figure 15.4). The overall process is progressively refined as more data is collected and analysed. Using iterations allows the insights from one phase to be applied to other phases and optimizes the fina outcomes.

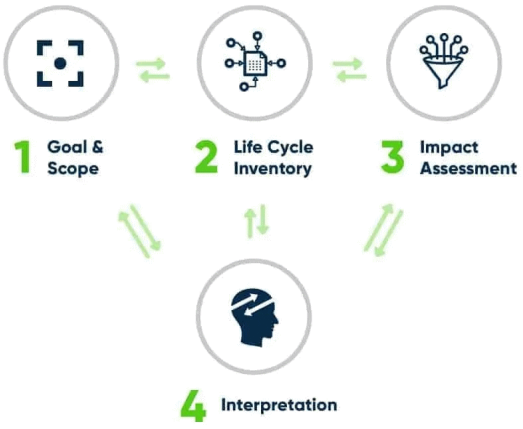

Figure 15.4: The phase of a Life Cycle Assessment [12].

Performing a full LCA is outside the scope of this course but there are some general steps you should consider. A condensed process is as follows.

15.2.1 Goal and Scope Definition

This phase has three important functions:

What will we be assessing? What product are we assessing? And how much of the product?

What system will we be assessing in? There are multiple environmental systems that we could be interested in (see https://ecochain.com/knowledge/impact-categories-lca/.) Which of these systems do we want to assess the impact of our product?

What will we not assess? LCAs and value chains can be complex, with multiple layers. We want to limit our assessment so it covers the necessary details without running forever.

15.2.2 Inventory Analysis

Now that we know what we are assessing, it's time to collect the data. We want to measure everything that flows into and out of the system we defined in the previous stage. These flows could be:

- Raw materials,
- Consumables (e.g. petrol),
- Energy (e.g. electricity),
- Water,
- Emissions.

Collecting the data can be a very complex process, with multiple types of data at each stage (see Figure 15.5.) In theory, you should iterate through each component in the inventory and look at its parent elements. Of course, if we always did this, the assessment would never complete: which is why setting a limit of the assessment is very important.

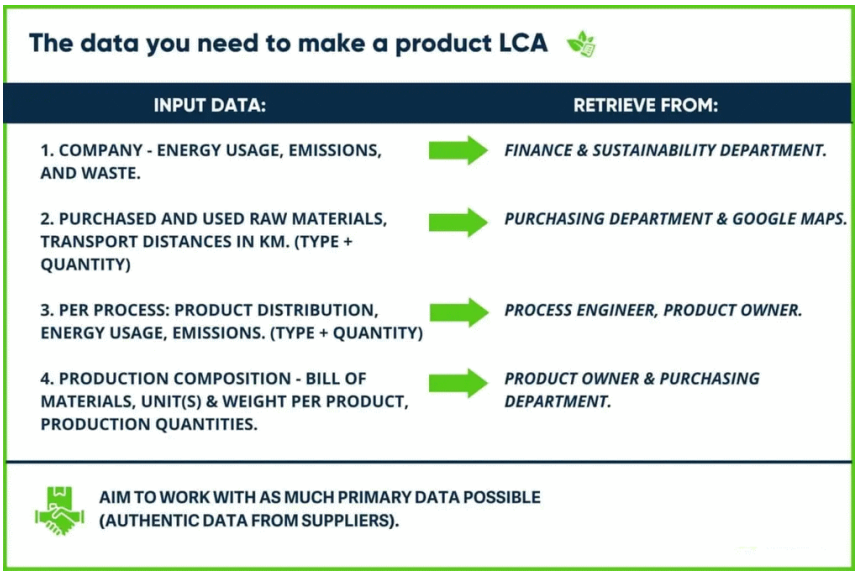

Figure 15.5: Examples of data at each step of the cradle to the grave cycle and where it could come from [12].

The good news is much of this information is already available. For an existing process, it would be possible to look at existing invoices and bills to get an idea of the data. Companies like EcoChain also collect common data and provide datasheets for different flows. Finally, it is also possible to ask suppliers for details on their products and incorporate these into the LCA.

Once the data is collected, the next step is to model the flows throughout the system (see Figure 15.6). This step allows you to see the inputs and outputs of each stage in the product life cycle. It also allows you to see what data you have and what is missing (remember, an LCA is an iterative process.)

Figure 15.6: An example of a flow model showing how items flow through the system [12].

15.2.3 Impact Assessment

Now that we have the data and flows, the next step is to evaluate how significant each impact is. This phase can be divided into three tasks:

Select indicators and models: in phase 1, you selected your impact categories. For example, if we are interested in global warming, we would be interested in CO_2-equivalents[2].

Classification: next, we assign the items in our inventory to each of the impact categories.

Impact measurement: finally, we calculate all our equivalents and sum them up for overall impact category totals.

The end result of this phase is a set of totals that shows the total life cycle impact on the environment. For example, we could calculate the total global warming potential in CO_2-equivalents.

15.2.4 Interpretation

Now that we have all the data, it is time to interprete the results to draw conclusions and make recommendations. This phase is important as it puts all the data collection and analysis into perspective. We can't just "assume" something is better because it has a "lower" number: we ned to look at the context and get a fuller overall picture. For example, we could reduce our CO_2-equivalent production but at a cost of greater water consumption. This doesn't mean the trade-off is bad, we have to decide what is our priority and what produces the greatest benefit.

Remember how you defined your goals up-front in phase 1? Now you want to return to those goals and use the data to address them. For example, if the goal was to reduce the amount of CO_2-equivalents produced, we could look at each step in the system and see what produces the most. We could then make some recommendations on how to reduce the CO_2-equivalent production: perhaps changing to a process that produces less methane or uses a location with lower transportation requirements.

Whatever your goals were in phase 1, you want your recommendations to use the data to accurately address them. We don't want to "make stuff up". Based our recommendations on the data and analysis means they will have an impact.

[2]Using equivalents allows us to combine together items that influence the impact category. For example, 1 kg of methane is the equivalent of 25 kg of CO_2.

15.3 Example

We don't expect you to do a full LCA for your project. Instead, you should choose some areas that you think will have the most impact and focus on these. This section contains a "toy" example looking at one aspect that might be important. Specially, we are interested in where we should manufacture our product[3].

For our goal and scope definition, we will say we are interested in comparing manufacturing our product in China vs New Zealand. We are specially interested in the impact on global warming, which we will measure via CO_2-equivalent production. We are going to limit the scope to manufacturing and distribution: we won't cover raw materials extraction, usage, and disposal. For the manufacturing we are only going to cover one transport step, e.g. getting the components to factory, not manufacturing the individual components. Thus, our scope is defined in Figure 15.7.

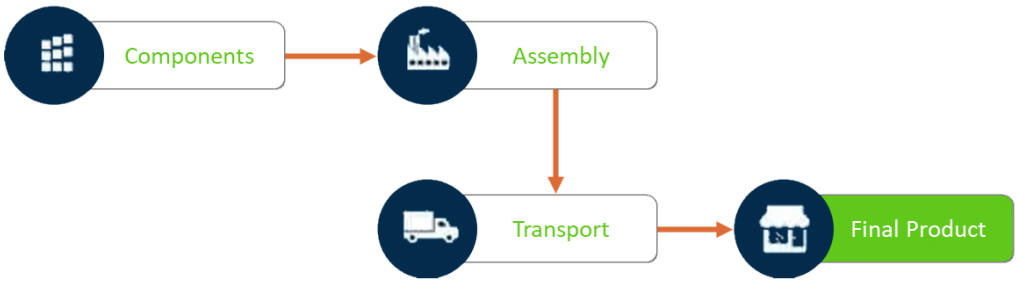

Figure 15.7: Initial scope of our LCA.

Of course, the real picture is more complex. We are not ordering one set of components, we are getting them from multiple places. Plus, we need to consider that it requires energy to assembly our components. We might have a system more like Figure 15.8.

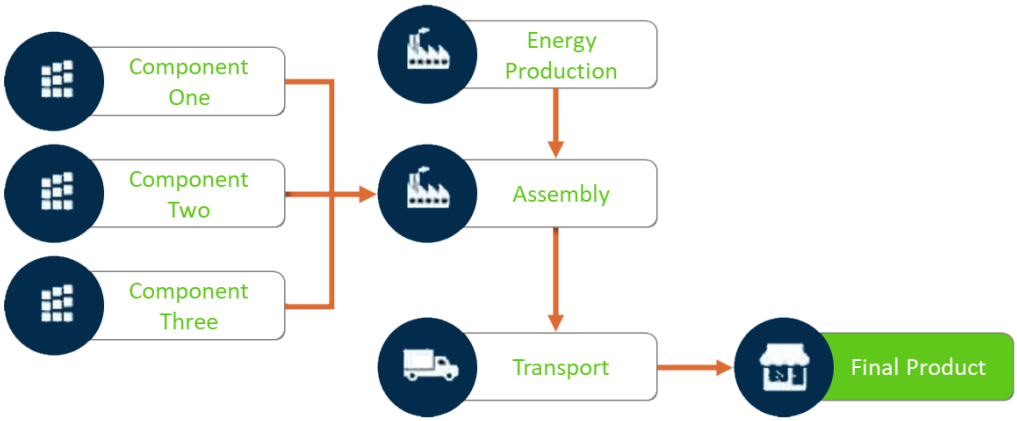

Figure 15.8: Expanded scope to include multiple components and enegery production.

We will assume the stages are the same for assembling in China and in New Zealand. The only difference is the assembly location, which will impact the flows between components and transport.

Now we have our scope. For the next phase, we need to determine all the flows between the stages in our system. Just going from the diagram, we will have the following flows:

[3]We will leave the exact product undefined, it is not important for this example.

Flow	China	New Zealand
Component One → Assembly		
Component Two → Assembly		
Component Three → Assembly		
Assembly → Transport		
Transport → Final Product		

We have also added columns for China and New Zealand that we can fill in later.

The next step is to add some details to this table. Normally, we would research the details and add them in. But for this top example, we will use some guesstimates. We will say components one and two are produced in Shenzhen, while component three is produced in Shanghai. If we go with China, the factory will also be in Shenzhen (its a major manufacturing centre with easy access to ports.) If in New Zealand, the factory will be in Auckland. The final products need to be distributed to Auckland, Wellington, and Christchurch.

With this information, let's add some distances to the table[4]:

Flow	China	New Zealand
Component One → Assembly	10 km	9,160 km
Component Two → Assembly	10 km	9,160 km
Component Three → Assembly	1,211 km	9,376 km
Assembly → Transport (Auckland)	9,160 km	10 km
Assembly → Transport (Wellington)	641 km	641 km
Assembly → Transport (Christchurch)	1,070 km	1,070 km
Total:	12,102 km	29,417 km

Again, we've made some assumptions:

- If transporting within a city, the distance will be 10 km.
- All goods from China will in via Auckland, so transport to Wellington and Christchurch are only distances from Auckland.
- We can transport all components and assembled goods together by component.

The other item in the system is enegery production. We're going to say each item takes 23 kilowatt-hours of electricity to assembly, test, and pack for distribution. Normally we'd look at our electricity bill to get this information, but its a made-up example so we're going to make up this number too.

On to the next phase: impact assessment. We're only interested in one measurement for this example: CO_2-equivalent production. Normally we'd have multiple different categories, with different measures for each. But we are keeping things simple for now.

Next, we need to calculate the CO_2-equivalent produced. There are different sites we can get this information from: we've used `https://ourworldindata.org/grapher/carbon-footprint-travel-mode`[5]. We've also made the following assumptions about transport modes:

- Within city transport is the equivalent to taking a bus (105 g/km).
- Within country transport is using trains (41 g/km).

[4] These are all from Google.

[5] Yes, this information is for passengers - remember how this example uses guesstimates?

- Between countries is the equivalent to long-haul flights (150 g/km).

With this information, we can now populate our table with some CO_2-equivalents:

Flow	**China**	**New Zealand**
Component One → Assembly	1 kg	1,374 kg
Component Two → Assembly	1 kg	1,374 kg
Component Three → Assembly	50 kg	1,406 kg
Assembly → Transport (Auckland)	1,374 kg	1 kg
Assembly → Transport (Wellington)	26 kg	26 kg
Assembly → Transport (Christchurch)	44 kg	44 kg
Total:	1,496 kg	4,225 kg

At this point, you're probably thinking that China wins hands down - afterall, the CO_2-equivalents is almost three times higher. But remember we made some assumptions: one of which is the costs per km are for a person. If the components are lighter, then the costs will be lower. So, time for some more assumptions:

- Component One weighs 100 g each and we order them in batches of 50 (total weight is 5 kg).
- Component Two weighs 50 g each and we order them in batches of 200 (total weight is 10 kg).
- Component Three weighs 5 kg each and we order them in batches of 10 (total eight is 50 kg).
- The finished product weighs 5.5 kg. We send them in batches of 25 (total weight is 137.5 kg).
- The average airline passenger weighs 84 kg[6].
- We will only adjust the costs for transport between cities (e.g. the cost within the city will be unchanged.)

There is a bit of a challenge given each item has a different batch size. To simplify things we are going to assume we are making the products in batches of 100 to minimize component and product waste.

Our new figures are:

Flow	**China**	**New Zealand**
Component One → Assembly	1 kg	82 kg
Component Two → Assembly	1 kg	164 kg
Component Three → Assembly	30 kg	837 kg
Assembly → Transport (Auckland)	4,498 kg	1 kg
Assembly → Transport (Wellington)	43 kg	43 kg
Assembly → Transport (Christchurch)	72 kg	72 kg
Total:	4,645 kg	1,198 kg

Now the numbers have swapped - we generate far more CO_2-equivalents assembling the components in China. Of course, if we were patient, we would ship the goods from China, which would reduce the emmissions significantly. Plus we've missed a few transport costs (goods still need to go from the port or airport to the factory or distribution centre.)

[6]This is including carry-on luggage - see https://www.easa.europa.eu/en/newsroom-and-events/news/easa-review-standard-passenger-weights-2022-shows-no-significant-change.

What else do we need to consider? Looking back at Figure 15.8 we see there is an energy production cost. Again, some rough estimates:

- Each item takes 23 kilowatt-hours of electricity to assembly, test, and pack for distribution.
- China emits 544 g/kilowatt-hour for electricity production.
- New Zealand emits 133 g/kilowatt/hour for electricity production.

The last two numbers are from https://ourworldindata.org/grapher/carbon-intensity-electricity.

So, per item, China would emit 12.5 kg, while New Zealand emits 3 kg, or 1,250 kg and 300 kg per batch. Not an insignificant amount, but certainly smaller than the transport emissions.

We could keep going on, but we're going to stop here. We've got some initial data estimates which will help us provide some recommendations (the final phase).

First, we can say the majority CO_2-equivalents cost in this example is for transport, so we should look at reduce these costs. The largest costs are transporting the heavier items from China to New Zealand. Some estimates put shipping at 10% of the plane emissions, so if we can wait, then putting goods onto a ship would reduce our emissions for transport costs to 628 kg for China and 231 kg for New Zealand. Second, the energy costs in New Zealand are much lower (a quarter the amount), so bringing assembly to New Zealand will greatly reduce emissions, even when we consider the shipping costs[7].

From an environmental perspective, we'll produced a good case for moving production to New Zealand. However, there are other factors to consider (economy and equity.) For a full sustainability picture, we would also need to consider these factors. For example, hourly wages are much lower in China, meaning we can assemble each product for a lower monetary cost. But at the same time, working conditions are poorer there, which reduces equity, making the product less sustainable over the long run. And of course, our toy example didn't include the two major stages of the lifecycle: usage and disposal. But this example should show how to start with a life cycle assessment to generate some sustainability recommendations.

15.4 Resources

- EcoChain, a technical company for helping with Life Cycle Assessments, has several resources on Life Cycle Assessments. For example: https://ecochain.com/knowledge/life-cycle-assessment-lca-guide/ is a beginner's guide and https://ecochain.com/knowledge/cradle-to-cradle-in-lca/ discusses the circular economy.
- There are also local resources. The Life Cycle Association of New Zealand is an organisation in New Zealand that provides support and guidance for sustainability: https://lcanz.org.nz/.

[7] We'll let you calculate these total costs.

16. Peer Reviewing

As part of this course, you will be peer reviewing the **Project Proposal** from two other teams. This tasks raises the question of how do you do a review of your peers' work? Or, even more fundamentally, "what is a peer review?" This chapter looks into what is a peer review, how do you do one, and what can you learn from your peers?

16.1 Introduction

Before we can explain how to do a peer review, we need to first explain what a peer review is. The term "peer review" different things to different people. We are going to use the definition by Clark, et al. [7]:

> "We define *peer review* as a student-led process during which learners provide and receive constructive feedback, reflect on that feedback, and revise their work in response to the feedback. This grow-oriented process improves students' work and understand of academic concepts, and develops their self-evaluative, collaborative, and practical workplace skills."

Thus, peer review is a process of giving and receiving feedback to help each other get better.

A peer reviewer is first and foremost a reader. They:

1. Are an active participant in the process,
2. Seek to understand,
3. Engage with the ideas,
4. And respond to provide help.

On contrast, peer reviewers are not:

Teachers: it is not your job to mark your peers' work. You are looking for how to improve their work, not whether they meet the marking criteria.

Proofreader: while we care about grammar and spelling in this course, it is your job to find these mistakes. Instead, you are looking at their ideas and their feasibility.

Writer: you didn't write their proposal (they did)! Thus, you can only make suggestions and recommendations: how can they improve their final project. You can "strongly" suggest but you cannot command.

S. Williams, from the University of Hawaii, said this as[1]:

> "As a peer reviewer, your job is not to provide answers. You raise questions; the writer makes the choices. You act as a mirror, showing the writer how the draft looks to you and pointing out areas which need attention."

16.2 Why Peer Review?

Research has identified many benefits of peer reviews. Some of the benefits are: they help you to form better judgements of quality, both in your own work and in other's [5]. They foster critical thinking, self-reflection, judgement making, and metacognitive self-awareness [2, 3]. It also exposes you to alternate ways of thinking and encourages collaboration [1]. Finally, it provides feedback from people on a similar level to you, using term you are more likely to understand [2]. Thus, peer reviews can help you to learn what your peers are doing and improve your writing ability.

However, peer review by itself is not a "magic-bullet": it won't automatically help you improve. Like any activity, it does take effort before you see the benefit. In order for peer reviews to be meaningful, you need to actively engage with the process: both for giving and receiving feedback. When done properly, peer review can build a dynamic feedback loop where you reflect on other people's work and use these reflections to improve your own work.

16.3 How to Review?

Peer reviewing is a two-way process that helps both the reviewers and the authors. The following are some suggestions to help you get the most out of the peer review process.

16.3.1 Before the Review

Before you submit your **Project Proposal**, talk in your group about what sort of feedback you are interested in receiving. Are you looking for how your project could be improved technically? How your writing could be improved? How well your idea meets the Project Brief? Etc. Try and be specific about what you are interested in learning. Add these items to the `feedback.tex` file in your GitHub repository. This process will automatically add the review questions to your peer-review submission.

Before the peer review, read the assignment guidelines (for the **Project Proposal** assignment, including the rubrics) and the Project Brief. This will help you understand what the teaching staff are looking for in the report. It may help you to rewrite the key points in your own words so you understand it. Re-read your group's report to see how you have applied the instructions: see how well you think your group applied the guidelines[2]. The aim of this step is to build your knowledge of the requirements[3].

16.3.2 During the Review

To get the most benefit out of the review process, you need to allocate some time for it. Don't expect to read the report in the ten minutes before it is due and do a good job. We recommend allocating at least an hour per report to read it, think about it, and write some quality feedback.

When you first start reading, read through the requested feedback (if included.) This information is what the authors are looking for, so try to help them in the process. Again, you can rewrite these to help you understand (if desired).

[1] From `https://serc.carleton.edu/sp/library/peerreview/tips.html`

[2] Be critical in this process and look for a mixture of positives and negatives. If you look at just one aspect (what was good or what was bad) you will miss opportunities for improvement.

[3] You can also talk about your understanding with your group and your mentor.

Then, do a quick scan through of the whole report. Look at the different headings, images, and tables to get an idea of what is in the report. This step should be quick as you are just getting an overview. Think about the criteria and the requests.

Now you are ready to do the actual review. Read through the whole report from beginning to end. During this process make some notes about what you are reading. These are not formal notes, they are to help you understand the report[4]. During this time, mark any places you think the authors have written well or poorly, any questions you have, and any potential errors or mistakes. These are your own personal notes, so you are the only person you needs to understand them.

After you have read through the whole report, go back and check your notes. Are there any points that have been clarified later in the report? Are there any inconsistencies you noticed? Do you have a mix of positives and negatives? Have you answered the questions the authors requested in the feedback? This stage is for you to organise your thoughts and think critically about what you have read.

Then, write up your feedback for the authors. Look to write a mix of positive and critical comments[5]. Use clear, helpful language that explains what "you" think about their report. These are your personal opinions, so they reflect on you more than the original authors. Make sure the authors can identify where the comments refer to[6]. It is also helpful to start with a general overview of your opinions. What do you think has worked well, what needs more work, and where things could be improved. If unsure, you can include questions asking the authors about what they have written.

Finally, before you submit your feedback, go back and re-read it all! Does it make sense? Does it refer to the correct places? Is the language polite and helpful? Do you have positive and critical comments? How would you feel if you received this feedback? **DO NOT** submit until you have double-checked your comments.

16.3.3 After the Review

Once the peer reviews have completed, you group has to make sense of the feedback. You will be receiving a lot of feedback about your reports that you have to condense into an actionable form.

Everyone in the group should read through several of the reports by themselves. Don't get one person (or more) to read everything, instead divide the labour. Each person should look for common things that have been mentioned in the reviews or items that stand out[7]. Remember to look for things that people mention you did well, in addition to areas that need improvement.

When everyone has read the reviews (hopefully as a group you will have read all of them) get together and compare your notes. If something has been mentioned in many reviews, it is an indication you should pay attention to it. At the same time, if there is anything you think is important, bring it up. Or if there is something you are unsure about. The aim is for the whole group to discuss the feedback to get an overall perspective of the reviews. By the end of this session, you should have a list of what your group thinks are the most important points from the feedback.

Then, go through these points and decide what you are going to do about them. Is is something the reviewers like? Make sure you keep it for the final report. Is it something critical? Decide if you're going to change it or not, and justify why. Decide which changes are the most important, and which will be done if you have time. Remember, it is your group's project, not the reviewers',

[4] You can use any tools you find helps with the process. Pen-and-paper is often good as you can focus on the reading and note-taking rather than the tool.

[5] Aim to have an even mix of comments. If you are being overly critical, go back and re-read the report for what you think was written well.

[6] You can use page and paragraph numbers, inline annotations, or sections headings: whatever makes the most sense.

[7] This will be a personal judgement: look for things that you think will help your group.

so you have the final say. Finally, are there things that the reviewers were confused about? Look at how you could make these items clearer in future.

If desired, you can also talk with your mentor about the feedback. They are here to help support you, so if there are things you think they can help with, let them know.

16.4 Some Guidelines

Here are some guidelines to help you reviewing:

1. Read the document all the way through before you start commenting. As you read, make notes of important points.
2. Use clear, constructive, considerate language. Remember, you are trying to help the other team improve.
3. Phrase your comments as suggestions, not commands.
4. Provide a range of comments: identify strengths (what worked well) as well as weaknesses.
5. Raise questions that you think of when reading their proposal, especially ones that the authors may not have thought of.
6. When making a comment, refer to the specific place in the proposal (e.g. page number and paragraph.) This helps the put the comment in context.
7. Reread your comments before submission to check they make sense and can be understood.

16.5 Resources

- The library has some books on peer-review. For example, What every student should know about practicing peer review by Michelle Trim and Student-Led Peer Review : A Practical Guide to Implementation Across Disciplines and Modalities. by Kimberly Lowe, *et. al.*
- There are resources online. However, make sure you find resources for performing student peer review, e.g. `https://serc.carleton.edu/sp/library/peerreview/tips.html`.

17. Te Tiriti o Waitangi

Te Tiriti o Waitangi, or the Treaty of Waitangi, is New Zealand's founding document. It is an agreement between the Monarch of the British Empire (Queen Victoria at the time), and the Māori, the local indigenous people. The intention of the treaty was to build a relationship between the two groups of people, although both groups had different expectations. However, te Tiriti is an important document in New Zealand's history.

In this chapter, we will explore some of the history around Te Tiriti o Waitangi and why it is important. We'll look at some history to see it in context, before moving onto why it is important for us as engineers. Finally, we'll look at data Sovereignity: what it is and why it is important.

17.1 Some Background

On 6 February, 1840, 40 rangatira[1] signed a treaty at Waitangi in the Bay of Islands. By the end of the year, around 500 rangatira had signed the "treaty": thus establishing New Zealand as a colony of Britain. But what is the Treaty of Waitangi, or Te Tiriti o Waitangi, and why is it imporant?

Captain William Hobson was sent from Britain to claim New Zealand as a British colony in 1839. At the time, there were worries that the French were trying to start a new colony in New Zealand[2] Given the proximity to New South Wales, this development was very alarming to the British government. In February 1840, Captain Hobson meet with several of the rangatira at Waitangi and discussed the possibility of a treaty. He tried to convince the Māori that a treaty would be in their best interests, and over the first few days of the month the local missionaries drafted a treaty document.

On the night of 5 February, Captain Hobson retired to his ship, the *HMS Herald*. The discussions throughout the day had been fruitless as none of the rangatira wanted to sign the treaty. But on the 6 February, Captain Hobson was summoned back Waitangi. Started with Hone Heke, the rangatira came up one by one and signed the treaty: thus starting the process of forming New Zealand.

But 40 signatures were not enough. Captain Hobson had additional copies of the treaty written and sent around Aotearoa[3]. Over 400 rangatira signed the treaty in the following months. As a result,

[1] Chiefs

[2] Akaroa was founded by the French in August 1840.

[3] The Māori did not have a name for the whole country. Using Aotearoa as the Māori name did not become common until after the 1880's.

on the 21 May Captain Hobson declared British sovereignty over all of New Zealand, even though rangatira were still signing the treaty.

For the British, the reasons for signing the treaty are obvious. But why did Māori sign the treaty? They did it for a variety of reasons, depending on where they were based and how much contact they had with Europeans. Some of the reasons are:

- Some iwi wanted mutual benefits to both them and the settlers,
- Other iwi wanted settlement to be controlled and limited,
- Others wanted the protections of British law and guarantees of their land,
- And other wanted their positions protected, especially from settlers.

17.1.1 The Text

Both Te Tiriti o Waitangi and The Treaty of Waitangi have an introduction and three parts (or articles). While the general intent of both texts is the same, there are some significant differences between the two.

A Modern Māori Translation	**English**
Victoria, The Queen of England, in her concern to protect the chiefs and subtribes of New Zealand and in her desire to preserve their chieftainship and their lands to them and to maintain peace and good order considers it just to appoint an administrator one who will negotiate with the people of New Zealand to the end that their chiefs will agree to the Queen's Government being established over all parts of this land and (adjoining) islands and also because there are many of her subjects already living on this land and others yet to come. So the Queen desires to establish a government so that no evil will come to Maori and European living in a state of lawlessness. So the Queen has appointed me, William Hobson, a captain in the Royal Navy to be Governor for all parts of New Zealand (both those) shortly to be received by the Queen and (those) to be received hereafter and presents to the chiefs of the Confederation chiefs of the subtribes of New Zealand and other chiefs these laws set out here.	Her Majesty Victoria Queen of the United Kingdom of Great Britain and Ireland regarding with Her Royal Favor the Native Chiefs and Tribes of New Zealand and anxious to protect their just Rights and Property and to secure to them the enjoyment of Peace and Good Order has deemed it necessary in consequence of the great number of Her Majesty's Subjects who have already settled in New Zealand and the rapid extension of Emigration both from Europe and Australia which is still in progress to constitute and appoint a functionary properly authorized to treat with the Aborigines of New Zealand for the recognition of Her Majesty's sovereign authority over the whole or any part of those islands - Her Majesty therefore being desirous to establish a settled form of Civil Government with a view to avert the evil consequences which must result from the absence of the necessary Laws and Institutions alike to the native population and to Her subjects has been graciously pleased to empower and to authorize me William Hobson a Captain in Her Majesty's Royal Navy Consul and Lieutenant Governor of such parts of New Zealand as may be or hereafter shall be ceded to Her Majesty to invite the confederated and independent Chiefs of New Zealand to concur in the following Articles and Conditions.
Article 1	

A Modern Māori Translation	English
The chiefs of the Confederation and all the chiefs who have not joined that Confederation give absolutely to the Queen of England for ever the complete government over their land.	The Chiefs of the Confederation of the United Tribes of New Zealand and the separate and independent Chiefs who have not become members of the Confederation cede to her Majesty the Queen of England absolutely and without reservation all the rights and powers of Sovereignty which the said Confederation or Individual Chiefs respectively exercise or possess, or may be supposed to exercise or to possess over their respective Territories as the sole sovereigns thereof.
Article 2	
The Queen of England agrees to protect the chiefs, the subtribes and all the people of New Zealand in the unqualified exercise of their chieftainship over their lands, villages and all their treasures. But on the other hand the chiefs of the Confederation and all the chiefs will sell land to the Queen at a price agreed to by the person owning it and by the person buying it (the latter being) appointed by the Queen as her purchase agent.	Her Majesty the Queen of England confirms and guarantees to the Chiefs and Tribes of New Zealand and to the respective families and individuals thereof the full exclusive and undisturbed possession of their Lands and Estates Forests Fisheries and other properties which they may collectively or individually possess so long as it is their wish and desire to retain the same in their possession; but the Chiefs of the United Tribes and the individual Chiefs yield to Her Majesty the exclusive right of Preemption over such lands as the proprietors thereof may be disposed to alienate at such prices as may be agreed upon between the respective Proprietors and persons appointed by Her Majesty to treat with them in that behalf.
Article 3	
For this agreed arrangement therefore concerning the government of the Queen, the Queen of England will protect all the ordinary people of New Zealand and will give them the same rights and duties of citizenship as the people of England.	In consideration thereof Her Majesty the Queen of England extends to the Natives of New Zealand Her royal protection and imparts to them all the Rights and Privileges of British Subjects.

From https://teara.govt.nz/en/document/4216/the-three-articles-of-the-treaty-of-waitangi.

In general, the three articles state:

1. The British would have "sovereignty" over all of New Zealand.
2. The Māori would have full chieftainship (tino rangatiratanga) over their lands and valuables (taonga). If they sold lands, it would be to the Crown.
3. Māori would have the same rights and protections as any other British citizen.

However, how the two parties understood these articles is different. The British thought Māori were giving them complete sovereignty (supreme power and authority) while Māori would have undisturbed possession of their lands, forests, fisheries, and other properties. The key word here

being “properties”. In contrast, Māori thought they were giving the Crown “complete governorship”, especially over their own citizens, while they would retain unqualified exercise of chieftainship over their lands and all other treasures. As you can see, there are some sharp contrasts between these two outlooks.

While Hobson, and his successor, Robert FitzRoy, were the governer-generals of New Zealand, the Crown generally abidded by the Māori understanding of Te Tiriti. However, under George Grey and later governer-generals, the Crown applied the English understanding, often siding with the settlers against Māori. As a result, Māori concerns were often ignored, with the Crown forcing their interpretation (sometimes with military force.) As a result, many Māori were forced off their lands and had their taonga confiscated. These confiscations resulted in many Māori living in poverty, with increased ill-health.

However, since the 1970’s there has been a slow reversal of this state. The New Zealand passed the Treaty of Waitangi Act in 1975, which established the Waitangi Tribunal to address concerns from Māori. This in turn has resulted in a number of “settlements” to address grievances about the way Te Tiriti o Waitangi was applied. Some of the settlements include returning land to different iwi and hapū, as well as recognising the Māori language (Te Reo Māori.) It has also resulted in organisations being more away of their Treaty obligations (more on this later.)

17.2 Te Ao Māori/The Māori World

Before we delve into the Treaty principles and obligations, let’s take take a quick look at Te Ao Māori[4].

First, Māori society is a hierarchal society, with traditional family, marae, hapū, and iwi values. Knowing which iwi and hapū you belong to is important. Often the first activity in a meeting is working out what relationships you have with the other person or people. Thus, society is built upon relationships and physical introductions. While COVID and the recent lockdown have changed some times, Māori still set much value in meeting kanohi ki kanohi (face to face).

Te Ao Māori is not new. It is based upon a set of tikanga that are thousands of years old. Tikanga refers to the customary practices, protocols, values, and principles that guide Māori behavior and decision-making. It encompasses the knowledge and wisdom passed down from generation to generation that shapes the way Māori people interact with each other, the natural environment, and the spiritual world.

Tikanga is deeply connected to Māori culture and identity and is central to the wellbeing of Māori communities. It is a way of life that reflects the interconnectedness of all things, including people, the natural environment, and the spiritual realm. Tikanga is expressed through a range of practices, including language, arts, music, storytelling, and customs. It is also closely related to the concept of mana, which refers to personal power, prestige, and authority. In Māori culture, an individual’s mana is closely tied to their adherence to tikanga and their ability to demonstrate respect for others and the natural world.

Whakapapa is another important concept: it refers to genealogy, or the tracing of a person’s ancestral lineage. It is a fundamental aspect of Māori culture and identity, and is considered the foundation of all relationships between Māori people. In Māori culture, whakapapa connects people to their ancestors, to the natural world, and to the spiritual realm. It is through whakapapa that Māori people understand their place in the world, and their obligations to their ancestors, their community, and the natural environment.

Whakapapa is traditionally passed down through oral histories, songs, and stories, which are used

[4]This is just an introduction, Māori have a rich society that a single chpater cannot do justice to.

to record and transmit genealogical information from one generation to the next. It is a complex and nuanced system that includes not only the tracing of bloodlines, but also the recognition of spiritual and cultural connections between people and places.

In modern times, whakapapa is still an important part of Māori culture, and is often used to strengthen connections between Māori communities and to maintain cultural traditions. It is also increasingly recognized as an important tool for understanding and addressing issues of social and economic disadvantage among Māori people, and for promoting cultural identity and wellbeing.

A final concept we will cover is kaitiaki. Kaitiaki refers to the concept of guardianship, or the role of protecting, preserving, and managing natural and cultural resources for present and future generations. Kaitiaki is a fundamental concept and reflects the close relationship that Māori have with the natural world. This stands in contrast to a European perspective, where lands and resources belong to specific people.

The role of kaitiaki is to ensure that natural resources are used in a sustainable and responsible way. This includes ensuring the spiritual, cultural, and physical wellbeing of the environment is maintained. It is closely related to the concept of mana (personal power, prestige, or authority.) Individuals and communities can gain mana by demonstrating their ability to act as kaitiaki and protect and preserve the natural world.

Today, the concept of kaitiaki is increasingly recognized and valued. It is often used to guide environmental management and conservation efforts. The concept of kaitiaki has been extended to include the protection and preservation of cultural heritage, such as language, arts, and customs, and is considered an important aspect of cultural revitalization and wellbeing.

17.3 Treaty of Waitangi Principles

The Treaty of Waitangi principles are a set of principles that have been developed to guide the relationship between the Māori and the Crown in Aotearoa/New Zealand. The principles were first established by the Courts in the 1980s and have since been recognized as an important aspect of the country's constitutional framework. The principles are:

Partnership: Te Tiriti o Waitangi as a partnership between Māori and the Crown. This principle recognizes that the Treaty of Waitangi established a partnership between Māori and the Crown, with both parties working together in good faith to achieve shared goals and objectives.

Participation: Māori should participate in decision-making. This principle recognizes the importance of active Māori participation in decision-making, particularly in matters that affect their rights and interests. Active participation means that Māori can influence the decisions, rather than just being on the receiving end.

Protection: This protection recognizes the need to protect Māori taonga, including their cultural, economic, and social wellbeing. The Crown should ensure that these are not compromised by the actions of the Crown or other parties.

Options: This principle recognizes the need for Māori to have options and choices in the way they exercise their rights and interests. As mentioned in the other principles, Te Tiriti o Waitangi is a partnership where both parties are active participants. The Crown should not only welcome Māori perspectives in decisions, but also provide options for Māori to implement the decisions in a way that benefits them.

Overall, these principles form an important framework for understanding the relationship between Māori and the Crown. They promote partnership, participation, and protection for Māori rights and interests.

How these principles are applied varies from government department to department. For example,

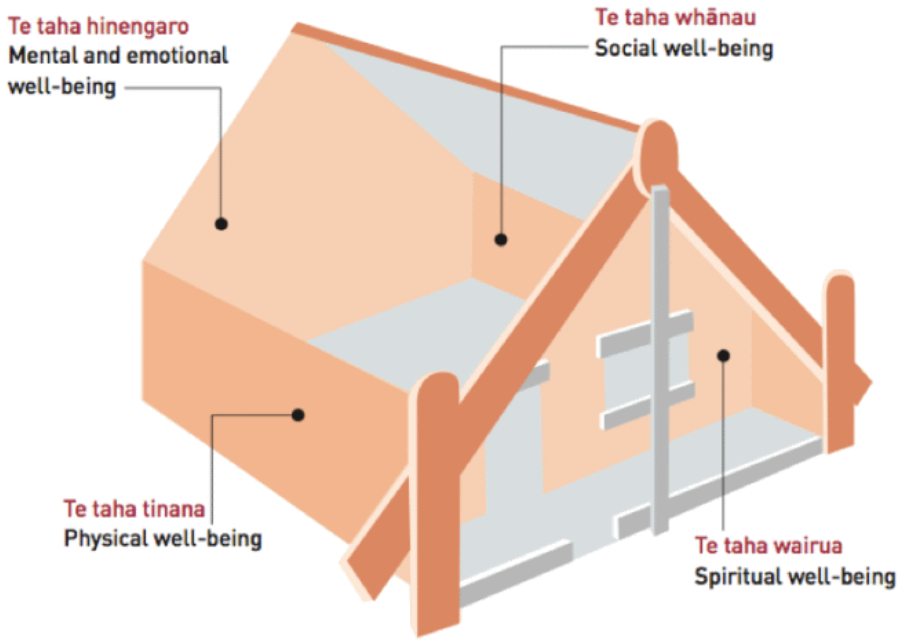

Figure 17.1: Te Whare Tapa Whā concept of hauora [8].

the Ministry of Health has built their application around the Te Whare Tapa Whā concept of hauora (see Figure 17.1). They define the principles as:

Tino rangatiratanga : The guarantee of tino rangatiratanga, which provides for Māori self-determination and mana motuhake in the design, delivery, and monitoring of health and disability services.

Equity : The principle of equity, which requires the Crown to commit to achieving equitable health outcomes for Māori.

Active protection : The principle of active protection, which requires the Crown to act, to the fullest extent practicable, to achieve equitable health outcomes for Māori. This includes ensuring that it, its agents, and its Treaty partner are well informed on the extent, and nature, of both Māori health outcomes and efforts to achieve Māori health equity.

Options : The principle of options, which requires the Crown to provide for and properly resource kaupapa Māori health and disability services. Furthermore, the Crown is obliged to ensure that all health and disability services are provided in a culturally appropriate way that recognises and supports the expression of hauora Māori models of care.

Partnership : The principle of partnership, which requires the Crown and Māori to work in partnership in the governance, design, delivery, and monitoring of health and disability services. Māori must be co-designers, with the Crown, of the primary health system for Māori.

17.4 Data Sovereignty

In contrast to the Western perspective, Māori communally own much of their knowledge. Māori Data Sovereignty refers to the inherent rights and interests Māori, whānau, hapū, iwi and Māori organisations have in relation to the creation, collection, access, analysis, interpretation, management, dissemination, re-use, and control of data relating to Māori, whānau, hapū, iwi and Māori organisations as guaranteed in Article II of Te Tiriti/Treaty of Waitangi (from Taiuru, K. 2020).

One way this is defined is:

> Datum, data, information or knowledge in any format or medium, which is about, from, is produced by Māori Peoples, whānau, hapū, iwi or Māori organisations either collectively or individually, describes Māori Peoples, whānau, hapū, iwi and Māori organisations and their environments, has relationships with, or is made by Māori Peoples, whānau, hapū, iwi and Māori organisations or contains any Māori Peoples, whānau, hapū, iwi and Māori organisations content or association or may affect Māori, whānau, hapū, iwi and Māori organisations. Māori Data are a living taonga and are of strategic value to Māori Peoples, whānau, hapū, iwi and Māori organisations (Taiuru, 2020).

17.5 Resources

- There is a lot of information available on the internet about Te Tiriti o Waitangi. During the writing of this chapter, we referred to resources from:
  - https://www.newzealandnow.govt.nz/live-in-new-zealand/history-government/a-brief-history
  - https://teara.govt.nz/en/history
  - https://nzhistory.govt.nz/politics/treaty/treaty-timeline/treaty-events-1800-1849
  - https://www.tepapa.govt.nz/discover-collections/read-watch-play/maori/treaty-waitangi/treaty-waitangi-close/making-treaty
- There are also resources online about Māori Data Sovereignty and what it means for organisations. For example: https://www.taiuru.maori.nz/compendium-of-maori-data-sovereignty/ and https://www.temanararaunga.maori.nz/.

18. Privacy

Privacy is an important topic in our modern societies. The Internet has brought new ways of collecting and sharing data, which in turn can have an effect on people. But, what is privacy. To quote the office of the privacy commissioner [15]:

> Privacy means different things to different people. A right to privacy can mean a right to be left alone, a right to control who sees information about you, or a right to make decisions about your personal life without government intervention.

Thus, privacy can be defined as the ability of an individual or group to keep personal information and activities away from public scrutiny or unauthorized access. It is the right to control what personal information is collected, stored, used, and shared with others. It applies to a wide variety of personal information, including health information, financial information, communications, and other sensitive data. It can also refer to physical privacy, which relates to a person's right to solitude and freedom from intrusion in their personal space.

However, privacy is not an absolute, essential right. There are times where privacy is less important than other issues. Again, the office of the privacy commissioner states [15]:

> The value of a right to privacy can also vary depending on circumstances, cultural context, time and personal preference. Although privacy is important, it is not absolute. Other social interests can be more important than privacy in some instances, such as preventing crime, ensuring safety, and ensuring that courts get information to make their decisions.

Thuis, it is important to know when privacy applies and when it doesn't. This differentiation is especially important when we are collecting, holding, and sharing personal information about people. In New Zealand, the Privacy Act 2020 sets out the legal requirements for privacy.

18.1 The Principles

The Privacy Act has thirteen principles relating to the collection, use, and disclosure of information. These are:

Principle 1 - Purpose for collection
Principle 2 - Source of information - collection from the individual
Principle 3 - What to tell the individual about collection
Principle 4 - Manner of collection

Principle 5 - Storage and security of information
Principle 6 - Providing people access to their information
Principle 7 - Correction of personal information
Principle 8 - Ensure accuracy before using information
Principle 9 - Limits on retention of personal information
Principle 10 - Use of personal information
Principle 11 - Disclosing personal information
Principle 12 - Disclosure outside New Zealand
Principle 13 - Unique identifiers

Together, these principles set out the following requirements:

- Organisations should only collect personal information only for lawful purposes and with the consent of the individual.
- They should take reasonable steps to ensure that personal information is accurate, up-to-date, and relevant.
- They should protect personal information from unauthorized access, use, disclosure, and loss.
- Individuals should have access to their personal information and the ability to correct it if necessary.
- Organisations cannot disclose personal information to third parties without the individual's consent, unless an exception applies.

The Act has important implications for the systems we develop, especially computer and software systems. Software developers and providers must implement appropriate security measures to safeguard personal information that is collected, stored, or transmitted through the software application.

18.2 Your Rights

Under the Privacy Act, people have the following rights [16]:

1. You know when and why your information is being collected,
2. Your information is used and shared appropriately,
3. Your information is kept safe and secure,
4. You can access the information an organisation holds about you.

These rights mean you, as an individual, can ask organisations about the information they have on you. And if the information is incorrect, you can ask for it to be corrected. These rights are personal right: you cannot ask for other people (unless you have their authority). From an organisations perspective, they need to handle these rights, while staying within the framework of the Privacy Act.

18.3 Your Responsibilities

First, the Privacy Act applies to every person, business, government department, and organisation. These include both public (e.g. government) and private organisations. There are some exceptions[1] but beyond these, everyone and every organisation is covered.

These responsibilities can be grouped into three categories.

[1] Some examples are courts and tribunals, news media, and Members of Parliment when they are working in their roles. The full list is available in the Act: https://www.legislation.govt.nz/act/public/2020/0031/latest/LMS272745.html

18.3.1 Collecting Data

The first thing anyone should consider when they are collecting data is "why are they collecting it?" You should only collect data for a valid, lawful reason. In addition, you should only collect the minimum amount of data you need to achieve the reason. For example, if you are delivering goods to a person's house, you would need to know their address. You don't need to know their age, gender, hours of work, or any other personal details.

When collecting data, you should collect it directly from the person and let them know that you are collecting it. Typically, this process involves telling the person what data you are collecting and why. At the same time, you can also verify that you can collect it and ensure you have the correct details.

There are times when you either connect collect data directly from a person or the collection may influence the outcome. Again, the Act has provisions in it for these circumstances, but a good recommendation is to err on the side of caution. There are consequences (including some very serious ones) for breaches for privacy.

Finally, there is the issue of data in the public domain. Information in the public domain includes information in a publicably available publication, like books, newspapers, public registers, and the Internet. Most of these are straight-forward but the Internet does raise some potential issues. It is now possible to take information that was disclosed in a private context or restricted site (e.g. a Facebook) and publicably share it without the original person's consent. When using information from the Internet you should always verify the source and whether the information really is public or not. Remember, when in doubt, err on the side of caution.

18.3.2 Holding Data

Once an organisation has collected personal information, there are requirements for holding the data.

First, any personal data must be held in a secure fashion. The more sensitive the data is, the stronger the safeguards should be. For example, information on a child's name, age, and address is typically seen as more sensitive than an adult's. Therefore, you would want to ensure this data has a lower risk of exposure. As a general policy, you should ensure that only authorised people have access to any personal details. For more sensitive data, you should also set up auditing to track who accesses the information and why.

As well as storing data securely, you should also have the ability to give the information to people when they request it and provide a mechanism for them to correct it. This does not mean you can just open up the system to anyone. You will need some mechanism to validate the person is authorised to ask for the information and that the requested corrections are accurate. How this mechanism is implemented is up to each organisation, but again, the more sensitive the data, the more stringent the mechanism should be.

Finally, once the data is no longer needed, it should be securely deleted. This means the data should be permanently removed with no possible way of recovering it. The exception to this is depersonalised or summarised data: both of which can no longer identify the original person[2].

18.3.3 Using and Disclosing Data

The final category is when the personal information can be used and shared. Again, you should only use it for the purpose it was collected. For example, a doctors clinic cannot collect patient

[2]However, you do have to be very carefull with depersonalising data - see https://www.wired.com/2007/12/why-anonymous-data-sometimes-isnt/.

information for clinical purposes and then use or sell it for marketing purposes. There are some exceptions but these are few, e.g. when required to enforce the law.

In addition to only using it for the specified purpose, you should not disclose it unless for a good reason. The Privacy Act specifies some reasons that you can disclose personal information (e.g.to the individual themselves, for legal reasons, or for taxation purposes.) When in doubt, you should refuse to disclose information until the requestor can provide a valid justification.

18.4 Resources

- The Office of the Privacy Commissioner (OPC) maintains an accessible sets of resources about the Privacy Act and how it applies in New Zealand: https://www.privacy.org.nz/
- Privacy is not just a New Zealand issue. The Organisation for Economic Co-operation and Development (OECD) has also published guidelines on privacy (which New Zealand tries to follow): https://www.oecd.org/digital/privacy/

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A. Coping With Hitchhikers And Couch Potatoes

By Barbara Oakley

You will usually find your university teammates as interested in learning as you are. Occasionally, however, you may encounter a person who creates difficulties. This handout is meant to give you practical advice for this type of situation.

To begin with, let's imagine you have been assigned to a combined group project this semester with three others: Mary, Arthur, and Jack. Mary is okay: she is not good at solving problems, but she tries hard, and she willingly does things like get extra help from the teacher. Arthur is irritating. He is a nice guy, but he just does not put in the effort to do a good job. He will sheepishly hand over partially worked work and confess to spending the weekend watching TV. Jack, on the other hand, has been nothing but a problem.

A.1 Jack, the Hitchhiker

Here are a few of the things Jack has done:

1. When you tried to set up meetings at the beginning of the semester, Jack just count not meet, because he was too busy.
2. Jack infrequently turns in his part of the work. When he does, it is almost always wrong-he obviously spent just enough time to scribble something down that looks like work.
3. Jack has never answered phone messages. When you confront him, he denies getting any messages. You e-mail him, but he is "too busy to answer."
4. Jack misses every meeting-he always promises he will be there, but never shows up.
5. His writing skills are okay, but he can not seem to do anything right for the reports. He loses the drafts, does not reread his work, leaves out tables, or does something sloppy like write equations by hand. You have stopped assigning him work because you do not want to miss the strict deadlines.
6. Jack constantly complains about his fifty-hour work weeks, heavy school load, bad textbooks, and terrible teachers. At first you felt sorry for him-but recently you have begun to wonder if Jack is using you.
7. Jack speaks loudly and self-confidently when you try to discuss his problems-he thinks the problems are everyone else's fault. He is so self-assured that you can not help wondering sometimes if he is right.

8. Your group finally was so upset they went to discuss the situation with Dr. Distracted. He in turn talked, along with the group, to Jack, who in sincere and convincing fashion said he had not really understood what everyone wanted him to do. Dr. Distracted said the problem must be the group was not communicating effectively. He noticed you, Mary, and Arthur looked angry and agitated, while Jack simply looked bewildered, a little hurt, and not at all guilty. It was easy for Dr. Distracted to conclude this was a dysfunctional group, and everyone was at fault-probably Jack least of all.

The bottom line: You and your teammates are left holding the bag. Jack is getting the same good grades as everyone else without doing any work. Oh yes-he managed to make you all look bad while he was at it.

A.1.1 What this group did wrong: Absorbing

This was an 'absorber' group. From the very beginning they absorbed the problem when Jack did something wrong, and took pride in getting the job done whatever the cost. Hitchhikers count on you to act in a self-sacrificing manner. However, the nicer you are (or the nicer you think you are being), the more the hitchhiker will be able to hitchhike their way through the university-and through life.

A.1.2 What this group should have done: Mirroring

It is important to reflect back the dysfunctional behavior of the hitchhiker, so the hitchhiker pays the price-not you. Never accept accusations, blame, or criticism from a hitchhiker. Maintain your own sense of reality despite what the hitchhiker says, (easier said than done). Show you have a bottom line: there are limits to the behavior you will accept. Clearly communicate these limits and act consistently on them. For example, here is what the group could have done:

1. When Jack count not find time to meet in his busy schedule, even when alternatives were suggested, you needed to decide whether Jack was a hitchhiker. Was Jack brusque, self-important, and in a hurry to get away? Those are suspicious signs. Someone needed to tell Jack up front to either find time to meet, or talk to the teacher.
2. If Jack turns nothing in, his name does not go on the finished work. (Note: if you know your teammate is generally a contributor, it is appropriate to help if something unexpected arises.) Many teachers allow a team to fire a student, so the would-be freeloader has to work alone the rest of the semester. Discuss this option with your instructor if the student has not contributed over the course of an assignment or two.
3. If Jack turns in poorly prepared work, you must tell him he has not contributed meaningfully, so his name will not go on the submitted work. No matter what Jack says, stick to your guns! If Jack gets abusive, show the teacher his work. Do this the first time the junk is submitted, before Jack has taken much advantage-not after a month, when you are really getting frustrated.
4. Set your limits early and high, because hitchhikers have an uncanny ability to detect just how much they can get away with.
5. If Jack does not respond to e-mails, answer phone messages, or show up for meetings, do not waste more time trying to contact him.
6. Keep in mind the only one who can handle Jack's problems is Jack. You can not change him-you can only change your own attitude so he no longer takes advantage of you. Only Jack can change Jack-and he will have no incentive to change if you do all his work for him.

People like Jack can be skilled manipulators. By the time you find out his problems are never-ending, and he himself is their cause, the semester has ended and he is off to repeat his manipulations on a new, unsuspecting group. Stop allowing these dysfunctional patterns early in the game-before

the hitchhiker takes advantage of you and the rest of your team!

A.2 Arthur, the Couch Potato

But we have not discussed Arthur yet. Although Arthur stood up with the rest of the group to try to battle against Jack's irrational behavior, he has not really been pulling his weight. You will find the best way to deal with a couch potato like Arthur is the way you deal with a hitchhiker: set firm, explicit expectations-then stick to your guns. Although couch potatoes are not as manipulative as hitchhikers, they will definitely test your limits. If your limits are weak, you then share the blame if you have Arthur's work to do as well as your own.

A.2.1 But I have Never Liked Telling People What to Do!

If you are a nice person who has always avoided confrontation, working with a couch potato or a hitchhiker can help you grow as a person and learn the important character trait of firmness. Just be patient with yourself as you learn. The first few times you try to be firm, you may find yourself thinking-'but now he/she will not like me-it is not worth the pain!' But many people just like you have had exactly the same troubled reaction the first few (or even many) times they tried to be firm. Just keep trying-and stick to your guns! Someday it will seem more natural and you will not feel so guilty about having reasonable expectations for others. In the meantime, you will find you have more time to spend with your family, friends, or schoolwork, because you are not doing someone else's job along with your own.

A.2.2 Common Characteristics that Allow a Hitchhiker or Couch Potato to Take Advantage

1. Unwillingness to allow a slacker to fail and subsequently learn from their own mistakes.
2. Devotion to the ideal of 'the good of the team' - without common-sense realization of how this can allow others to take advantage of you. Sometimes you show (and are secretly proud of) irrational loyalty to others.
3. You like to make others happy even at your own expense.
4. You always feel you have to do better-your best is never enough.
5. Your willingness to interpret the slightest contribution by a slacker as 'progress.'
6. You are willing to make personal sacrifices so as to not abandon a hitchhiker-without realizing you are devaluing yourself in this process.
7. Long-suffering martyrdom-nobody but you could stand this.
8. The ability to cooperate but not delegate.
9. Excessive conscientiousness.
10. The tendency to feel responsible for others at the expense of being responsible for yourself.

A.3 A related circumstance: you are doing all the work

As soon as you become aware everyone is leaving the work to you-or doing such poor work that you are left doing it all, you need to take action. Many teacher allow you the leeway to request a move to another team. (You cannot move to another group on you own.) Your teacher will probably ask some questions before taking the appropriate action.

A.3.1 Later on-out on the job and in your personal life

You will meet couch potatoes and hitchhikers throughout the course of your professional career. Couch potatoes are relatively benign, can often be firmly guided to do reasonably good work, and can even become your friends. However, hitchhikers are completely different people-ones who can work their way into your confidence and then destroy it. Occasionally, a colleague, subordinate,

supervisor, friend, or acquaintance could be a hitchhiker. If this is the case, and your personal or professional life is being affected, it will help if you keep in mind the techniques suggested above.

From [6], used with permission.

B. Using Git and GitHub

You will be using Git and GitHub throughout this project. This appendix has some background information on these tools, plus instructions how to use them in your project.

B.1 What is GitHub?

At a high level, GitHub is a website and cloud-based service that helps developers store and manage their code, as well as track and control changes to their code. To understand exactly what GitHub is, you need to know two connected principles:

- Version control
- Git

B.1.1 What Is Version Control?

Version control helps developers track and manage changes to a software project's code. As a software project grows, version control becomes essential. Take WordPress... At this point, WordPress is a pretty big project. If a core developer wanted to work on one specific part of the WordPress codebase, it wouldn't be safe or efficient to have them directly edit the "official" source code.

Instead, version control lets developers safely work through **branching** and **merging**.

With **branching**, a developer duplicates part of the source code (called the **repository**). The developer can then safely make changes to that part of the code without affecting the rest of the project.

Then, once the developer gets his or her part of the code working properly, he or she can **merge** that code back into the main source code to make it official.

All of these changes are then tracked and can be reverted if need be.

B.1.2 What Is Git?

Git is a specific open-source **version control system** created by Linus Torvalds in 2005.

Specifically, Git is a **distributed version control system**, which means that the entire codebase and history is available on every developer's computer, which allows for easy branching and merging.

B.1.3 Back to GitHub

GitHub is a for-profit company that offers a cloud-based Git repository hosting service. Essentially, it makes it a lot easier for individuals and teams to use Git for version control and collaboration.

GitHub's interface is user-friendly enough so even novice coders can take advantage of Git. Without GitHub, using Git generally requires a bit more technical savvy and use of the command line.

GitHub is so user-friendly, though, that some people even use GitHub to manage other types of projects: like writing books[1].

From https://kinsta.com/knowledgebase/what-is-github/

B.2 How does this project use Git and GitHub?

Each team will have a single GitHub repository. This repository should store all your artifacts for the project, including:

- Source code (embedded, backend, and both frontends),
- PCB designs,
- Bill of materials,
- Reports (risk analysis, project proposal, and final),
- And other assets generated (including images, documentation, media, etc.)

Putting everything in a single repository provides you with a safe, secure backup facility, as well as providing version tracking and change control. It also provides evidence of your work on the project in the case of any disputes.

Your GitHub repository will be pre-populated with a template. This template contains the following items:

```
\final-report
- \parts
  - appendices.tex *
  - business-case.tex *
  - conclusion.tex *
  - summary.tex *
  - technical-hardware.tex *
  - technical-overview.tex *
  - technical-software.tex *
- business.tex *
- full.tex *
- readme.md
- technical.tex *
\images
- ecse-decal-title.png *
- readme.md
- spca-large.png
- spca-medium.png
- spca-small.png
- spca.svg
\project
- readme.md
```

[1] This course manual uses GitHub.

```
\proposal
- \parts
   - appendices.tex *
   - business-case.tex *
   - conclusion.tex *
   - feedback.tex *
   - summary.tex *
   - technical-hardware.tex *
   - technical-overview.tex *
   - technical-software.tex *
- business.tex *
- full.tex *
- readme.md
- technical.tex *
\risk-analysis
- analysis.tex *
- full.tex *
- readme.md
.gitignore
capstone.cls *
readme.md
team.tex *
```

Files marked with an asterisk (*) are required for the report generation process and **MUST NOT** be deleted.

In addition, the template contains build actions for automatically compiling your three reports. On the readme.md file in the root folder there are status icons that indicates the outcome of these jobs:

B.3 Installing Git

Before you can use GitHub, you will need to sign up and get a GitHub account (if your don't already have one), and install Git on your machine.

Sign-up instructions: https://docs.github.com/en/get-started/signing-up-for-github/signing-up-for-a-new-github-account

Git installation instructions: https://docs.github.com/en/get-started/quickstart/set-up-git

You may also want to install a code editor like Visual Studio Code (https://code.visualstudio.com/download).

When your teams are allocated, we will send you a communcation explaining how to access your repository.

B.4 Resources

GitHub cheat sheet : https://training.github.com/downloads/github-git-cheat-sheet/

Pro Git Book (v2) : https://git-scm.com/book/en/v2

C. Using LaTeX

All the documentation for the project will be generated using LaTeX (stylized as LaTeX). This appendix explains what LaTeX is and how it is used in this project.

C.1 What is LaTeX?

At its most simple, LaTeX is a document typesetting application. It allows you to focus on the "what" in your document, rather than how the document "looks". It does most of the professional layout and typesetting for you, and uses well-establisted rules for making your document look good most of the time. It also has excellent math and formulae suppport (one of the main reasons for the original TeX system), as well as handling bibliographies, indexes, tables of contents, and cross-referencing with ease.

To quote the LaTeX project:

> "LaTeX is a high-quality typesetting system; it includes features designed for the production of technical and scientific documentation. LaTeX is the de facto standard for the communication and publication of scientific documents. LaTeX is available as free software. You don't have to pay for using LaTeX, i.e., there are no license fees, etc."

From https://www.latex-project.org/

And yes, this whole course manual was written using LaTeX. If you want to see the full code of the manual, contact the course coordinator (*Dr Craig Sutherland*).

C.2 How Does This Course Use LaTeX?

In this course, we will be using LaTeX (and GitHub) to generate all your documentation and reports. This means you can focus on what you want to say and we don't have to worry that you meet the formatting requirements. It also gives us the ability to split out the documents in different ways to help us mark and review them.

Whenever you need to submit a written document, you will submit it using in LaTeX format. We will then download the documents and automatically generate them into the final document. If necessary, we will then upload a version of the final document to Canvas for you to review (if

desired.) We have also provided all the templates so you can generate the documents yourself (mainly for checking before the final submission.)

For each of your reports, we have provided one (or more) LaTeX templates. These contain a skeleton that you can use: you will need to replace the contents of the template with your specific content. The report generator will then import your content into a "formatting" template. This template contains the formatting instructions and style for the complete document. Thus, there is a clean seperation between 'format' and 'content'.

C.2.1 GitHub-based Documents

The files for the main team deliverables (**Risk Analysis**, **Project Proposal**, and **Final Report**) are in your team's GitHub repository. This approach will allow you to work together on the documents, while providing tools like change tracking and rollback (in case you make a mistake.) Each of the repository contains multiple LaTeX templates: one for each part of the report.

In the root level of the repository is `team.tex`. You will need to edit this file to contain the name and members of your team.

For the **Risk Analysis** report you need to modify the `analysis.tex` file in the `risk-analysis` folder.

For the **Project Proposal** and **Final Report** reports you have the following templates:

`summary.tex` : should contain an executive summary of your project.
`business-case.tex` : should contain all the documentation related to the business case, including issues relating to sustainability, Te Tiriti o Waitangi, ethics, and privacy.
`technical-overview.tex` : should contain an overview of all the technical components. This part should be written so a technical person who is not an expert in any of the specialisations can understand it.
`technical-hardware.tex` : should contain any technical documentation specific to the hardware components in the project, including electrical, PCB, and physical elements.
`technical-software.tex` : should contain any technical documentation specific to the software components in the project, including embedded, backend, and frontend.
`conclusion.tex` : should contain a conclusion to the whole report. This part should be understandable without needing to read the three technical parts.
`appendices.tex` : should contain additional appendices to the project. This part is optional and should only include ancillary information.

In addition, for **Project Proposal** there is an additional file for feedback (`feedback.tex`).

These files are under the `parts` folder in the relevant report folder (either `final-report` or `proposal`).

Ideally, you should assume we will generate a final document using the above templates in order (i.e. we start with `summary.tex` and finish with `conclusion.tex`). However, we may extract some of these sections (e.g. for marking) so also make sure each template is complete in itself.

After the final submission, we will generate a complete copy of your report and upload it to your Canvas team site.

C.2.2 Canvas Documents

You will also submit some reports to Canvas dropboxes: these submissions are for the individual reports. These reports will only be a single file: once again, we will generate the final document from the file.

The following assignments use Canvas dropboxes:

- **Status Reports**
- **Course Reflection**

The final versions of these assignments will be available to you on request.

C.3 Installing LaTeX

The easiest way to use LaTeX is to install a TeX distribution like MiKTeX[1]. MiKTeX contains everything needed to build a LaTeX document, plus additional tools to simplify your life (like package management tools).

Installing MiKTeX is easy: go to `https://miktex.org/download`, select your operating system, download the installer, and then follow the installation instructions.

There are also "free" online tools for working with LaTeX documents. `https://www.overleaf.com/` is one of the more popular: it allows for collaborative editing of documents, online compilation, and other tools. Unfortunately, GitHub integration is not part of the free version, so you will need to copy and paste between your system to check into GitHub[2].

C.4 Quick Reference Guide

This section contains some quick help to get you started with LaTeX. It is not the full reference but should have enough to get you started. If there are other things you **really** want to do, raise a help request in Teams and we will see what we can do to help.

C.4.1 Comments and Reserved Characters

A comment can be added to a LaTeX document by using a % character:

```
% This is a comment - LaTeX will ignore it
```

LaTeX will ignore the rest of the line.

Like any programming language, LaTeX has a number of reserved characters. The following characters have a special meaning in LaTeX:

```
# $ % & { } _ ~ ^ \
```

To use these characters in your document, you will need to use the following mappings:

```
#   \#
$   \$
%   \%
&   \&
{   \{
}   \}
_   \_
~   \~{}
^   \^{}
\   \textbackslash or \textbackslash{}
```

[1] Yes, like all TeX derivatives, MiKTeX has weird capitisation!

[2] Yes, GitHub is required: we need it for generating the final documents and for tracking who is working on the documents.

C.4.2 Text Styles

The following commands are used to change the text style:

`\textbf{text}`	Bold **text**
`\textit{text}`	Italic *text*
`\texttt{text}`	Typewriter `text`
`\textsc{text}`	Small capitals TEXT

Text styles can be nested together. For example:

```
\textit{\textbf{The Faculty of Engineering}}
```

will produce ***The Faculty of Engineering***.

C.4.3 Lists and Bullets

To produce a bulleted list, use the itemize environment:

```
\begin{itemize}
    \item Electrical Engineering
    \item Computer Systems Engineering
    \item software Engineering
\end{itemize}
```

This will produce:

- Electrical Engineering
- Computer Systems Engineering
- software Engineering

To produce a numbered list, use the enumerate environment:

```
\begin{enumerate}
    \item Electrical Engineering
    \item Computer Systems Engineering
    \item Software Engineering
\end{enumerate}
```

This will produce:

1. Electrical Engineering
2. Computer Systems Engineering
3. Software Engineering

Likewise, these commands can be nested. For example, to produce a list of departments with specialisations:

```
\begin{itemize}
    \item Electrical, Computer Systems, and Software
       Engineering
    \begin{enumerate}
        \item Electrical Engineering
        \item Computer Systems Engineering
        \item software Engineering
    \end{enumerate}
    \item Mechanical and Mechatronics Engineering
    \begin{enumerate}
```

```
        \item Mechanical Engineering
        \item Mechatronics Engineering
    \end{enumerate}
\end{itemize}
```

This will produce:

- Electrical, Computer Systems, and Software Engineering
  1. Electrical Engineering
  2. Computer Systems Engineering
  3. software Engineering
- Mechanical and Mechatronics Engineering
  1. Mechanical Engineering
  2. Mechatronics Engineering

If you want to include a newline in a list item, use the \newline tag:

```
\begin{enumerate}
    \item Item 1 \newline This is on a second line
    \item Item 2
\end{enumerate}
```

This will produce:

1. Item 1
   This is on a second line
2. Item 2

C.4.4 Tables

The tabular environment will add a basic table. The basic syntax is:

```
\begin{tabular}{ll}
    cell-1-1 & cell-1-2 \\
    cell-2-1 & cell-2-2 \\
\end{tabular}
```

This will produce the following table:

cell-1-1	cell-1-2
cell-2-1	cell-2-2

The entire table must be between the \begin{tabular} and \end{tabular} tags. The cells are separated by a & character and each row is ended with a \\. You **MUST** end each row with \\ and you **MUST** have the correct number of cells based on the column specifications.

The arguments in the second set of curly braces are the column specifications. Each letter has a specific meaning and aligns the text according to the following codes:

l	Left-align the text.
c	Center-align the text.
r	Right-align the text.
p{*width*}	Left-align the text and wrap after *width* width.
|	Adds a vertical line that spans the height of the table.

You can add as many columns as needed. Be aware that LaTeX will automatically size the table based on the columns you added.

To add a horizontal line, use the \hline tag.

For example, the following code:

```
\begin{tabular}{|lcr|}
    \hline
    Left & Center & Right \\
    \hline
    First cell is here & cell-1-2 & cell-1-3 \\
    cell-2-1 & This is the middle & cell-2-3 \\
    cell-3-1 & cell-3-2 & Last cell is here \\
    \hline
\end{tabular}
```

will generate the following table:

Left	Center	Right
First cell is here	cell-1-2	cell-1-3
cell-2-1	This is the middle	cell-2-3
cell-3-1	cell-3-2	Last cell is here

C.4.5 Document Structure

A document can be divided up into sections and sub-sections (and even sub-sub-sections, although we don't recommend it.) These are used to provide logical groupings of paragraphs, so that the reader can see how things fit together. Sections and sub-sections are also used to build a table of contents, which allows for quick navigation through your reports.

\section{name} is used to generate a new section, while \subsection{name} is used to generate a sub-section. The names are what will appear in the table of contents.

The following code will generate a section with two-sections:

```
\section{Introduction}
This section introduces the document and explain why it is
   important.
\subsection{Rationale}
The rationale would be here.
\subsection{Empty Sections}
Please don't leave any empty sections in your document.
```

You can also add anchors to sections and sub-sections. These make it easier to maintain cross-references between elements in your document. An anchor is added by the \label{label-name} tag, where label-name is the name of the anchor. By convention, the anchor is normally a multi-part string, seperated by colons. The first part is the type of anchor (e.g. section, subsection) then the remaining parts are a meaningful name for the anchor.

To use the anchors later, we use the \ref{label-name} to refer to the anchor. label-name must match the name you gave the anchor in the \label tag.

So, we could re-write our example above to include some anchors:

```
\section{Introduction}
This section introduces the document and explain why it is
   important. Sub-section~\ref{subsection:rationale} is first,
    followed by Sub-section~\ref{subsection:empty}.
```

```
\subsection{Rationale}\label{subsection:rationale}
The rationale would be here.
\subsection{Empty Sections}\label{subsection:empty}
Please don't leave any empty sections in your document.
```

Note: you can add a tilde (~) between a \ref tag and its preceding text. This will ensure that LaTeX always keeps the two together. You don't **have** to do this, but it is good practise (and makes it easier to read.)

C.4.6 Images

By default, LaTeX does not include the ability to insert images: after all, it is a text-based format. But don't worry, you can still insert images into your document, you just need to do a bit more work.

The first task is to draw (or generate or build) your image[3]. The image format should be png, jpg or pdf. Once you have your image, copy it into the images/ sub-folder for your directory[4]. Finally, you need to embed it into your document by adding the following code:

```
\begin{figure}[tbh]
    \centering
    \includegraphics{ExampleImage.png}
    \caption{An example image with an anchor.}
    \label{fig:example}
\end{figure}
```

This results in the following output:

Figure C.1: An example image with an anchor.

This has generated a nice image, with a caption and an anchor. The anchor can be used when referencing your image in the text[5]. The main part for you to change is the name of the image: in our example, the filename of the image is ExampleImage.png, you will need to change it to the actual filename.

By convention, figure labels are always prefixed by `fig:` of `figure:`. Like all other anchors, each image anchor should be unique.

[3] Actually, the first step is to include the graphicx package but we have already included it, so you don't have to worry. If you are writing your own document in LaTeX then remember to include it.

[4] Again, this is something extra that we have implemented. By having all the images in a single sub-folder it makes it easier to find them and easier to tell what is an image or not.

[5] Always, always, always include a caption and reference your image in the text! Nothing annoys the markers like an unlabeled, unmentioned image (poor old thing)!

You can also adjust the size and position of the image. For example, adding a `width` argument will make your image wider or narrower:

```
\begin{figure}[tbh]
    \centering
    \includegraphics[width=0.33\textwidth]{ExampleImage.png}
    \caption{A narrow image.}
    \label{fig:narrow}
\end{figure}
```

This results in the following output:

Figure C.2: A narrow image.

Where `\textwidth` means the width of the text and the `0.33` means multiply it by 0.33.

There are lots more options for adjusting images but we will leave it to you to research these.

C.4.7 Mathematics and Formulae

Mathematical formulae is where LaTeX shines. The formulae generated by LaTeX are crisp and clear, making them easier to read (unlike another word processor that we won't mention.) The only downside is you are effectively "programming" the equations, so it can take a bit more time to get them correct (unlike writing them with pen-and-paper.)

There are three basic ways to include mathematic equations in your document:

LaTeX code	Output
Everybody knows \$E = {mc^2}\$ Everybody knows \begin{displaymath} E = {mc^2} \end{displaymath}	Everybody knows $E = mc^2$ Everybody knows $$E = mc^2$$
Everybody knows \begin{equation} E = {mc^2} \end{equation}	Everybody knows $$E = mc^2 \quad \text{(C.1)}$$

The final approach, using `equation`, also allows you to add an anchor. This is useful when you need to refer to equations in your text.

```
\begin{equation}\label{equation:famous}
    \lim_{h \rightarrow 0 } \frac{f(x+h)-f(x)}{h}
\end{equation}
```

which gives the following output:

$$\lim_{h \to 0} \frac{f(x+h) - f(x)}{h} \tag{C.2}$$

Matrices are inputed as follows:

```
\begin{equation}
    \mathbf{X} = \left[
        \begin{array}{ccc}
            x_{11} & \cdots & x_{1p} \\
            \vdots & \ddots & \vdots \\
            x_{n1} & \cdots & x_{np}
        \end{array}
    \right]
\end{equation}
```

which gives:

$$\mathbf{X} = \begin{bmatrix} x_{11} & \cdots & x_{1p} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{np} \end{bmatrix} \tag{C.3}$$

We can also align equations:

```
\begin{eqnarray}
    (a+b)^2 & = & (a+b)(a+b)              \nonumber\\
            & = & a^2 + ab + ab + b^2     \nonumber\\
            & = & a^2 +2ab + b^2
\end{eqnarray}
```

giving:

$$\begin{aligned} (a+b)^2 &= (a+b)(a+b) \\ &= a^2+ab+ab+b^2 \\ &= a^2+2ab+b^2 \end{aligned} \tag{C.4}$$

Note: we are using the **eqnarray** environment rather than the **equation** environment. You don't need to nest it within an **equation** environment (it will give an error) and you can use labels in the same way.

There are far too many commands in LaTeX for us to desribe them all. Instead, here are the some commonly used commands:

Command	Example	Output
\time	a = b \times c	$a = b \times c$
\le	a \le 2	$a \le 2$
\ge	b \ge 5	$b \ge 5$

Command	Example	Output
\pm	c = 10 \pm 4	$c = 10 \pm 4$
\infty	d \le \infty	$d \leq \infty$
^	2^{10}	2^{10}
_	p_0	p_0
\sqrt	\sqrt{x^2+y^2}	$\sqrt{x^2+y^2}$
\frac{numerator} {denominator}	2\frac{1}{2}	$2\frac{1}{2}$
\sum	\sum_{i=1}^{n}i	$\sum_{i=1}^{n} i$
\pi	\pi r^2	πr^2
\int	\int^z_{-\infty}	$\int_{-\infty}^{z}$

The WikiBooks page on mathematics in LaTeX contains more details on how to write formulae. There is a link to this page in the resources at the end of this chapter.

C.4.8 Program Code

If you want to insert code into a LaTeX document, there are two ways to do it[6]. If you don't care about syntax highlighting, the easiest way is to use the `verbatim` environment. This will generate the output in a monospaced font, maintain whitespace, and ignore any LaTeX commands:

```
\begin{verbatim}
class HelloWorld {
    public static void main(String[] args) {
        System.out.println("Hello, World!");
    }
}
\end{verbatim}
```

This will produce the following output:

```
class HelloWorld {
    public static void main(String[] args) {
        System.out.println("Hello, World!");
    }
}
```

The other way is to use the `lstlisting` environment[7]. This provides some additional functionality on top of the `verbatim` environment, including the option of colour-coding based on syntax. For example, since we are using Java, we could rewrite the above example as:

```
\begin{lstlisting}[language=Java]

class HelloWorld {
    public static void main(String[] args) {
        // Ignore me
        System.out.println("Hello, World!");
    }
}
```

[6] We are not saying you should, we are just providing the options. Only include code in your reports if it is **REALLY** necessary.

[7] This environment uses the `listings` package, which is included by default in your templates.

```
\end{lstlisting}
```

which looks like:

```
class HelloWorld {
    public static void main(String[] args) {
        // Ignore me
        System.out.println("Hello, World!");
    }
}
```

The `lstlisting` environment supports a large range of languages. Some of the languages that you might use are:

C, C++, HTML, Java, Matlab, Python, SQL, XML, and (of course) TeX.

Some of these languages offer different dialects. For example, C has ANSI, Objective, Sharp, and TeX has LaTeX. To use a dialect, you will need to include the dialect in square brackets ([and]) before the language. For example, we use `\begin{lstlisting}[language=[LaTeX]TeX]` when including the LaTeX code in this appendix.

C.4.9 Basic Document Structure

You won't need these commands, as the formatting templates contain them for you. However, we have included this section so you can understand how a basic LaTeX document 'works'.

A LaTeX document always has the basic structure:

```
\documentclass[options]{format}
\begin{document}
...
\end{document}
```

The most common format specification is `article`, although `report`, and `book` are also very common. For your reports, you will be using the `report` format specification. The options specification consists of a list of options separated by commas. For example, using `a4paper` will set the paper size to A4. Using `11pt` will set the font size to 11 points.

All of your content goes where the elipsis is (between the `\begin{document}` and `\end{document}` tags.)

Sometimes you will want to use additional functionality beyond what is beyond "vanilla" LaTeX. To do this, you can import packages with extra functionality[8]. While there is a wide variety of packages available, we are going to limit what you can use for these reports (mainly so we don't need to debug things when they break!) But if you are writing your own LaTeX documents and want to include a package, you would use the following command:

```
\usepackage{package-name}
```

Where `package-name` is the name of the package you want to use. The Comprehensive TEX Archive Network (or CTAN) is a central store of packages for LaTeX (https://www.ctan.org/). If you want to use a package to include some extra functionality for your report, please contact the course coordinator (*Dr Craig Sutherland*) **BEFORE** you use it.

[8] This is how LaTeX adds new functionality, the base LaTeX code is only changed for bug fixes.

In Section C.4.5, we mentioned that sections and sub-sections can generate a table of contents. The tag to do this is \tableofcontents, however you don't need to include it as we have included it in the formatting template

C.5 Resources

Core Documentation : https://www.latex-project.org/help/documentation/
A (Not So) Short Introduction to LaTeX 2ε : https://www.ctan.org/tex-archive/info/lshort/english/
Mathematics in WikiBooks : https://en.wikibooks.org/wiki/LaTeX/Mathematics

D. Change History

This appendix lists all the changes to this document.

Version	Description
1.0	Initial Version.