University of Southern Queensland
Faculty of Health, Engineering & Sciences

Low cost computing solution for dynamic educational activities

A dissertation submitted by

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Abstract

Puzzle-based teaching and learning activities offer a compelling approach to engage students, promote information retention, and improve educational outcomes. This engineering thesis explores the potential of low-cost computing hardware in creating dynamic puzzle-based learning devices designed to support constructive alignment in education. through the report a demonstration, prototype, modular platform, known as "the Tesseract," was developed, incorporating the versatile SparkFun RedBoard Turbo as its computing core. This portable cube-like device features an "ingress box" style, housing a series of modular challenge panels that culminate in unlocking the box. The Tesseract's design allows for both seamless scalability and adaptability, making it a valuable tool for educators aiming to align their teaching activities with specific learning outcomes.

The thesis outlines a comprehensive assessment of the viability of low cost computing based educational devices and, using the tesseract prototype as a demonstration, how they can be effectively employed in curriculum. The research conducted in this project culminates in the evaluation, of the concept and the device, by education subject matter experts. The positive reception by experts underscores the device's potential in educational contexts, while the development of the tesseract ensures its practicality and effectiveness. In conclusion, this thesis provides evidence that low-cost computing-based devices, exemplified by the Tesseract, are a viable and innovative solution for enhancing educational activities, catering to students diverse learning needs and ultimately fostering constructive alignment in curriculum design.

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[redacted]

A. Hampshire

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Contents

Chapter 1

Introduction

1.1 Outline

Puzzle-based Teaching and Learning (T&L) activities are a widely used method of challenging students in ways that are in line with the learning outcomes of their educational curriculum. The reason for this is that thought provoking puzzle-based educational activities are proven to increase students information retention, understanding, results, and motivation. This project seeks to analyse and assess whether low-cost computing technology can be used to develop viable and effective devices for conducting dynamic puzzle-based learning activities. These devices would provide educators with a method of both developing and implementing bespoke puzzle-based T&L activities based on the intended learning outcomes of their courses for the benefit of the students.

It is hypothesised that low-cost computing hardware, such as the ranges of Arduino and raspberry pie devices, will be able to be used to create dynamic puzzle-based educational devices that are both cheap and fully capable of fulfilling the requirements of the T&L activities. This is because, firstly, the devices are easily configurable with a multitude of compatible additional hardware options that can be used to provide the devices with further capabilities and features. Secondly, there has already

been some successes in using these technologies to facilitate both educational and analogously structured activities. Additionally, the low initial implementation costs for a simple device, that is capable of being configured for multiple activities and applications, reduces the initial resource commitment required to implement educationally beneficial puzzle-based learning activities. However, it should be noted that there is a risk that the additional work required, and time spent, by educators in the designing of the activities and in the configuration of the devices may be out of proportion to the additional benefits that the activities give to the students.

In order to assess whether the proposed low-cost computing-based devices will be able to facilitate meaningful T&L activities that are capable of supporting complex learning objectives this project will:

- Review the literature regarding the effectiveness of low-cost computing in the generation of puzzle-based activities to ensure that there is sufficient evidence for the project to be viable.

- Review current pedagogical systems utilising puzzle-based T&L activities to ensure that there is enough evidence to warrant the use/creation of dynamic, configurable, and multi-purpose devices designed to support/enable T&L activities.

- Design, and construct a basic multi-function device utilizing low-cost computing technology, then configure the device to run/support/enable a simulated puzzle-based T&L activity in a way/method that has been proven to provide measurable benefits to students understanding of the learning outcomes.

- Test the device by having multiple people, including potential end users, complete the activity, that has been developed and ran through the created device,

and provide feedback on the operation of the device, the effectiveness of the device as a T&L tool, and how well the device/activity was able to target the intended learning outcomes of the activity.

1.2 Aim

The intent of this project is to demonstrate that, dynamic/multi-purpose, low-cost computing based devices present a viable solution, in pedagogical design, for the generation of meaningful puzzle-based T&L activities to assist in conveying/teaching of complex information that is both relevant to the targeted curriculum learning objectives, and will improve the academic performance/motivation of students.

1.3 Background

1.3.1 What is a Teaching and Learning activity and why is it important?

'Teaching and learning' is a section within the greater ark of a pedagogical design that refers to the general principle of "the lecturer and students do things" Don't Feed Cheese to Lactose Intolerant Volcano Gods 2023. In this project, this references the manner that an educator interacts with the students in an attempt to convey information and understanding of a topic. While this is covered in more detail in chapter two, for T&L activities effective they must not only be fun informative and educational for the students, but also targeted to support the learning outcomes of the course curriculum.

1.3.2 Why a puzzle-based activity, what's the benefit?

"When students are actively involved in the learning task, they learn more than when they are passive recipients of instruction" Cross, K. Patricia, Teaching for Learning, 1987. This statement is from 1987 and speaks for itself, it's general wisdom that activities that engage students have a superior effect on their educational outcomes over other less (where people are active in something) teaching methods. In addition to the increased retention of course content, challenging puzzle-based activities have shown a significant improvement in classroom flow, classroom climate, and social behaviours. (Escape Rooms as a Learning Strategy for Special Education Master's Degree Students, 2021)

1.3.3 What do we mean by low-cost computing?

Within this project, low-cost computing, and low-cost computing based devices are referred to often in discussions of the construction of devices capable of hosting puzzle-based learning activities, but what are they? For the purposes of this project 'low-cost computing hardware' will be used as a catch all term to refer to any low cost and low power, single board computer (SBC) or microcontroller based computational hardware. Examples of the types of hardware that would be considered low-cost computing hardware are products such as the Asus Tinker Board S R2.0, Libre Computer Board AML-S905X-CC, Raspberry pie 4, Arduino uno, Teensy 4.1, and SparkFun Redboard.

1.3.4 Why is low-cost computing a good fit for the application?

low-cost computing, as defined in this project, has general properties that make it ideal for use in the types of small, adaptable, devices that are targeted within this project. low-cost computing — as being easy to use, adaptable, low-power, portable, and expandable/modular. Together these — allow the rapid construc-

tion and configuration of relatively inexpensive dynamic puzzles, that utilize multiple(swappable) application specific sensors. These puzzle devices can then be individually configured, by educators, to provide learning activities that directly support the learning outcomes of the curriculum.

1.3.5 How is it envisioned that the hardware will be utilised in education curriculum design?

Low-cost computing hardware will serve as the backbone for activity development platforms, enabling educators and creators to design and deploy a versatile range of educational activities. These compact computing devices, such as Raspberry Pi or Arduino, provide the computational power needed to run educational software, manage data, and support various sensors and interfaces. By integrating these affordable components, the platform becomes highly adaptable, offering hands-on learning experiences in diverse subjects, from coding and robotics to science and arts. The 'ease-of-use' of these devices would make a modular design preferable for the platform. A modular design will allow users to easily add or remove components, customizing the platform for specific activities and age groups. With low-cost computing hardware at its core, a portable platform could empower educators to foster creativity and critical thinking while making learning accessible, engaging, and fun.

1.4 Outcomes/objectives

This project will provide an analysis on the viability of using of multi-function low-cost computing devices to create bespoke T&L activities that are targeted to specific curriculum learning outcomes.

Throughout this project the available information related to the viability of the proposed system will be assessed to determine the theoretical viability of the sys-

tem. Then an exemplar multi-purpose device will be created and configured to support/enable a, single targeted, puzzle-based learning activity to functionally demonstrate the effectiveness of the hypothesised system.

A successful outcome to this project will demonstrate, with evidence, the effectiveness of using readily available low-cost computing hardware in the creation of devices designed to facilitate the generation of puzzle-based learning activities, by educators. These devises will help educators to focus learning activities to the intended learning outcomes as well as provide an alternate method of assessing students understanding of the learning outcomes. This benefits the students by providing an alternate method of information delivery that may assist in the comprehension of the curriculum content.

Chapter 2

Literature Review

This chapter will focus on the discussion, and review, of all relevant information regarding the viability/effectiveness of using of multi-function low-cost computing devices to create bespoke T&L activities that are targeted to specific curriculum learning outcomes. The key details that factor into the viability of this study are:

- The effectiveness of low-cost computing in generating puzzle-based activities.

- Whether the use of puzzle-based T&L activities in pedagogical design will contribute to any measurable benefits to the student outcomes.

These factors, as well as their component issues, will be reviewed to provide evidence as to the viability/feasibility/efficacy of the research topic, as well as to provide appropriate context relevant to further decisions/assessment made within this project.

2.1 Low cost computing

2.1.1 How do we define low cost computing?

As defined in chapter one, in this project 'low-cost computing hardware' will be used as a catch all term to refer to any low cost and low power, single board computer (SBC) or microcontroller based computational hardware. This section will explain further details of low-cost computing devices and analyse existing evidence of puzzle-based activities that utilize low-cost computing hardware as their primary method of data computation and analysis.

2.1.2 What is the benefit of using these devices in this project?

There are several benefits to using low-cost computing devices in the generation of devices, such as the device described in this project. The benefits of these devices can generally be described under the headlines of versatility, affordability, scalability, power consumption, learning opportunities, accessibility, and customization community.

Versatility- These low-cost devices can be programmed to perform a row wide variety of tasks making versatile tools for educational activities. With a well set up base program, educators can create activities for subjects ranging from science and mathematics to programming and electronics without extensive experience in programming.

Affordability- These devices are relatively inexpensive making them accessible to a wide range of educations and schools including those with limited budgets this affordability can help reduce the barriers to adopting the platforms.

Scalability- Specifically with the design for this project, the platform can be designed in such a way to accommodate various hardware configurations. this allows end users to use the platform, multiple times, in various roles, without making it boring for students.

Power consumption- using low-cost computing devices has the additional benefit at least devices require less power to operate. this allows for the devices to be more modular and portable increasing their effective use cases.

Learning Opportunities- These devices are designed as platforms for educational activities however, they can also act as educational activities themselves. Due to the nature of the devices students can design and implement their own activities and modules without risk to the devices or students.

Accessibility- These low-cost devices are readily available incoming purchasing bulk allowing educational institutions to equip multiple classes with the necessary hardware. This also allows the educators freer rein in designing their own module and activities for the platform.

Customization community- For all the above reasons, these devices have a large and active community of developers. This means there is a wealth of resources, tutorials, and projects available, for free, to educators, lowering the knowledge barrier for use of the platform.

2.1.3 Role of low cost computing devices in the project:

Low cost computing device will play a pivotal role in this project. It would be fair to consider the computing hardware in this project to be the brain of the intended project platform. It will be the computing device that will both runs the platform and allow educators to control the activities.

The computing hardware will be used to power all of the individual activities, to analyse the inputs from those activities, and to run the program that will bring all of the individual activity elements together to make activity work. In a sentence, it will act as a central hub that controls and facilitates both the generation and application of the activities.

While there may be many devices that would be capable of running the platform, the choice of device will influence the cost, capabilities, requirements, usability, support, customisability, and construction of the final project activity platform.

In considering what device to use in the project, the factors that are examined are ease of use, requirements, cost considerations, customisation, capabilities, support and resources, and integration. Prior to these however, this report will examine examples of low cost computing devices used as part of puzzle based activities to ensure that the appropriate considerations are examined when selecting a computing device for the project.

2.1.4 Can low-cost computing be used to generating meaningful puzzle-base activities?

Low-cost computing devices offer a significant opportunity in the realm of education by serving as the base for the creation of engaging in stimulating puzzle-based activity platforms. These versatile devices, such as Arduino and Raspberry Pi, provide an accessible and cost-effective means to craft immersive learning experiences for various subjects and age groups. By utilizing their computational powers educators can design interactive puzzles that challenge students' problem solving

abilities, foster critical thinking, and promote collaborative learning. While the platform envisaged as an outcome to this project is a novel use of these devices, they are often utilised in the design of other puzzle based activities. Some examples are:

Escape room

Generally, an escape room is intended to be a thrilling roleplaying experience where players must depend on their problem-solving skills, and the teamwork/skills of their crew, to complete a number of cascading challenges in order to unlock advancement towards a final critical goal, often involving leaving the room. (Nicholson, 2016).

The use of electronics in an escape rooms allows the generation of different forms of puzzle for the players to interact with. These additional puzzles often take the form of a physical challenge but may also be interacted with, by the players, to create an additional 'virtual space' where the participants can be challenged. (Nicholson, 2015).

Low-cost computing technology has been utilized in order to develop both electronic challenges and to enable access to 'virtual spaces' in escape rooms. In an article (Lubyagin 2017) authors Lubyagin, and Ivanova, utilised an Arduino nano, in conjunction to some additional electronics, to create a multi-use key matching puzzle that could be implemented to restrict players progress until it is completed successfully.(Lubyagin 2017)

In another example, Raspberry Pi's have been used as the key method of puzzle operation for full escape rooms. Palace Games, A San Francisco based escape room business, utilises a bank of Raspberry Pi's to control the entire 'Edison Escape Room'. In an article released by The Raspberry Pi they state that "The Raspberry

Pis are used to read various types of sensors and to drive actuators that control lights, open doors, or play back media. And Raspberry Pis also drive the control panels that employees use to enter settings and keep tabs on the game." (Gan, Damien 2019)

Treasure/scavenger hunt

On the surface a scavenger hunt and a treasure hunt appear quite similar; this is because they are. Although the terms 'scavenger hunt' and 'treasure hunt' are often used interchangeably there are some key differences that affect the way that the activities are set up and ran. So first both terms must be defined, withing the scope of this project.

Scavenger hunts are activities that are defined by participants following a number of clues to collect a given list of items. These items are often relevant to a specific theme or subject and can contribute to a final goal/activity.
(Dictionary 1989)

A treasure hunt is an activity where participants attempt to follow clues and instructions in order to achieve a final critical goal, such as finding a specific treasure. In a treasure hunt there are often intermediate/sequential goals or further clues that are to be found, prior to the final treasure, that are required to allow the participants to achieving their final goals.
(Dictionary 1989)

Puzzle safe/box

A puzzle box, or an ingress box, is in essence the opposite of an escape room. A puzzle box requires the players to solve a combination of tasks, riddles, or challenges to access the contents of a locked box. These puzzle boxes can be combined with

other activities, such as a scavenger hunt, to create broader activities.

These physical puzzle containers typically feature a series of locks, hidden compartments, and cryptic clues that participants must decipher and manipulate to unlock the box and reveal its contents. In the process of solving the intricate puzzles. Beyond the satisfaction of successfully opening the box, these engaging challenges also promote resilience, patience, and a growth mindset as the participants learn from their mistakes and persist in the face of complexity. Ingress and puzzle boxes, therefore, serve as a fun and highly effective activity.
(?)

In addition to the enjoyment of the users, there are practical considerations. a significant benefit of an ingress activity over an escape room is that the participants are not locked into a situation where they may not feel comfortable. this is especially important in an educational setting.

2.1.5 Examples of low-cost computing devices

With low-cost computing defined and the current use cases for these computing devices in puzzle-based activities explored. Some examples of low-cost computing devices can be given.

Micro:bit

The Micro:bit is a pocket sized microcontroller designed for education. It makes a great entry point students learning about electronics and programming. While it is simple to use, and has decent community support, it is lacking some of the more intricate capabilities of the other low-cost devices on the market.

Arduino

Arduino boards are microcontrollers designed for electronics projects. they are widely used for prototyping and creating interactive electronic systems. Arduino makes multiple boards depending on the use case of the device. The three most common boards the Arduino Mega, Uno, and Micro. These boards are programmed using the same interactive development environment (IDE). The main differences between the devices are the number of i/o pins, the maximum output power on the power rails, and the memory of the devices.(*Arduino UNO R3 Product Reference Manual* 2023)

Raspberry pie

Raspberry Pi is a popular single board computer. it comes in various models with different features depending on the use case. These devices are versatile and powerful. the Raspberry Pi operates using a PC style operating system (OS) making it more powerful than other options but also significantly more complex to use.(**?**)

BeagleBone Black

Similar to the Raspberry Pi the BeagleBone Black is a single board computer suitable for various applications. it has GP IO pins for hardware interfacing and is often used for embedded projects. This device fills a hardware gap between a Raspberry pie and an Arduino, however there is less community support for it compared to the more popular devices.(Coley n.d.)

SparkFun RedBoard Turbo

The RedBoard Turbo is a powerful microcontroller based development board that has been developed in the same form factor as the Arduino UNO. The RedBoard

Turbo is also programmed using the easy to learn Arduino IDE. This makes the Artemis board simple for beginners to use while the onboard Sparkfun Artemis module provides it with more utility than the standard Arduino boards.(**?**)

2.1.6 Selecting the low-cost computing device to be used in this project:

As defined above. The selection of a device for this project will be based on the following considerations: Ease of use, requirements, Cost considerations, Customisation and versatility, capabilities, Support and resources, and Integration. A decision matrix will be used to assess these properties and select a device. Each of the selection criteria will be weighted and each computing device that is being considered will be awarded a value corresponding to their qualities within that category. Each section will have a minimum requirement, if a device is not able to meet the minimum requirement in any category it will be considered inappropriate for this project.

There are many low-cost computing devices that could be considered for this project, due to other concerns (such as access, cost, and familiarity) only 5 will be assessed. The devices being considered for this project are: Micro:bit v2.2, Arduino Mega R3, Arduino Uno R3, SparkFun RedBoard Turbo, Raspberry pie 4 model 3, and beagleBone Black Rev c devices

Ease of use.

Device envisioned in this project is intended to be used in classroom situations by educators. This necessitates simplicity of setting up and using the device. Having the platform be both easy to set us and easy to use will reduce barriers of technical knowledge required to fully utilize the platform. These lowered barriers for

adoption will significantly reduce the learning curve imposed on educators using the platform making the device far more likely to achieve wider adoption in education establishments. It will also allow both students and educators to be more innovative and creative in the applications and utilisation of the device.

The ease of use has a weighting of 10 due to its relative significance to this project. The minimum score for this section will be 7. This is a high bench mark and was selected because if the system is to be used as intended the end users must be able to operate the system with minimal background or prior knowledge.

Micro:bit 10/10

The micro:bit is exceptionally user friendly. It received a score of 10/10 in this section due to its simplistic design and low barriers for entry.
The Micro:bit was specifically designed for educators and young learners. The Micro:Bit is intended to be used in fun activities intended to teach the basics of programming to students.
The Micro:Bit uses a simple visual programming environment. Using this programs can be created by dragging and dropping the pre made code blocks into the environment.
Additionally, due to the Micro:bit being developed for education it is likely that the users will already have interacted with the device.

Arduino Uno 9/10

The Arduino Uno is known for its exceptional ease of use making it a favourite amongst beginners. The Uno received a grade of 9/10 passing the benchmark for this section.

The Uno utilises the simple to use and easy to learn Arduino IDE to program the device. The IDE provides a simple yet user-friendly programming environment. The integrated development environment adopts a language similar to C/C++, however, it simplifies many of the intricacies inherent in the languages, it easily understandable even for novices.
The Arduino Uno hardware setup is intuitive and easy to use. It works with a simple USB connection to a computer. It has clearly marked digital and analogue pins. This this prevents the requirement of extra circuitry or components for attaching hardware.

Arduino Mega 8/10

The Arduino Mega is less well known known than its smaller sibling, the Uno, however it still maintains many of the same features that make the Uno easy of use. The Mega received a grade of 8/10 due to it having some additional complexities, however it does still pass the benchmark for this section.
The Arduino mega is similar to the Arduino uno however it has additional capabilities due to its increased memory and I/O capacity. The Mega uses the same IDE as the Arduino, the programming of the mega is almost identical to the setup of the Uno, making it quite user friendly.
Where the mega suffers in ease of use is in its increased complexity. Due to its expanded IO capabilities and its size the mega can be overwhelming to new users.

SparkFun RedBoard Turbo 9/10

As the RedBoard Artemis has the same form factor as the Arduino UNO and because it is programmed using the same IDE. The Artemis shares all of the same ease-of-use consideration factors as the Arduino UNO.

Raspberry pie 7/10

The raspberry pi scored slightly lower in this section. The Raspberry pi is relatively user-friendly however it comes with certain complexities. With a 7/10 the Raspberry pie just passes the benchmark for this section.
The raspberry pi runs a full operating system. While these are often simplified such as the Linux based Raspbian (now Raspberry Pi OS), they remain more complicated than some of the other options. Operating the command line interfaces may be a challenge for some beginners.
The raspberry pie has a steeper learning curve than other options. While it is certainly possible for anyone to use, there is significant time required in learning the system before use.

BeagleBone Black 6/10

The BeagleBone black is a powerful device with a wide range of applications, it does however require a significant level of prior knowledge to begin use. With a score of 6/10 the BeagleBone Black does not meet the benchmark criteria for this section, so it will not be selected for this project. The BeagleBone black is a powerful device with a wide range of capabilities and use cases, however it is not right for this project.
The BeagleBone Blacks setup is more involved than setting up other low-cost computing devices. Users typically need to flash an operating system image to a microSD card, configure various settings, and connect to the board using a terminal or SSH. This process may require more technical knowledge, which can be intimidating for beginners.
The BeagleBone Black also often uses more advanced Linux distributions These

may not be as beginner-friendly as the Raspberry Pi OS or the Arduino IDE. Navigating and configuring the Linux environment can be challenging for newcomers.

Requirements

Each into low-cost computing devices selected have requirements. these requirements cover both the physical requirements for operation (eg. Supply power), and ancillary support requirements (eg OS or IDE). These requirements should be minimised to ensure that minimal infrastructure is required to support the platform.

In this section, each device will receive a grade out of 7. This weighting is chosen because the final selected device will be contained within a housing. While the housing has space for some additional hardware it is limited so this section will have a minimum grade of 4. Additionally, any device that requires hardware that can not be powered for up to 2 hours using a portable power supply will be found to be not suitable for this project.

Micro:bit 5/7

The Micro:bit received a score of 5/7. Although the device itself is relatively self-reliant, it would require additional support hardware if any additional hardware was added as part of the design.
The Micro:Bit operates using a 3v power connection. According to the data provided by Micro:bit (*BBC micro:bit* n.d.) the device can operate in excess of 31 hours using two 1Ah AAA batteries. The negatives are that the project would require additional power sources to support any additional hardware used in the project.
The Micro:bit also requires a small simple breakout board to connect the PCB contact points to header pins.

Arduino Mega 6/7

The Arduino mega received a grade of 6/7 for this section. The Arduino mega can operate using a 5v input or 7-12v input (*Arduino Mega 2560 Rev3 Product Reference Manual* 2023). With this capability the Arduino can operate using a rechargeable battery or a 9v battery (connected using a barrel jack).

While the Arduino mega has a larger footprint compared to the Uno the base pins of the mega and the Uno are in the same locations. Due to this, the same I/O expansion shields are able to be used with both devices. The shields offer both the potential for expanded capabilities and the ability to compact the hardware down to a smaller footprint.

According to testing conducted by DiyIOt (*Arduino Mega Tutorial* n.d.) the Arduino mega had a power consumption of 73.19mA, while connected through a barrel jack to a 9v supply. According to the energiser Max 9v battery data sheet (**?**) the Energiser Max 9v battery has a capacity of 500mAh when connected to a 100mA load (Figure X). Assuming a constant load this gives a battery life of 6hours and 49minutes (battery life =capacity/load). This is corroborated by the datasheets constant current performance graph, where a 70Ma load will drain the battery to 6v in slightly less than 7 hours.

The minimum input power for the Arduino mega is 7V and the power consumption used does not take into account the power consumption of any additional connected devices. So, while the mega is considered suitable for the project and the power consumption of the mega is not considered to be excessive, testing should be done to confirm the battery life if the mega is successful in this section.

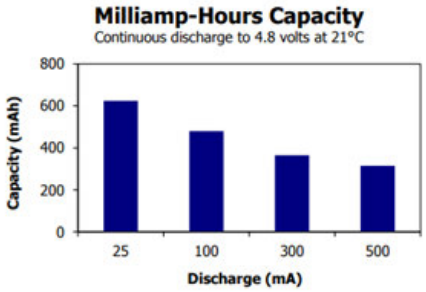


Figure 2.1: 9v battery milliAmp hours capacity

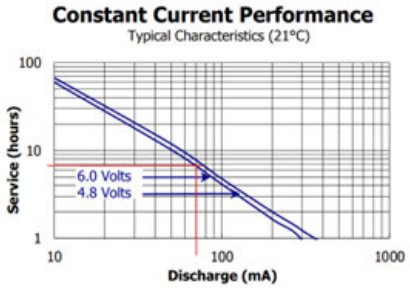


Figure 2.3: 9v Constant current performance

Arduino Uno 6/7

The Arduino Uno received a grade of 6/7 for this section. The Uno can operate using a 5v input or 7-12v (**?**). With this capability the Arduino can operate using a rechargeable battery or a 9v battery (connected using a barrel jack).

Due to popularity of the Arduino Uno I/O expansion shields have been developed to be able to expand the capabilities of the device without greatly expanding the footprint. The shields offer both the potential for expanded capabilities and the ability to compact the hardware down to a smaller footprint.

According to testing from DiyIOt (**?**) the Arduino Uno had a power consumption of 98.43mA, while connected through a barrel jack to a 9v supply. According to the energiser Max 9v datasheets constant current performance graph, a 100Ma load will drain the battery to 6v in slightly over 3 hours.

The minimum input power for the Arduino Uno is 7V and the power consumption used does not take into account the power consumption of any additional connected devices. So, while the Uno is considered suitable for the project and the power consumption of the Uno is not considered to be excessive, testing should be done to

confirm the battery life if the Uno is successful in this section.

SparkFun RedBoard Turbo 6/7

The Sparkfun Turbo received a grade of 6/7 for this section. The Sparkfun Turbo can operate using a 5v input (The Sparkfun Turbo sheet——). With this capability the Turbo can operate using a rechargeable battery.

While the Turbo Turbo able to opperate using a 9v battery through the barel jack like a standard Arduino the Turbo makes up for this with its smaller footprint and lower power consumption. The pinouts on the Turbo meet the Arduino 1.0 footprint standard meaning the shields avalible for the arduino are compatible with the Turbo.

Raspberry pie 3/7

The raspberry pi was graded as a 3/7 for this section. This grade was given due to the higher hardware requirements of the raspberry pi. the raspberry pie is a powerful single board computer however it is deemed inappropriate for this project due to the additional requirements for both connecting peripheral devices and powering the pi.

According to the raspberry pi data sheet (**?**) the raspberry pie requires a 5v DC supply at 3A. additionally an independent article by Dr. Helmut Neukirchen (*Power consumption of Raspberry Pi 4 versus Intel J4105 systeml* n.d.) , a Professor of Computer Science and Software Engineering, found that the Raspberry pie drew between 3.8 and 6W during operation (depending on the processing load and cores used). While there are power supplies that can provide for this, they would be too large to integrate into the final design.

BeagleBone Black 5/7

The BeagleBone Blac received a grade of 5/7 for this section. The BeagleBone Blac operates using a 5v input (BeagleBone Blac data sheet——). With this capability the BeagleBone Blac can operate using a rechargeable portable power supply.
In the BeagleBone Blac data sheet the it is stated that the device uses between 210 and 460 mAh during standard operation. Assuming a smaller 1400mAh battery is used this gives an operational time of over 3 hours.

Cost considerations

The purpose of this report is to provide accessible education devices using low-cost computing. The primary goal of the project is to ensure educators and educational establishments are able to utilize puzzle-based activities without significant overhead. This section considers both the cost of the computing device and any additional specific hardware required for the computing hardware to operate.

This section considers only the base cost of the low-cost computing device. In this section the devices will be given a grade out 10 they will receive 10 for any price under $40 and loose a point for every $10 over 40.

Micro:bit 10/10
As of mid-2023, The Micro:bit costs $30.50 Australian dollars (inc GST) . This price includes the Micro:bit as well as a portable power supply for the Micro:bit.

Arduino Mega 9/10
As of mid-2023, The Arduino Mega R3 costs $47.10 Australian dollars (inc GST) .

Arduino Uno 10/10

As of mid-2023, The Arduino Uno R3 costs $16.90 Australian dollars (inc GST) .

SparkFun RedBoard Turbo 9/10

As of mid-2023, The SparkFun Redboard Turbo costs $38.90 Australian dollars (inc GST) .

Raspberry pie 7/10

As of mid-2023, The Raspberry pie 4 model B (1GB) costs $62.00 Australian dollars (inc GST) .

BeagleBone Black 5/10

As of mid-2023, The BeagleBone Black rev c costs $88.10 Australian dollars (inc GST) .

Customisation and versatility

It is a requirement that this platform is customisable by the operators. If the platform isn't customisable then the activities can not be tailored to the requirements of the learning outcomes. This section is marked out of 15 due to its relative importance.

This section covers the capabilities for customising not only the device but the system in which the device is installed. The section also assesses the expansion capabilities of the system based on the capabilities of the computational hardware.

Micro:bit 8/15

The Micro:bit, while offering some degree of combustibility, does have certain limitations. Its onboard sensors, though valuable, are somewhat basic. The programming environment, while accessible for beginners, may be somewhat restrictive for those with more advanced coding skills who seek greater flexibility. Additionally, the physical design of the Micro:bit can be limiting, as it lacks expand ability options for adding more connectors or interfaces directly on the board. Therefore, while it is customisation to a certain extent, it encounter constraints in terms of sensor diversity and hardware expandability.

Arduino Mega and Uno Mega 14/15, Uno 11/15

Due to the vast adoption of the Arduino products in consumer electronics, there are a significant number of peripheral devices that either are designed specifically for the Arduino platform or are readily available in packages intended to be connected to Arduino devices. Additionally, these peripherals tend to be low cost and available at consumer electronics stores.

The key significant differences between the Uno and the mega (in this case) are the expanded io ports and the on-board memory. The Arduino uno has 14 digital IO pins, 6 analogue pins and 6 PWM pins (included in digital pins). This is compared to the 54 digital IO pins 16 analogue pins and 15 PWM pins. The Arduino mega also uses the ATmega2560 chip giving it 8KB of SRAM, 256KB FLASH, and 4KB of EEPROM. This is a significant increase to the 2KB of SRAM, 32KB FLASH, and 1KB of EEPROM from the Uno's ATmega328P.

SparkFun RedBoard Turbo 14/15

The SparkFun RedBoard Turbo offers significant combustibility. It features a user-programmable ATSAMD21G18 microcontroller, which can be easily programmed using the Arduino IDE, providing extensive customisation options. Additionally, the RedBoard Turbo includes the standard arduino profile of multiple digital and

analog pins, PWM outputs, and I2C, allowing integration with a variety of sensors, displays, and peripherals.

Raspberry pie 14/15

The Raspberry Pi is a highly customizable platform. it has a versatile toolkit for a wide range of applications. Its open-source nature allows for the software and hardware to be tailored to meet specific project requirements. The Pi has connections for a wide array of peripherals, sensors, and accessories through the GPIO pins, enabling the development of complex custom solutions. Its modular design and a vast repository of software libraries enhance its combustibility. The operating system can be adapted for specific use cases, this adaptability allows for optimized performance in specific projects.

BeagleBone Black 14/15

While the versatile nature of the BeagleBone Black allows it to be connected to most devices, relatively few peripherals are designed for intended use with the platform. This does not limit the usability of the device however it does increase the complexity of using the platform compared to other options.

Support and resources

All of the low cost computing options selected for assessment in this project have significant communities of developers that assist others in using the devices. This criterion covers the quality and accessibility of those resources. This section is marked out of 5. Although it is important that the device is accessible to a wide range of people the existence of an existing support community is desired but not strictly required.

Micro:bit 4/5

The Micro:bit already exists in many education establishments as an existing tool. Due to its widespread adoption, there are many community groups and support blogs available for educators who wish to further develop the activity platform.

Sparkfun Redboard Turbo, Arduino Mega and Arduino Uno 5/5

The Arduino products have been widely adopted by not only the hobby electronics market but also within education and automation. Due to this widespread use there are significant resources available to anyone seeking assistance with any manner of issue regarding the hardware software or setup of the Arduino system.

Raspberry pie 4/5

While not a prolific as the Arduino products the raspberry Pi has a large and active community. This community of active developers helps by providing a wealth of online resources, tutorials, and project ideas. This strong community support can be highly beneficial for users seeking guidance and solutions.

BeagleBone Black 2/5

The BeagleBone Black, while a very versatile and capable platform, presents some challenges in terms of readily available support and resources compared to other single-board computers. It has a dedicated user community and comprehensive online documentation, but it can not match the scale of support seen for other popular platforms, like the Arduino or Raspberry Pi. Finding specific troubleshooting solutions or detailed project examples is difficult and time-consuming. However, the

BeagleBoard.org community is dedicated, and the official website provides technical documentation and beginner project ideas. The BeagleBone Black requires significant self-reliance and a deeper understanding to use successfully.

Decision matrix

This assessment of the relative merits of the options available has concluded that the Arduino mega is the right option for selection in this project. The SparkFun Turbo, Arduino mega and the Arduino uno where closely matched in this assessment.

Decision Matrix						
	Options					
Criteria	Micro:bit	Arduino Mega	Arduino Uno	RedBoard Turbo	Raspberry pie	BeagleBone black
Ease of use. 10	10	8	9	9	7	6
requirements 7	5	6	6	6	3	5
Cost considerations 10	10	9	10	9	7	5
Customisation and versatility 15	8	14	11	14	14	14
Support and resources 5	4	5	5	5	4	1
Totals	37	42	41	43	35	31

Figure 2.5: Decision Matrix for Computing Hardware

As all 3 of these contenders use the same IDE to develop programs and the only significant advantages between them are that the Mega has an expanded IO capacity and the Turbo has significantly larger memory resources. As the most competitive option the Redboard Turbo will be used for this project however it should be noted that any of the 3 units, the uno mega or Turbo, would be an adiquite choice for a

development device.

2.1.7 Additional information required for understanding the final device hardware setup.

I2C

I2C is a widely used communication protocol in electronics. It's a method for multiple electronic components, such as sensors, memory chips, or display screens, to exchange data with a microcontroller or microprocessor (this will come in handy later). What's unique about I2C is that it uses just two wires for communication: one for data (SDA - Serial Data) and another for a clock signal (SCL - Serial Clock). Devices connected to the same I2C bus can communicate with each other by sending and receiving data packets, making it a practical and efficient way to link various components within an electronic system.

I2C is a synchronous, multi-master, multi-slave serial communication protocol. It is often used in short distance embedded systems applications. Each device has a 7-bit address and can operate as either a master or slave. I2C's simplicity, low hardware overhead, and support for multiple devices on the same bus make it a popular choice for connecting peripheral devices in an electronic systems.

2.2 Measurable benefits of puzzle-based T&L activities

Does the use of puzzle-based T&L activities in pedagogical design contribute to any measurable benefits to the student outcomes?

2.2.1 A bit about education.

Before reviewing the educational benefits of the proposed puzzle-based learning activities within the greater systems of pedagogical design are discussed, a review of our collective understanding of the relevant educational principles should be conducted.

Pedagogical design

According to Professor Joost Lowyck of the University of Leuven Belgium 'Pedagogical design' "refers to any systematic choice and use of procedures, methods, prescriptions, and devices in order to bring about effective, efficient, and productive learning" (lowyck 2002) but what does this mean when designing a device/activity for use in an educational setting. For this project. the most important aspect of Pedagogical design is that it is all the approaches that are used for conveying specific course relevant information, or more succinctly "all the stuff that's involved with how we teach" (McAlister, Hills 2023).

With an understanding of the concept of a pedagogical design, it becomes clear that different designs for the construction of curriculum will result in higher degrees of student success, dependant on the students, information, and teaching staff. One course design methodology, that is used to generate meaningful/targeted course content is the pedagogical design of constructive alignment.

constructive alignment

Constructive alignment presents an outcome-based pedagogical design approach, for teaching and learning, that uses a progressive development process to take the intended course learning outcomes (CLO) and iteratively develop informed, content

supported, learning outcomes, assessment tasks, and learning activities. (Kandlbinder, 2014)

The process of developing a course curriculum using the constructive alignment process starts with the question 'what are the desired outcomes of the course'. One you have the answer to that question you have your Intended Learning Outcomes (ILO's). the ILO statement should be focused on 'what do we want the learner to be capable of' and 'how well do we want the learner to be able to do it'. With this statement in hand the next step is to develop the Teaching and Learning (T&L) activities to support the teaching/lecturing content of the course. These T&L activities should be designed with the requirement that the students be able to apply the content of the course in dynamic ways, to simulate the process of using the information in a practical, post education, situations. With the educational activities developed, it is then required that the students are assess as to how well they can apply this knowledge; this is done through the development of Assessment Tasks (ATs). These ATs should ideally be designed in a way such that they not only test the student's absorption of the information, but the students understanding of the content, and ability to practically apply that knowledge/skills in practical situations.

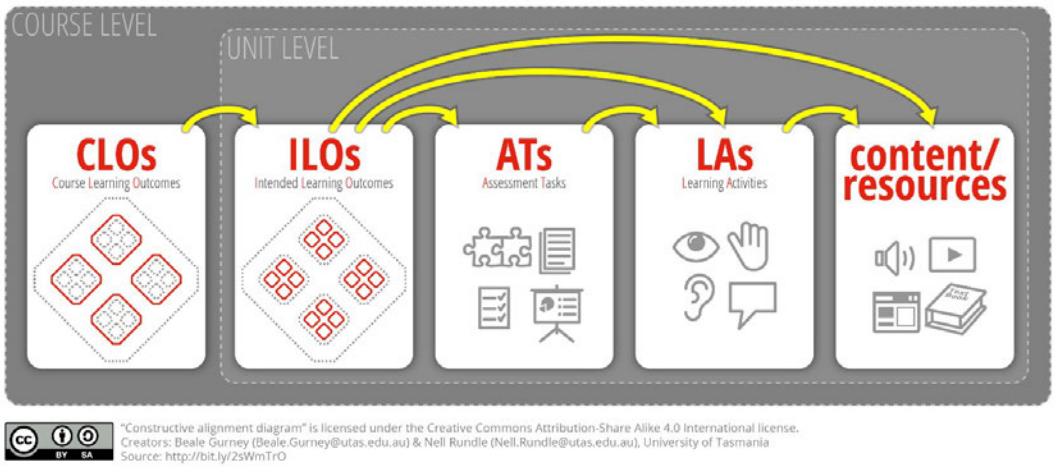


Figure 2.6: Map of Constructive Alignment, (Gurney 2017)

2.2.2 what makes a good learning activity?

In constructive alignment, a good teaching and learning activity is one that aligns with the desired learning outcomes and engages students in active and meaningful learning experiences. Here are some key characteristics of a good teaching and learning activity within the framework of constructive alignment:

Relevance.

The activity should be relevant to the learning outcomes and connect to real-world applications or contexts. It should help students see the value and applicability of what they are learning.

Active learning.

The activity should promote the engagement of students with their learning process. It should encourage them to think critically, solve problems, analyse information, and apply their knowledge and skills actively.

Authenticity.

The activity should simulate authentic or real-life situations to help students understand how the concepts or skills being learned are applied in practice. Authentic tasks can include case studies, simulations, projects, or role-plays that mirror real-world scenarios.

Collaboration.

The activity should provide opportunities for collaborative learning. It can involve group discussions, teamwork, peer feedback, or cooperative projects, allowing students to learn from each other and develop their interpersonal and communication skills.

Feedback and reflection.

The activity should incorporate mechanisms for timely feedback and reflection. Students should receive constructive feedback on their performance and have opportunities to reflect on their learning progress, identify areas for improvement, and set goals for future learning.

Variety and flexibility.

The activity should offer a variety of instructional strategies, resources, and materials to cater to diverse learning preferences and needs. It should be flexible enough to accommodate different learning styles and allow for adaptations based on individual or group differences.

Progression.

The activity should be designed to facilitate progressive learning and skill development. It should build upon prior knowledge and provide opportunities for students to deepen their understanding and competence as they progress through the learning process.

Motivation and engagement.

The activity should be designed to motivate and engage students. It can incorporate elements such as problem-solving challenges, hands-on experiences, multimedia resources, gamification, or interactive technologies to enhance student interest and participation.

The design of teaching and learning activities should be aligned with the intended learning outcomes and consider the diverse needs of all students. With the use of appropriate learning activities educators can promote greater understanding and skills development in students. (Loughlin, 2021)

Some typical declarative and functioning knowledge verbs by SOLO level

	declarative knowledge	*functioning knowledge*
unistructural	memorize, identify, recite.	count, match, order.
multistructural	describe, classify.	compute, illustrate.
relational	compare and contrast explain, argue, analyze.	apply, construct, translate, solve near problem, predict within same domain.
extended abstract	theorize, hypothesize, generalize.	reflect and improve, invent, create, solve unseen problems, predict to unknown domain.

Figure 2.8: Language for Learning, (Biggs, 201)

2.2.3 How does a puzzle-based activity fulfill the requirements?

"Learning takes place through the active behavior of the student: it is what he does that he learns, not what the teacher does." (Tyler, 1949)

"An educational process in which students learn about a subject through the ex-

perience of solving an open-ended problems and that allows for learners to develop skills used for their future practice." Developing Technology Mediation in Learning Environments, 2020

Puzzle-based learning activities have been shown to be effective at getting students actively involved and thinking critically. When they tackle puzzles, they need to scrutinize and use their knowledge to solve difficult problems. This approach helps develop a deep understanding of the topic. Puzzles also stimulate curiosity and motivation because students want to figure out the mystery or win the game. The enjoyable challenge of puzzles makes learning interesting and fun. Plus, they regularly offer chances for students to work with others in teams, promoting communication and problem-solving abilities/skills.
(Howard, 2007)

When it comes to teaching, puzzle-based activities have proven to be a remarkable method for educators to enliven their lessons. These puzzles can be customized to align with specific learning objectives, making them highly adaptable to diverse subjects and levels of education. They can be utilized to establish connections with new students and facilitate recollection of prior knowledge, as well as to evaluate the level of comprehension attained by the learners. Additionally, the challenge level of these puzzles may be personalized to accommodate unique learning styles and abilities. Furthermore, puzzle-based activities encourage active participation of students, thereby promoting ownership in the learning process. As opposed to listening to monotonous lectures all day, actively engaging in such activities helps students establish meaningful connections, retain knowledge more effectively, and achieve success academically.

Overall, puzzle-based learning activities provide a highly effective and enjoyable approach to both teaching and learning, promoting critical thinking, collaboration, and active engagement among students.

2.2.4 Are there any real-world examples of the benefits?

Yes, there sure are. There have been benefits in student performance noted as a result of puzzle-based learning activities. Various activities have been tested in educational settings in order to determine the benefits that they offer. While this project does not seek to demonstrate every possible activity that could be implemented using low cost computing the following is a list of pre-existing puzzle-based learning applications, as well as their beneficial qualities, that could be implemented using techniques from this project.

Escape rooms have gained popularity as a puzzle-based learning activity. Students are presented with a scenario or theme and have to solve a series of puzzles and riddles to "escape" within a time limit. This activity promotes teamwork, critical thinking, and problem-solving skills as students work together to unravel the clues and complete the challenges. It can be adapted to various subjects, such as math, science, history, or language arts, allowing students to apply their knowledge in a hands-on and engaging way.
Moore, 2021)

(Manzano-Le'on,2021)

Problem-based learning (PBL) is an instructional approach that presents students with real-world problems or scenarios to solve. PBL engages students in active learning and critical thinking as they analyse the problem, conduct research, and propose solutions. This approach encourages independent thinking, collaboration, and the application of knowledge in a practical context. PBL can be implemented across various subjects and disciplines, allowing students to develop their problem-solving skills while deepening their understanding of the content. (Duch, Barbara

J and Groh, Susan E and Allen, Deborah E, 2001

Treasure hunts involve students following a series of clues or riddles to discover hidden treasures or objects. This activity encourages problem-solving skills, critical thinking, and collaboration. Students must decipher the clues, analyse the information, and apply their knowledge to progress through the hunt. Treasure hunts can be tailored to various subjects, such as history, science, or literature, by incorporating relevant content into the clues. This makes the learning experience interactive, memorable, and enjoyable, as students actively explore and apply their knowledge in a fun and engaging way. (Mobius, Markus and Phan, Tuan and Szeidl, Adam,2015),

Scavenger hunts require students to search for and collect specific items or information based on a provided list or set of clues. This activity promotes observation skills, teamwork, and decision-making. Students need to think creatively, strategize, and communicate effectively to successfully complete the scavenger hunt. Scavenger hunts can be adapted to any subject or learning objective. For example, in a nature scavenger hunt, students may have to identify and collect various plant species, encouraging them to learn about different plants and their characteristics. This hands-on and experiential approach to learning enhances students' understanding and retention of the subject matter.
(Lindsay, 2012)
(Lau, 2022)

These examples demonstrate the effectiveness of puzzle-based activities in promoting learning outcomes, fostering critical thinking, collaboration, and engagement among students.

2.3 The trial activity.

The device created as a part of this project is designed to act as a modular activity development platform. As a part of the testing of the device, a learning and teaching exercise will be created. This exercise will them be assessed by subject matter experts to provide data regarding the value and classroom utility of the device.
The subject matter experts that have agreed to review the platform are qualified professionals employed in the field of engineering education. As such the exemplar activity that will be developed for the device testing will be a first-year engineering student, campus orientation exercise. The first-year engineering student, campus orientation exercise has been chosen due to the broad scope of the information delivered in an orientation as well as to reduce the potential of accidental copyright infringement or revelation of secure IP.
This section will review the requirements of a first-year engineering student, campus orientation. In order to enable the creation of a well aligned exercise for testing.

Within the UniSQ institution the orientation of new students is an important step of the educational journey. The orientation prepares new students for the culture of the university and for the requirements of university education.
The university dictates that the learning objectives of the orientations are to:

- Introduce students to facilities, services, resources and the key stakeholders of the UniSQ community.

- Offer clarity around academic culture and the expectations of academic study.

- Encourage a sense of belonging and connectedness with the UniSQ community and assist them to identify with their learning institution.

- Provide students with the opportunity to develop their perceived self-efficacy for help seeking and independent learning.

- Provide students with opportunities to relate the relevance of their study to their career aspirations and employability development.

- Identify specific high-need student cohorts and develop activities to meet their unique needs.

While the university recognises the importance of orientations. Some of the learning goals are nebulous and the information is often dry and not engaging for the new students. This presents a perfect situation for a puzzle based activity to demonstrate how students can absorb lessons and information through the tangential use of the same information in active and engaging puzzles and games.

If prepared correctly, a puzzle small group based activity will be able to teach students the important information regarding the universities facilities and culture, demonstrate some of the key skills that they will require to succeed in a university environment, connect them with their peers and some potential mentors, and introduce them to the facilities available to them as new students.

Chapter 3

Risk-Management, Consequences, and ethics

This section analyses the potential risks related to the construction and testing of the proposed platform as well as the consequences of the project to ensure that it will have a positive influence on society.

3.1 Confidentiality and information security.

Part of the testing involved in this project requires the input of subject matter experts. These experts will provide their justified opinions regarding the creation and utility of the project device. While the report will include the results of the testing and the summarised comments of the experts, their names, employment status, and the specifics of their experience will be anonymised in the reporting.

3.2 The project analysis

This project will provide an analysis on the viability of using of multi-function low-cost computing devices to create bespoke T&L activities that are targeted to specific curriculum learning outcomes.

The potential follow on consequences of this analysis conducted as a part of this project are:
- Educators will be informed as to the capabilities of low cost computing when used in the creation of T&L exercises.
- This project may provide a basis for future projects, analysing other specific implementations of low cost computing or generating T&L activities using alternative technologies.
- Puzzle based T&L activities may be seen as more accessible in educational settings.

3.3 Construction

This project required the design and construction of a physical prototype. The construction of the device will be conducted by a qualified individual, using appropriate tooling, with access to appropriate PPE.

3.4 Device testing

Through the course of this project an exemplar multi-purpose device will be created and configured to support/enable a, single targeted, puzzle-based learning activity to functionally demonstrate the effectiveness of the hypothesised system.

This system will then be tested to confirm its functionality. This testing will consist of a crew of educators using the constructed device to complete the designed T&L activity. They will then review the utility of the device.

The ethical considerations regarding the testing of the system are:

Are the test results accurate? The system will be tested by a crew of educators in order to ensure that the results of the testing are as accurate as possible.

is the activity safe? The T&L activity to be tested will be reviewed prior to the testing to ensure that there are no safety concerns.

3.5 The system.

A successful outcome to this project will demonstrate, with evidence, the effectiveness of using readily available low-cost computing hardware in the creation of devices designed to facilitate the generation of puzzle-based learning activities, by educators. These devises will help educators to focus learning activities to the intended learning outcomes as well as provide an alternate method of assessing students understanding of the learning outcomes. This benefits the students by providing an alternate method of information delivery that may assist in the comprehension of the curriculum content.

Chapter 4

Methodology

This chapter aims to further elaborate on the rational, processes, and technology involved in the creation of the project activities, device selection, and device construction. This will build upon the analysis of the project concept's feasibility provided in the previous section.

With the evidence presented regarding the capability of low-cost computing based systems being successfully implemented in the generation of puzzle-based activities as well as the beneficial uses of puzzle-based T&L activities in pedagogical design, having been previously established in chapter two. This chapter will aim to further elaborate on the rational, processes, and technology involved in the creation of a multi-role low-cost computing based device that has capabilities intended to facilitate the operation of puzzle-based activities. An exemplar T&L activity will then be designed, based on activities that have proven to provide positive/beneficial outcomes to students.

4.1 Device overview

To demonstrate the capabilities of a simple multi-purpose/dynamic device designed explicitly for the generation of T&L activities, utilizing low-cost computing hard-

ware, an example device must be created. To this end, this section will explore the design, and design rational, behind the creation of *The Tesseract*

The Tesseract is a portable six (6) sided demonstration cube with a secret. It is designed to be used as a multi role, ingress box, activity platform. This style of activity design has proven to be safe and effective in educational applications and it is capable of demonstrating the versatility of a low-cost computing-based educational device.

The *Tesseract* device will be a 6-sided cube covered in components intended to facilitate puzzle-based activities. The design of the device is also intended to be modular. This modularity will allow the end users to customize the platform to their individual requirements. To this end, the platforms' general structure will be a cube with five (5) modular sides that can be swapped out depending on the activities that the operator wants to run. The final side will contain an access door. This final side is not intended to be modified. This access side is used as the final goal of the activities ran using the platform.

The activity platform is ran using an Arduino based RedBoard turbo, this microcontroller is the coordination point for components on the device. The RedBoard is mounted to the inside of the box and is powered using a 9v battery connected to the barrel jack of the RedBoard.

4.2 Platform Design rationale

This section demonstrates the design considerations around the creation of the activity platform. It will cover the concept development of the platform, the generation of the Activity panels, and the considerations relating to the modular aspects

of the initial design.

4.2.1 Ingress box

A small portable ingress box, with modular activity panels, has been chosen as the platform to be developed as part of this project. To fulfill the requirements of the project this platform will operate using a SparkFun RedBoard Turbo microcontroller as the computational core of the device.

For this ingress box to be effective in this configuration it must:

- Have external facing activities that cannot be removed by the participants during operation but are easily swapped, by the user, during the setup process.

- Have an access panel that can contain the prizes for the participants. For this it is assumed that the prizes will be no larger than 40x20x10mm and that there will be no more than 5 participants.

- Be a simple method of accessing the internal components during operation in case of an error in the operation of the platform.

- Be structurally sound. The device frame should be able to survive being handled, and dropped, as a part of its use.

- Be portable, specifically the box must be of a size and weight where children could carry and manipulate the box without significant effort.

(Howard, 2007)

Through the analysis of puzzle based activity platforms currently in use, it was found that the style of platform with both the greatest number of use cases and the best feedback from participants, was the escape room. While the escape room has shown itself to be incredibly capable in an education environment that have been notable issues with the implementation and use of this platform. The ingress box platform that will be developed as a part of this project is intended to replicate the success of escape rooms while mitigating the effects of the escape rooms drawbacks.

The drawbacks noted in the use of escape rooms are:

Setup and permanence It is rare that an educational activity will be implemented in a single location in perpetuity. While there are examples of deployable escape rooms, these often require a significant amount of setup time and space. An ingress box is not susceptible to this issue. If an activity is developed for the platform the activity can be quickly deployed on location with minimal preparation or setup requirements in either time or resources.

Portability. By definition, an escape room requires the participants to complete the tasks assigned within a limited area. Specifically, within educational environments, this limitation prevents some activities form providing the greatest benefit to the participants. The ingress box, as a portable device, can be used to develop activities that take the participants from location to location enabling users to reinforce learning objectives with location specific activities.

Multi use. While escape rooms are a notably effective platform for educational activities they suffer from their inherent rigidity. Once a participant has completed an escape room, there are only a limited number of ways that the room can be

reconfigured to allow for the creation of new learning activities. This limits the capability of a single escape room being used to develop multiple activities for the same participant base. The ingress box envisioned for this project can utilize both the activities developed as part of this report, and any other activities developed for the modular sections, in various ways resulting in a new experience for participants.

Safety and user comfort Especially when working with younger students or groups of un introduces people, there is a safety concern when locking participants in a room without an easily available exit. This confinement can cause some people discomfort and is something that must be accounted for in escape room design. With an ingress box, this issue is avoided. The nature of an ingress activity is that the participants are attempting to access an area, this limits the safety concerns of the activity and can avoid discomfort for the participants.

4.3 Initial design concept

The initial design of the tesseract is a 6-sided cube with the approximate dimensions of 180x180x180mm. 5 of the 6 sides of the cube will have a 150x150mm cutout in the centre of the face to expose the external faces of the modular activity panels. The sixth side of the cube will be removable and will contain the access hatch that is the final goal of any activity ran in this device. Inside of the cube their will be an internal structure that provides rigidity and supports the activity panels. (—The initial design sketches for the tesseract —-)

4.3.1 Activities faces chosen.

Multi-Role IO

The multi roe IO face is intended as the main IO face for participants to receive information directly from the device. It will also act as an input panel, it will have the ability for participants to input text answers to puzzles.

To accomplish this the face will contain:
-An LCD screen. This will be the main communications method for the device to communicate text to the users.
-5 buttons. There will be 4 buttons arranged in a diamond with a fifth in the center. This button array will act as an input method allowing the device to be configured to receive information from the participants.

Magnetic Keys

This face will appear to be a plane face with shapes drawn on the surface. These shapes will correspond to plastic pieces that the participants will find thought the activity. The plastic pieces will magnetically latch to the side of the device and act as keys. This allows for these keys to be placed in the environment and for the participants to be given clues to find them in order to unlock the box.

Having this scavenger hunt style activity, as a part of the device, allows the user to develop activities where the participants will need to need to perform tasks or otherwise interact with outside environments to complete the activity.

Switch bank

The switch bank is a face that houses an array of 9 (3x3) switches. Internally this face will have the switches connected in such a way that, for their to be a closed circuit through all 9 switches, the switches will all have to be set to a pre-selected position.

The external facing side of this panel can be drawn on by the user in order to create puzzles where the participants must have all of the switches set correctly. This can be used to create activities where the participants sort objects/concepts/people into 2 categories. This face has significant utility for generating puzzles for a variety of educational objectives.

GPS location

This face is equipped with a GPS antenna. This antenna allows the user to develop activities that require participants to go to specific external locations. This face has extra utility when considering the development of activities for mature participants.

4.3.2 Molecularity

The focus of the modularity in this platform will primarily be in the swapable activity panels. All of the faces listed in the above section will be semi permanently mounted within a larger frame. This will ensure that they are secure during operation but will allow them to be removed by the user outside of operation. This process is intended to be simple and should only require the use of basic tools (screwdriver).

Due to the nature of the Arduino setup the modules will be able to connect directly

to the computing device through the use of a screw shield. This will give the user the range to customize the device to their specific requirements.

4.4 Orientation exercise development

To test the platform that will be developed through this project, an activity will be developed. This activity will be developed to reinforce the learning and teaching outcomes of a specific, real-life, curriculum.

Creating an activity that reflects the learning objectives of a curriculum, that is seen in real life, will allow the testing to more accurately assess the success of the developed activity and the utility of the device. The testing will include an assessment of both the developed activity and the platform by educators who, acting as subject matter experts, will be able to better understand and provide feedback on the potential flaws and successes of the device and activity.

The exemplar test activity, for the device, will be developed to reinforce the learning objectives of the first-year engineering student, campus orientation.

The first-year engineering student, campus orientation exercise has been chosen due to the broad scope of the information delivered in an orientation as well as to reduce the potential of accidental copyright infringement or revelation of secure IP.

This section will review the requirements of a first-year engineering student, campus orientation. In order to enable the creation of a well aligned exercise for testing.

4.4.1 Intended learning outcomes

Within the UniSQ institution the orientation of new students is an important step of the educational journey. The orientation prepares new students for the culture of the university and for the requirements of university education.
The university dictates that the learning objectives of the orientations are to:

- Introduce students to facilities, services, resources and the key stakeholders of the UniSQ community.
- Offer clarity around academic culture and the expectations of academic study.
- Encourage a sense of belonging and connectedness with the UniSQ community and assist them to identify with their learning institution.
- Provide students with the opportunity to develop their perceived self-efficacy for help seeking and independent learning.
- Provide students with opportunities to relate the relevance of their study to their career aspirations and employability development.
- Identify specific high-need student cohorts and develop activities to meet their unique needs.

In addition to the learning outcomes of the general university induction, the engineering orientation seeks to:

- Introduce key academic staff.
- Provide an overview of the recommended enrolment pattern.
- Introduce School-specific facilities.

- Communicate the general expectations of students and what students may expect from staff.
- Provide opportunities for students to meet their peers.

While the university recognises the importance of orientations. Some of the learning goals are nebulous and the information is often dry and not engaging for the new students. This presents a perfect situation for a puzzle based activity to demonstrate how students can absorb lessons and information through the tangential use of the same information in active and engaging puzzles and games.

4.4.2 Activity

This section contains a brief overview of the activity that is developed for this platform. A more detailed description of the activity is included in the testing.

Before the Activity:

1. Provide students with a tour of F block (the engineering building), highlighting important information:
1a. Location of fire exits.
1b. Emergency exit maps with the emergency assembly point.

2. Distribute a booklet with general university information including:
2a. Location of the help desk.
2b. Location of the security offices.
2c. Location of the library.
2d. Suggested enrolment patterns for their degrees.

3. Discussion regarding safety, boundaries, personal conduct, and PPE.
4. Introduce the activity. (see resources section on next page)

Puzzle 1: Bridge Crossing

(puzzle and answer are located in appendix item AAAA, activity resources)

• Provide each student with a piece of paper containing the "Bridge Crossing" puzzle.

• Challenge students to find the fastest time for all four students to cross the bridge safely.

• Once they solve the puzzle, and enter the correct answer into the device. They will get the clue for Puzzle 2.

Puzzle 2: Emergency Exit Haiku

(Haiku is located in appendix item AAAA, activity resources)

• The students will read a haiku clue off the screen.

• The clue directs students to the emergency exit maps for F block, leading them to the emergency assembly point.

• When the student are outside the gps will track their positions and the leds on the gps Pannel will flash faster as they approach the target location.

• Once at the assembly point, the student will unlock the third puzzle.

Puzzle 3: Head of School's Room Number

• The students will be asked to provide the Room Number for the engineering head of school.
• Students should visit the help desk (as mentioned in the booklet) to inquire about the phone extension.
• Once they obtain the extension, they will be given a puzzle piece and provided the next clue.

Puzzle 4: Resistance Challenge

(resistor sequence is located in appendix item AAAA, activity resources)
• The students will be given a resistance value and a set of resistors (on the switch Pannel).
• Instruct them to build the specified resistance by connecting resistors in series and parallel.
• Students should visit the library to seek assistance from the librarian, who will provide a sheet explaining resistor values and connections.
• Once they construct the correct resistance, they will be provided with the next clue.

Puzzle 5: Room Access

• The next clue will direct students to enter a locked room that they do not have access to.
• They must approach a member of staff or campus security to request access to the room.
• Once inside, they get the final puzzle.

Puzzle 6: Degree Course Count

• The final puzzle asks students to determine how many individual courses are in their degrees.
• If they don't know the answer, they can find it in the booklet provided before the activity.
• Once they answer correctly, they have completed all challenges.

Reward:

• Reward students with a Lego minifigure for successfully completing all challenges.

This orientation activity encourages teamwork, problem-solving, and familiarity with important campus locations and resources while engaging students in fun puzzles. It offers a great way to welcome first-year engineering students to the university and their degree program.

4.5 Manufacturing capabilities assessment:

The development of the Tesseract activity platform requires the physical manufacturing of components. This section analyses the capabilities of the manufacturing of the platform. This includes an assessment of the capabilities of the manufacturing method, the personal competencies, the equipment access, and the material access.

4.5.1 3D design and 3d printing

Fused Deposition Modeling (FDM) 3D printing is a widely used additive manufacturing, 3D printing, method. In FDM printing an object is built layer by layer using thermoplastic filaments. FDM printers are available at various price points, making them accessible. FDM 3D printers offer a high level of design freedom, enabling the creation of complex geometries and custom components. FDM is also relatively simple to operate, making it a practical choice for rapid prototyping, and it supports a variety of materials, including PLA, ABS, and PETG.

However, FDM 3D printing does come with some weaknesses. While it's excellent for rapid prototyping and creating functional parts the mechanical properties of FDM-printed objects can vary based on factors like layer orientation, infill density, and material, which may require careful consideration during the design phase. In summary, FDM 3D printing is a versatile and cost-effective manufacturing method, but it does not produce components that have superior surface finish or reliable durability.

Personal competence

The designer of the Tesseract is competent in the operation of 3D printer and in the design of 3D printable components.

Equipment access

The designer of the Tesseract had reliable access to 3D printing.

Access to material

The designer of the Tesseract had reliable access to 3D printing material (PLA).

4.5.2 Laser cutting

Laser cutting is a precise and versatile manufacturing process that uses a focused laser beam to cut or engrave materials with a high degree of accuracy. It provides clean and precise cuts with minimal material waste. This accuracy is vital for creating intricate and detailed parts. Laser-cut parts have smooth edges and exhibit a high level of precision, making them suitable for various applications, including user facing components. Laser cutting also allows for fine-tuned control, making it possible to cut intricate patterns with ease.

Laser cutting is best suited for relatively thin materials, and for thicker materials, it may not provide the same level of precision and efficiency. Despite these limitations, laser cutting remains a highly efficient and versatile manufacturing method for creating detailed parts in various materials.

Personal competence

The designer of the Tesseract is competent in the operation of low power laser cutters and in the design of components intender for laser cutting.

Equipment access

The designer of the Tesseract had reliable access to laser cutting equipment.

Access to material

The designer of the Tesseract was able to source 3mm acrylic and 3mm plywood for use in the laser cutter.

4.5.3 Basic hand and power tool operations.

This includes the use of manual and powered hand tools. These basic hand tools allow the creation of specific components as well as the refinement and post processing of manufactured components.

Personal competence

The designer of the Tesseract is competent in the use of hand tools.

Equipment access

The designer of the Tesseract had reliable access to hand tools.

4.5.4 Soldering

soldering is a fundamental technique in electronics and manufacturing, where solder, a low-melting-point alloy, is applied to bond components. It involves the use of a soldering iron, a handheld tool with a heated tip, to melt the solder and create a secure and conductive joint.

Personal competence

The designer of the Tesseract is competent in the use of soldering equipment.

Equipment access

The designer of the Tesseract had reliable access to soldering equipment.

4.6 Design

This section covers the general design of the Tesseract and the interactions of improvement that the platform has undergone through development.
The design drawings for the device can be found in the appendix C to E.

The version of the platform is tracked between each device test. The specific layout of the device as well as the version of each individual component is tracked through the use of a layout code.
The layout code of the device is:
X1.B1.C1.A1.F.D1 (frame, left panel, right panel, top panel, bottom panel, back panel)

In this code the letters represent specific faces and their associated number represents the design version of that component.
Additionally the order in which the components are listed describes the layout of the device. Specifically: the frame, left panel, right panel, top panel, bottom panel, back panel
In this code:
X- Represents the structure.
B- Represents the Switch panel.
C- Represents the Magnetic Key panel.
A- Represents the Multi Role IO panel.
F- Represents the Blank microcontroller mounting panel.
D- Represents the GPS panel.

4.6.1 Structure

The structure of the platform consists of the external and internal components that form the base frame that houses the modular activity faces as well as the door panel.

the structure is all of the permanent non changeable components of the design.

The Outer Shell The outer shell was designed in 5 parts. These five components had interlocking fingers that allowed them to fit together. The components where laser cut from 3mm acrylic, this gave them a smooth finish and acrylic was used for its rigidity and durability. As a post process the components where glues together and a marble look vinyl wrap was applied for aesthetic value.

Inner Structure The inner shell of the device was designed and printed in PLA using a 3D printer. The original design had 4 components that where printed and glued together to create a rigid body. This body was secured into the shell with 4 8G 10mm button head screws secured into the bottom of the inners structure through holes in the bottom of the shell. This prevented the inner shell from moving in the shell.

Door Face The design chosen for the door face was a circular rotating bank vault style door. This door was inserted into the door face and rotated to lock.
The door was held in place by a solenoid pin that, when activated, would protrude into the path of the door.
The door and door face were created using layers of laser cut 3mm acrylic. the door and external

The door face has slots to join with the shell but it was mounted to the inner structure through the use of 4 8G 10mm button head screws. The screws hent through the face and screwed into the inner structure.

4.6.2 Modular Faces

In this design, the modular faces consist of the faces of the cube that can be removed and replaced to create new activities. The modular faces house the sensors and io components used to generate activities using the platform.

Multi-Role IO The IO face was created with 5 buttons and a 2x16 LCD. The panel is lasered cut 3mm thick birch ply. The five buttons are inserted through holes in the panel and are secured using a the treaded section of the buttons and a nut from the external face of the panel. The face of the LCD is seen through a section cut from the panel. The screen is mounted to the inside of the panel using a 3d printed standoff. The standoff is clued to the panel and the LCD is screwed to the standoff.

Power is provided through a +5v and ground connection to the shield. The 4 i2c wires from the LCD and the 5 signal wires for the buttons are directly connected back to the shield.

Magnetic Keys The magnetic key panel was created using a 150x150mm panel of laser cut plywood. On the inside face of the panel there were 3 glass reed switches connected in series. These reed switches were mounted into a 3d printed frame that was glued to the panel. The 3 magnetic keys were 3D printed from PLA and had an 8mm magnet glued into them to trigger the read switches.

The reed switches where directly connected to the microcontroller via the screw shield.

Switch bank The Switch bank panel was created using a 150x150mm panel of laser cut plywood. The 9 switches were inserted through the holes in the face. On the interior face the 9 SP-DT (double pole double throw) switches where wired such that there was a specific order that the switches had to be switched to create a closed circuit. The switches where directly connected to the microcontroller via the screw shield.

GPS location The GPS panel was created using a 150x150mm panel of laser cut plywood. The GPS receiver protruded out of the face of the panel. The individually addressable led strip was visible through holes cut in the face of the panel.
The LEDs and the GPS module where screwed to a 3d printed frame that was glued to the inside of the panel

The connections for the GPS and the LEDs were connected to the microcontroller via the screw shield.

4.7 Device V1

Initial version of each face and the frame.
X1.B1.C1.A1.F.D1

4.7.1 Initial component testing (T1)

The initial testing is intended to confirm the viability of the project and to test the component panels individually in order to ensure that the components function correctly. This was done by connecting the panels individually and testing the

components function as well as the structure and useability of the panels.
Further details regarding the test methodology and the results of the testing can be found in the testing and results chapters.

Through testing it was found that improvements to the device could be made. The improvements that were noted are:
Through testing it was found that the solenoid responsible for locking the door was unreliable. The solenoid did not consistently deploy and retract. The design was changed to remove the solenoid and replace it with a hinge and a servo motor to control the door.

The inner structure could be redesigned and permanently mounted into the shell. This redesigned inner structure would allow faces to be swapped out individually. The redesigned structure would also allow for panels of various withs to be used.

The LED strip in the GPS panel was not visible from wider angles. Having the LEDs mounted protruding from the face would increase their visibility. Additionally, the GPS receiver was slightly recessed from the face of the panel. Creating a new mounting method for the receiver provides it with a less interrupted connection.

The use of the buttons to input text to the multi role io panel was clunky and frustrating. The addition of a rotary encoder for text inputs would make the process easier for the users.

4.7.2 Modifications Made

The sections that were modified in version two where the inner structure, the multi role io and the GPS panel.

The design of the door mechanism was changed to remove the solenoid and to incorporate a 5v servo motor. This servo motor is responsible for rotating the door into the locked or unlocked position. The hinge allows the door to be opened when the servo unlocks the door.

The design of the inner structure was changed to make the process of swapping faces simpler for the user. The new design of the inner structure consists of 3 bodies and 2 styles of mounting connectors.
The main structure is permanently glued into the shell and provides a frame for the panels to sit in. the two connection brackets, the pillar brackets, and the corner brackets, are used to secure the faces inside of the frames.
The two removable sections of the frame are used to mount the door panel. The suspension frame is inserted on a slight angle then straightened and moved to the front of the frame. The frame face is then inserted and this locks the suspension frame into the structure.
When the door face is put onto the frame 4 M4 25mm bolts secure the door to the suspension frame.

multi role io

The multi role IO face was upgraded to include a rotary encoder. This i2c encoder was connected to the microcontroller via the screw panel and was used to select characters for text inputs.

GPS panel

The led panels was removed and replaced with 4 LEDs that protrude from the face of the panel. Additionally, the GPS unit was mounted into a 3d printed frame that is glued into the panel. This improves the visibility of the LEDs and exposes the receiver for a better connection to the satellites.

4.8 Device V2

The version code for the tesseract v2 is **X2.B1.C1.A2.F.D2**

4.8.1 Device testing (T2)

The second round of testing was intended to assess the whole system. This was done to assess whether the utility of the design could be improved through minor modifications or design improvements.
The testing was conducted by assembling the device and operating each of the faces individually to determine where modifications to the device could improve its usability.

It was found that the modularity of the faces could result in a lack of IO ports if too many inputs/outputs were required. To solve this issue each of the faces were updated to use I2C multiplexers. This meant that there is a common connection method for any additional panels. In addition to the improvement to modularity the changes made the wiring of the device significantly simpler.

In addition to updating the communications method. Changes were made to the multi role IO face, the switch panel, and the magnetic switch panel.

Multirole IO

It was found that the limited size of the LCD screen on the multi role io panel resulted in limitations to the information that could be presented to the participants. As a solution to this the multirole IO panel was updated with a larger screen.

Switch panel

It was found that the switch panel both, did not have adequate responsiveness to the user inputs, and that the preset connection of the switches, resulting in a single correct pathway, limited the use and re-use capabilities of the platform.

Magnetic switch panel

The glass reed switches used in the magnetic key panel were found to be too fragile. The glass reed switches broke during handling and were found to be fragile and not particularly sensitive.

Additionally, the magnetic switches did not provide feedback to the user when connected to the panel. This lack of feedback could be disappointing to participants who have recently found a key.

4.8.2 Modifications Made

To remove the limitation to the modularity of the system each of the panels was upgraded with the addition of an i2c multiplexer. The multiplexers allowed each of the panels to be connected to the microcontroller via i2c. This simplifies the connection of the panels and makes the addition of further panels easier by removing the limitations of IO pins on the microcontroller.

Multirole IO

The IO panel was altered to accommodate a larger 20x4 LCD screen. The addition of this screen allows for longer messages to be sent to the screen without the need for multiple screens of text.

The new larger screen is screwed into a 3d printed holder. This holder is glued to the panel, securing the screen in the panel.

Switch panel

To provide users with feedback on the status of the switch panel, the switch panel

was altered to add two LEDs, the LEDs added to the panel where green and red. While the switches are not all set to the correct setting, the red led is on. When all of the switches are set correctly, allowing for a closed circuit across all of the switches, the green LED turns on.

In addition to the addition of the status LEDs, the panel was altered to add 9 SPDT microswitches to the inner face of the panel. These microswitches allow the correct positions of the external facing switches to be set by the user. This gives the panel additional utility and re-use value.

Magnetic switch panel

The glass reed switches used in the magnetic key panel were found to be too fragile. In an attempt to replace them with a more rugged design, the glass reed switches where replaced with plastic cased reed switched.

To provide the participants with more satisfying feedback when a magnetic key is attached to the device the magnetic keys where re designed to accommodate 3 wirelessly powered LEDs. These LEDs will turn on when the key is attached to the panel and the led is in range of the coil that is mounted to the back of the panel.

An additional change that was implemented was, the reed switches where no longer connected in series. The reed switches could be read individually, this allowed the device to determine the number of keys attaches to the kef face at any time.

4.9 Device V3

The version code for the Tesseract v3 is **X2.B2.C2.A3.F.D3**

4.9.1 Device testing (T4)

The final testing T4 and T5 were the final tests of the device and the activity developed for the device.
In T4 the designer independently implemented the orientation activity on location and assessed the final device for broader utility. This test also assessed the orientation activity ran using the device to provide a self-assessment as to the device's operation as part of an activity and to self-assess the efficacy of the developed activity.

4.9.2 Involved device testing (T5)

Test 5 is the final prototype testing. This test was conducted by subject matter experts (education). This test was intended to achieve a non-biased professional opinion on the utility of the device in educational settings and a critical assessment of the activity developed for the device.
The results of this test final testing were used to determine the outcome of the project.

Chapter 5

results and Discussion

5.1 Introduction

This chapter covers the analysis of the results of the testing conducted through the course of developing the prototype low-cost-computing based activity device. The tests conducted on the device can be separated into two sections.

The first two tests demonstrate the continuous development of the Tesseract platform. These tests where conducted in order to refine the function of the device by analysing the function of the components of the device and reviewing the device in relation to its intended design goals.

The final tests, Tests 3 and 4, are intended to provide evidence of capability of low cost computing solutions in educational applications. While the first two tests allow for the development of the prototype, these final tests where used to confirm the results of this research. Test 3 and 4 are intended to simulate a real-world education activity that has been developed and deployed using the project design of a prototype low-cost-computing-based puzzle-activity-development-platform. The results of the final testing will be used to conclude the project and to determine the practical capabilities of low-cost-computing based puzzle devices in regards to their use in educational roles.

5.2 Test 1

5.2.1 Test Objective and Procedure

The initial test conducted during the development phase of the Tesseract modular multi-role activity platform aimed to assess the overall viability of the system's concept. It also included a comprehensive examination of individual component panels to ensure their proper functionality. The test was divided into two main categories: structural analysis and component operational analysis.
The structural analysis focused on evaluating the physical integrity of each component, while the component operational analysis analized the operational aspects of each component on all of the modular panels designed for the Tesseract device. This panels referenced are: the multi-role IO, the switch array, the magnetic switches, and the GPS. Following these assessments, a final evaluation was conducted to determine the project's overall viability and to identify potential areas for improvement.

5.2.2 Test Outcomes

The results of this test unveiled several crucial insights that paved the way for significant improvements to the Tesseract system:

Solenoid Reliability: The initial design featured a solenoid mechanism responsible for door locking, but it exhibited inconsistency in deploying and retracting. As a result, the solenoid was deemed unreliable. To address this issue, the design was overhauled, replacing the solenoid with a hinge and a servo motor. This modification ensured more dependable door control.

Redesigned Inner Structure: The inner structure underwent redesign, with a permanent mounting into the shell. This revised design allowed for the individual swapping of faces and the use of panels with varying widths. This adaptation enhanced the system's adaptability and versatility.

GPS Panel Visibility: Testing revealed that the LED strip in the GPS panel was not adequately visible from wider angles. To rectify this, the LEDs were repositioned to protrude from the panel's face, increasing their visibility. Additionally, a new mounting method was developed for the GPS receiver to establish a more reliable connection.

User Interface Enhancement: Analysis of the device from a user perspective demonstrated the clunkiness and frustration associated with text input via buttons on the multi-role IO panel. To address this, a rotary encoder was proposed as an improvement for text inputs, offering a more user-friendly interface.

5.2.3 Discussion

The outcomes of the initial test provided valuable insights into the Tesseract system's concept and components. The identified areas for improvement not only enhance the device's reliability but also extend its adaptability, user-friendliness, and overall effectiveness. These modifications reflect a commitment to refining the system's design, ensuring its seamless integration into educational activities.
The iterative nature of this testing and improvement process underscores the project's dedication to continuous enhancement, setting the stage for further development and refinement in subsequent tests and iterations.

5.3 Test 2

5.3.1 Test Objective and Procedure

The second test, conducted to assess the Tesseract multi-role platform, it was aimed to gauge the system's capabilities and pinpoint potential areas for improvement. The evaluation encompassed three core aspects: the construction of the platform, the electrical connections between modular activity panels and the microcontroller, and a comprehensive assessment of the operation of each connected component.

The test's primary focus was to determine the device's effectiveness, with a specific emphasis on potential enhancements.

5.3.2 Test Outcomes

The results of this test uncovered several noteworthy observations, leading to a series of strategic improvements:

Modularity Enhancement: An essential discovery during this test was the potential for a shortage of input/output (IO) ports if numerous inputs/outputs were required. To address this concern, each of the faces was updated to incorporate I2C multiplexers. This modification introduced a common connection method for additional panels, streamlining the device's wiring and significantly enhancing its molecularity.

Multi-Role IO Panel Update: The limited size of the LCD screen on the multi-role IO panel imposed constraints on the information that could be presented to participants. To overcome this limitation, the multi-role IO panel was upgraded with a larger screen, expanding its information-display capabilities.

Switch Panel Improvements: The switch panel experienced challenges related to user responsiveness and the preset configuration of switches, which mandated a single correct pathway. These limitations not only hindered user experience but also restricted the platform's versatility and re-usability. Changes were made to enhance user interaction and provide more flexibility in pathway configurations.

Magnetic Switch Panel Enhancement: The glass reed switches used in the magnetic key panel were found to be fragile, breaking during handling. Additionally, they lacked user feedback when connected to the panel, potentially leading to participant disappointment after successfully finding a key. These findings prompted the exploration of more robust and user-friendly alternatives for the magnetic switch panel.

5.3.3 Discussion

The outcomes of the second test underscore the project's commitment to iterative improvement. Notably, the implementation of I2C multiplexers enhances the molecularity and simplifies the device's wiring, rendering it more adaptable to various scenarios. The enlargement of the multi-role IO panel's screen addresses limitations in the user interactions, improving the platforms capability to present information to the participants.

The updates to the switch panel not only enhance user responsiveness, but they also unlock greater potential for creativity and variation in challenge configurations. These changes have the result of, increasing the platform's re-usability. Additionally, the examination of alternative options for the fragile glass reed switches in the magnetic key panel provides an increase to the devices reliability.

These findings and subsequent improvements demonstrate the project's commitment to refining the Tesseract system, ensuring its seamless integration into educational activities while addressing usability concerns. The iterative nature of these tests and adaptations demonstrate the project's continuous enhancement, setting the stage for further development and refinement in subsequent phases.

5.4 Test3

5.4.1 Test Objective and Procedure

The third test was a rigorous assessment of a proposed multipurpose activity platform within an educational setting, specifically as a simulated first-year orientation activity for engineering and surveying students. Notably, this trial was performed by a single conductor. The test was structured to include a pre-activity assessment that addressed safety considerations, defined the trial's purpose and intent, and outlined testing parameters.

Subsequent to the briefing, the conductor independently undertook the trial activity using the proposed platform. This solitary exploration provided a valuable assessment of the system's molecularity and application. Following the trial, a post-activity assessment was conducted by the conductor, analysing the system's design, with a particular emphasis on the versatility and functionality of the panels.

The final phase comprised a post-activity review where the conductor offered a comprehensive self-assessment of the practicality of both the activity platform and the trial orientation activity. This solo assessment was integral to the process, as it aimed to determine the suitability of the activity platform for educators, identify potential areas for platform enhancement, and explore avenues for improving the trial orientation activity.

5.4.2 Results

The Activity

Through an independent assessment of the orientation activity it was found that some aspects of the activity could be optimised prior to teh activity being conducted using student participants. The area that where noted included:
It was found that the staff of the library, Iconnect, and security where often busy. This would have to be prepared for in deployment by either simulating the interaction through the use of other staff or by pre-warning the other staff in those locations of the activity.
Another potential issue is that a conductor would be required to stay with the group through the activity. If IOT capabilities where added the conductor could supervise the activity remotely.

The Device

Through an independent assessment the device it was found that there were some areas for improvement.
When the device was take outside it required a minute before the GPS was able to find the location. This can be solved by powering the device in an outdoor location for a limited time (approximately two minutes) prior to the activity in order for the GPS unit to sync with the satellites.
There is no permanent external indication of the time left to complete the activity. Adding an individually addressable LED ring to the door of the box would create an indicator device to show how much time has elapsed in the task.

5.5 Test4

5.5.1 Test Objective and Procedure:

The final test conducted sought to evaluate the viability and effectiveness of a proposed multipurpose activity platform within an educational environment. The trial, designed as a simulated first-year orientation activity for engineering and surveying students, was conducted by the platform designer using academic staff members as the activity participants. Fhe academic staff member was well-versed in orientation processes and learning-and-teaching methodologies. The test comprised several key phases, commencing with a pre-activity briefing that covered safety considerations, the purpose and intent of the trial, and defined testing parameters.

Following the briefing, participant engaged in the trial activity using the proposed platform. This phase provided an opportunity to assess the system's molecularity and the diverse applications of the activity panels employed. Subsequently, a post-activity presentation delved into the system's design choices, emphasising its modular nature and the versatility of the panels. The final phase included a post-

activity review and discussion, where teh subject matter expert provided valuable insights into the practicality of both the activity platform and the trial orientation activity. The comprehensive reviews from this expert aimed to determine the utility of the activity platform for educators, identify areas for potential platform enhancements, and explore avenues for improving the trial orientation activity.

The test was conducted with meticulous attention to logistics, ensuring a smooth process from pre-briefing to post-briefing, and was executed in a manner that allowed participants to complete the trial activity without external assistance. The trial also incorporated elements where the conductor assumed the role of a university staff member during specific puzzles to maintain the normal campus operation. Post-activity discussions and review documents facilitated the collection of feedback regarding the strengths and areas for improvement in both the equipment and the trial activity, creating a robust foundation for refinement and development.

5.5.2 Results

The Activity

The subject mater expert who reviewed the device provided the following comments:

General comments

-The activity appears to be well planned, engaging and constructively aligned. I think it would make a fantastic Orientation activity for our first year engineering students.

In the pre-Activity checklist

-The risk assessment should consider the weather conditions.

-The students should have a water bottle.

-The discussion of the safety considerations boundaries and PPE, should be conducted prior to the building tour.

The Bridge Puzzle

-Explaining the task prior to giving the students the device would bo optimal.

-The expert suggested that the information to answer the task could be divided amongst the whole group in order to foster communication.

The Emergency Haik Puzzle

-no comment.

The Head of School's Room Number Puzzle

-no comment.

The Resistance Challenge Puzzle

-The expert suggested that the activity would be more beneficial if the students where required to find a book within the library. This could be done by providing the students the ISBN of a electronics book and having them locate it.

Room Access

-No comment.

Degree Course Count Puzzle

-It was noted that this puzzle could cause confusion if the students are from degrees with varying unit numbers. It was suggested that a single program could be used and that the analysis of a program would still benefit the students.

Finish/Reward

-It was noted that there should be a note in the box instructing the students to go to the next destination.

The result of this testing was significantly positive. The subject mater expert determined that the activities where appropriate and worked, in a creatively aligned manner, to benefit and reinforce the education of the student participants.

The Device

The subject mater expert, an academic with expertise in education, warmly received the proposed multipurpose activity platform during the trial, confirming its utility and benefits within an educational context. Several specific aspects of the device garnered their appreciation:

Status LEDs, Success Messages, and Wireless LEDs. The inclusion of status LEDs, success messages, and wireless LEDs was well-received by the expert. They noted that these features provided valuable feedback to participants, enhancing the overall user experience.

Push Buttons, Rotary Encoders, and Toggle Switches. The expert expressed positive feedback regarding the push buttons, rotary encoders, and toggle switches present on the device. These elements were commended for their sensory feedback, making the platform particularly useful for neurodiverse students.

Despite the overall positive reception, the expert panel also suggested some beneficial enhancements for the device:

Colour Coding. They recommended the implementation of colour coding for each face of the device. This visual differentiation would simplify and expedite the identification of specific components, streamlining the user experience.

Button Labelling. Improved labelling of the buttons on the IO face was advised. Clear and descriptive labelling would enhance user guidance and comprehension, ensuring a smoother interaction with the platform.

Text Input Cursor Behaviour. An adjustment to the code was suggested to modify the behaviour of the text input cursor. Currently, the cursor loops back to the start of the text when shifted off the screen to the right. The experts recommended a modification to prevent this, creating a more user-friendly text input experience.

The positive feedback from the expert, coupled with their insightful recommenda-

tions for improvements, reinforces the potential of the multipurpose activity platform as a valuable addition to educational settings. These constructive insights are invaluable for refining the platform and tailoring it to the diverse needs of students and educators, fostering an inclusive and effective learning environment.

Chapter 6

Conclusions

In the pursuit of enhancing educational activities, this project has embarked on an exploration of the vast potential offered by low-cost computing hardware. With the assessment of the available resources and through the introduction of the Tesseract, a modular, puzzle-based learning device, we have demonstrated that such devices can play a pivotal role in reshaping the educational landscape. The report's primary question—whether low-cost computing hardware, exemplified in this report by the SparkFun RedBoard Turbo, can be harnessed to create educational devices that align with constructive alignment—has received a resounding affirmation.

Through the assessment of the available research regarding the pedagogical utility of the active involvement of students in educational puzzle-based activities; this research project successfully confirmed the utility of puzzle-based educational activities. It is found that, when correctly implemented, these activities not only foster active learning in other ares of the students study but also significantly contribute to improvements in academic performance and classroom dynamics. It was found that the use of these active learning-activities could present opportunities for the development of teaching an learning exercises, within constructive alignment, that would be otherwise difficult to achieve.

Through the course of this project the viability of of the concept of low-cost computing-based puzzle-based activities was analysed. The review of the capa-

bilities of the currently available low cost computing devices, as well as the analysis of existing puzzle based devices utilising low cost computing hardware, confirmed the consensual viability of the concept. It was found that there is significant room for the development of low cost computing based devices intended to be used in an educational setting.

In the execution of this project, not only have the concepts been explored, but they where also it into tangible action and tested, thereby confirming the viability of low-cost computing-based puzzle-based activities. The development and successful implementation of the Tesseract as a modular dynamic puzzle-based learning device actively demonstrates the feasibility of the projects concept. The Tesseract platform demonstrated the adaptability, versatility, and effectiveness of a low cost computing based activity platform for education. The Tesseract prototype represents the potential of a real-world application of low-cost computing hardware in education. The iterative development process, accompanied by rigorous testing and assessments from education subject matter experts, provided conclusive evidence that such devices can integrate into educational settings and contribute to improvements in a students educational experience. This confirmation underscores the innovative and pragmatic nature of low-cost computing-based puzzle activities, affirming their role in shaping the future of education.

In summary, this project has identified the capacity of low-cost computing hardware exemplified by the prototype device that has been developed as a method for the generation of meaningful, and dynamic activities in education. The Tesseract platform serves as an example of a basic, cost-effective, versatile, and adaptable solution that can empower educators with the personal ability to tailor activities to their curriculum. These user adaptable activities allow for an increase in the precise targeting of leaning outcomes, aligning them seamlessly with the curriculum. By fully utilising these devices, educators stand better prepared to generate constructively aligned lessons that challenge the boundaries of conventional education. The future of pedagogy is dynamic, and it will be defined by innovative and adaptable solutions such as the Tesseract.

6.1 Future development

While the development of the Tesseract device and the deployment of the device, covering an existing curriculum, was successful, the assessments of the subject matter expert showed areas in both the design of the platform and the creation of the activity where improvements could be made. The future development of the activity would involve consultation with the school's orientation team to do further testing with an aim to using it as part of Orientation activities. The future development of the device would involve slight modifications to the aesthetics and some of the processes of the device as well as developing the device from a rough prototype to a functional product. Additionally, the modules created for this project where chosen to allow for the broadest selection of potential activities possible. This was both important and appropriate considering the intention of the research, however, there remains significant room for further development of the concept and other potential modules for the device. Additional concepts for panels are listed in the appendix (Appendix item M).

It should be noted that, while the developed prototype device was successful, it was intended as a proof of concept to prove that low-cost-computing can be utilised successfully for education applications. This project should be used as a spring board for the development of further low-cost-computing based devices.

References

amachinetech (2014), 'Arduino treasure hunt'.

Arduino Mega 2560 Rev3 Product Reference Manual (2023).

Arduino Mega Tutorial (n.d.).

Arduino UNO R3 Product Reference Manual (2023).

BBC micro:bit (n.d.).

Biggs, J. & Tang, C. (2010), Applying constructive alignment to outcomes-based teaching and learning, *in* 'Training material for "quality teaching for learning in higher education" workshop for master trainers, Ministry of Higher Education, Kuala Lumpur', Vol. 53, pp. 23–25.

Coley, G. (n.d.), 'Beaglebone black system reference manual'.

DerekD (2011), 'Rfid treasure hunt game'.

Dictionary, O. E. (1989), 'Oxford english dictionary', *Simpson, Ja & Weiner, Esc* **3**.

Duch, B. J., Groh, S. E. & Allen, D. E. (2001), *The power of problem-based learning: a practical" how to" for teaching undergraduate courses in any discipline*, Stylus Publishing, LLC.

Gan, D. (2019), 'Escape room game component design using raspberry pi'.

Gurney, B. & Rundle, N. (2017), 'Constructive alignment diagram'.

Howard, J. (2007), 'Curriculum development'.

Kandlbinder, P. (2014), 'Constructive alignment in university teaching', *HERDSA News* **36**(3), 5–6.

Lau, E. V. & Gopalai, A. A. (2022), Scavenger hunt activity to reinforce engineering fundamentals, *in* 'Collaborative active learning: Practical activity-based approaches to learning, assessment and feedback', Springer, pp. 155–178.

Lindsay, E., Gray, S. & Lloyd, N. (2012), Students' responses to a scavenger hunt for first year engineering orientation, *in* 'Proceedings of the World Engineering Education Forum (WEEF) 2012: Engineering Education for Sustainable Development and Social Inclusion', Unable to source information.

Loughlin, C., Lygo-Baker, S. & Lindberg-Sand, Å. (2021), 'Reclaiming constructive alignment', *European Journal of Higher Education* **11**(2), 119–136.

Lowyck, J. (2002), 'Pedagogical design', *Handbook on information technologies for education and training* pp. 199–217.

Lubyagin, I., Ivanova, A. & Loginov, S. (2017), Microcontrollers in automation systems of escape rooms, *in* 'HUMAN. ENVIRONMENT. TECHNOLOGIES. Proceedings of the Students International Scientific and Practical Conference', number 21, pp. 164–169.

Manzano-León, A., Rodríguez-Ferrer, J. M., Aguilar-Parra, J. M., Martínez Martínez, A. M., Luque de la Rosa, A., Salguero García, D. & Fernández Campoy, J. M. (2021), 'Escape rooms as a learning strategy for special education master's degree students', *International Journal of Environmental Research and Public Health* **18**(14), 7304.

McAlister, C. & Hills, C. (2023), Don't feed cheese to lactose intolerant volcano gods, *in* 'Proceedings of Association of Public Authority Surveyors Conference (APAS2023)', pp. 26–36.

McLain, B. (2017), 'Project — arduino scavenger hunt'.

Mobius, M., Phan, T. & Szeidl, A. (2015), Treasure hunt: Social learning in the field, Technical report, National Bureau of Economic Research.

Moore, L. & Campbell, N. (2021), 'Effectiveness of an escape room for undergraduate interprofessional learning: a mixed methods single group pre-post evaluation', *BMC medical education* **21**, 1–8.

Nicholson, S. (2015), 'Peeking behind the locked door: A survey of escape room facilities'.

Nicholson, S. (2016), 'The state of escape: Escape room design and facilities', *Meaningful Play* pp. 18–26.

Power consumption of Raspberry Pi 4 versus Intel J4105 systeml (n.d.).

Appendix A

Project Specification

Project specifications

Eng4111/4112 Research project

Course: ENG4111/4112

For: Angus Hampshire

Title: Low cost computing solution for dynamic educational activities.

Major: Electrical/Electronic Engineering.

Supervisor: Catherine Hills.

Enrolment: ENG4111 – EXT S1, 2022

ENG4112 – EXT S2, 2022

Project aim:

The intent of this project is to research existing low-cost computing solutions and how they could be implemented in the design of dynamically deployed education engagement activities. Due to the dynamic nature of the system suggested; the deployment scope and parameters will be refined through the research stages of the project.

This project will facilitate educators to develop situationally relevant dynamic pedagogical activities that may be used either, in conjunction with conventional learning and teaching strategies to enforce classroom knowledge or independently as introductory activities to increase engagement.

Objectives:

1. Investigate options for using low cost computing in related deployable devices.
2. Investigate use cases for the project; both direct in educational environments and in the broader business market.
3. Use the knowledge of the available technology and use cases to refine the scope of the project for development and testing.
4. Expose the project scope to potential end user educators and adjust based on the feedback received.
5. Develop the operational requirements based on the project scope and the hardware available.
6. Create a risk assessment for the application of the technology within the project scope.
7. Analise low-cost manufacturing techniques and how they could be utilised in the project.
8. Create a plant for the test applications of the project.
9. Prototype the individual components of the wider project to ensure that they are independently operational.

Should time and resources permit.

1. Prototype the project wholistically in a simulated real-life situation; to ensure that the components are mutually compatible and that they capable of operating in concurrently.
2. Deploy the prototype in a non-critical real-life situation and collect feedback from both students and educators to the developed project.
3. Refine the design using the testing results from the prototyping and testing phases.

Appendix B

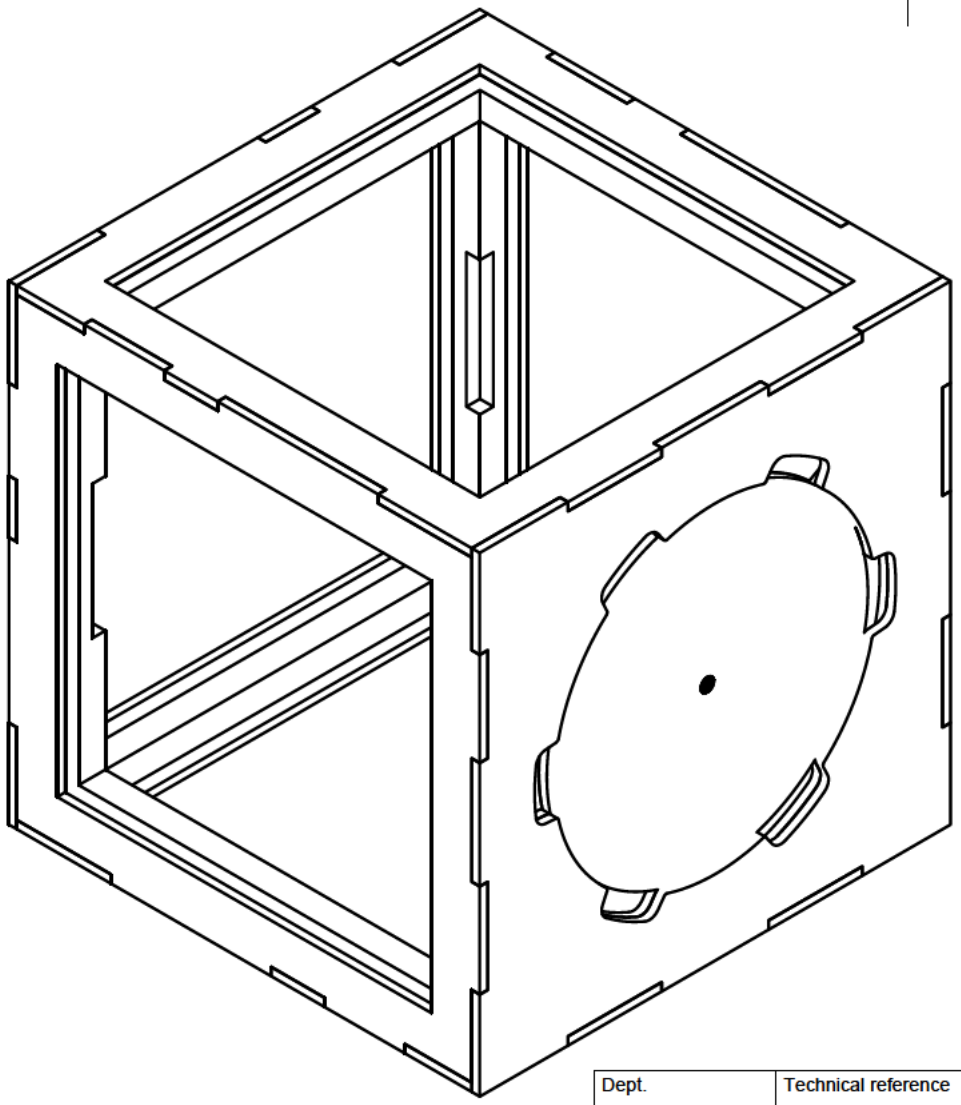
Risk Management Plan

i dont manage risks i am risks

Appendix C

Design Version One

Design Code **X1.B1.C1.A1.F.D1**



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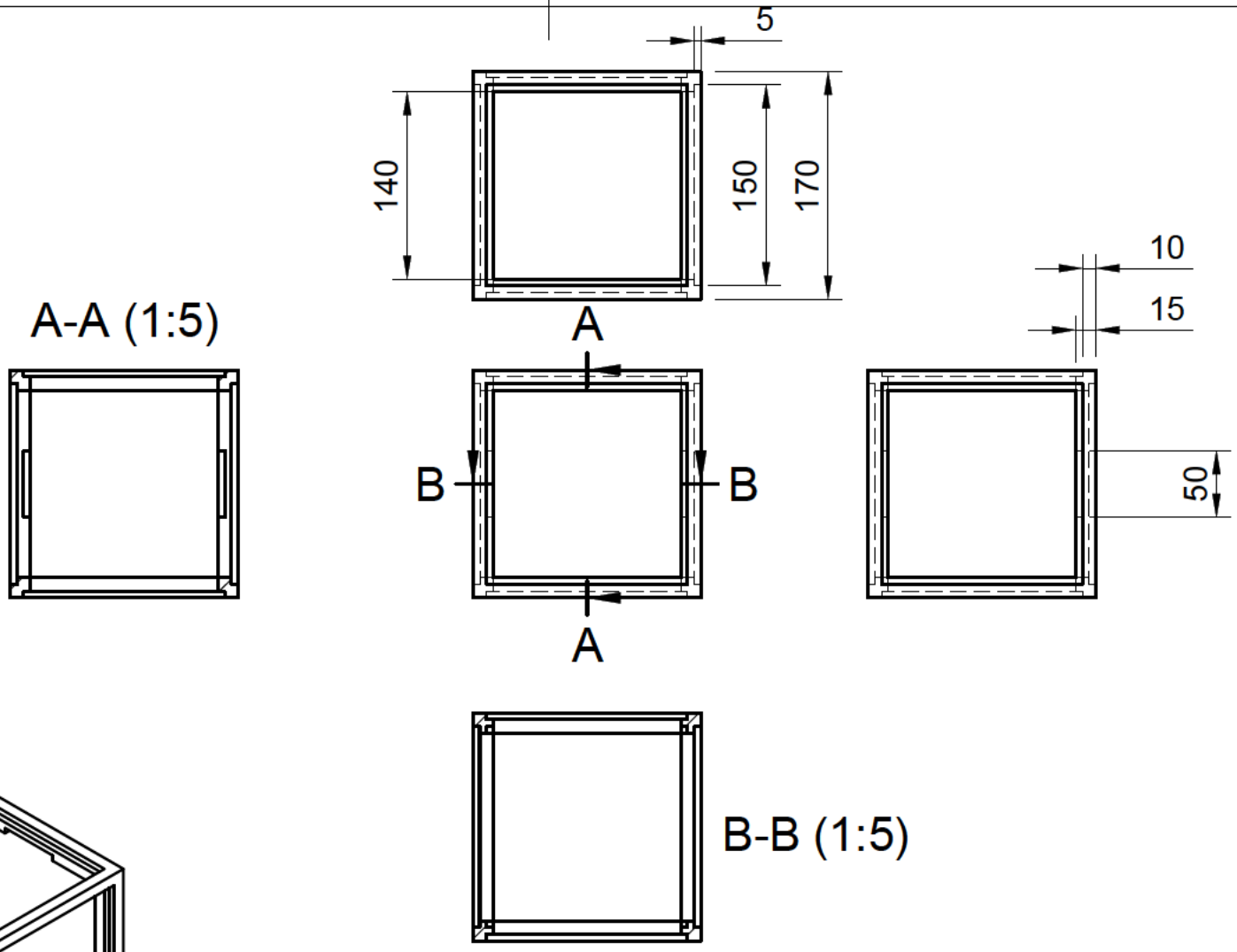

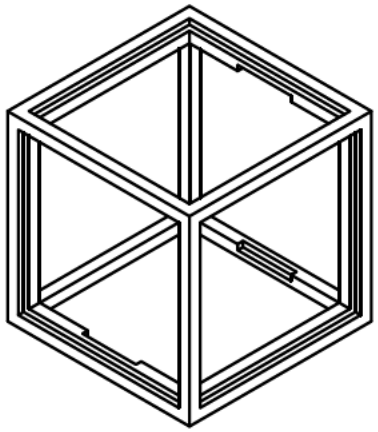

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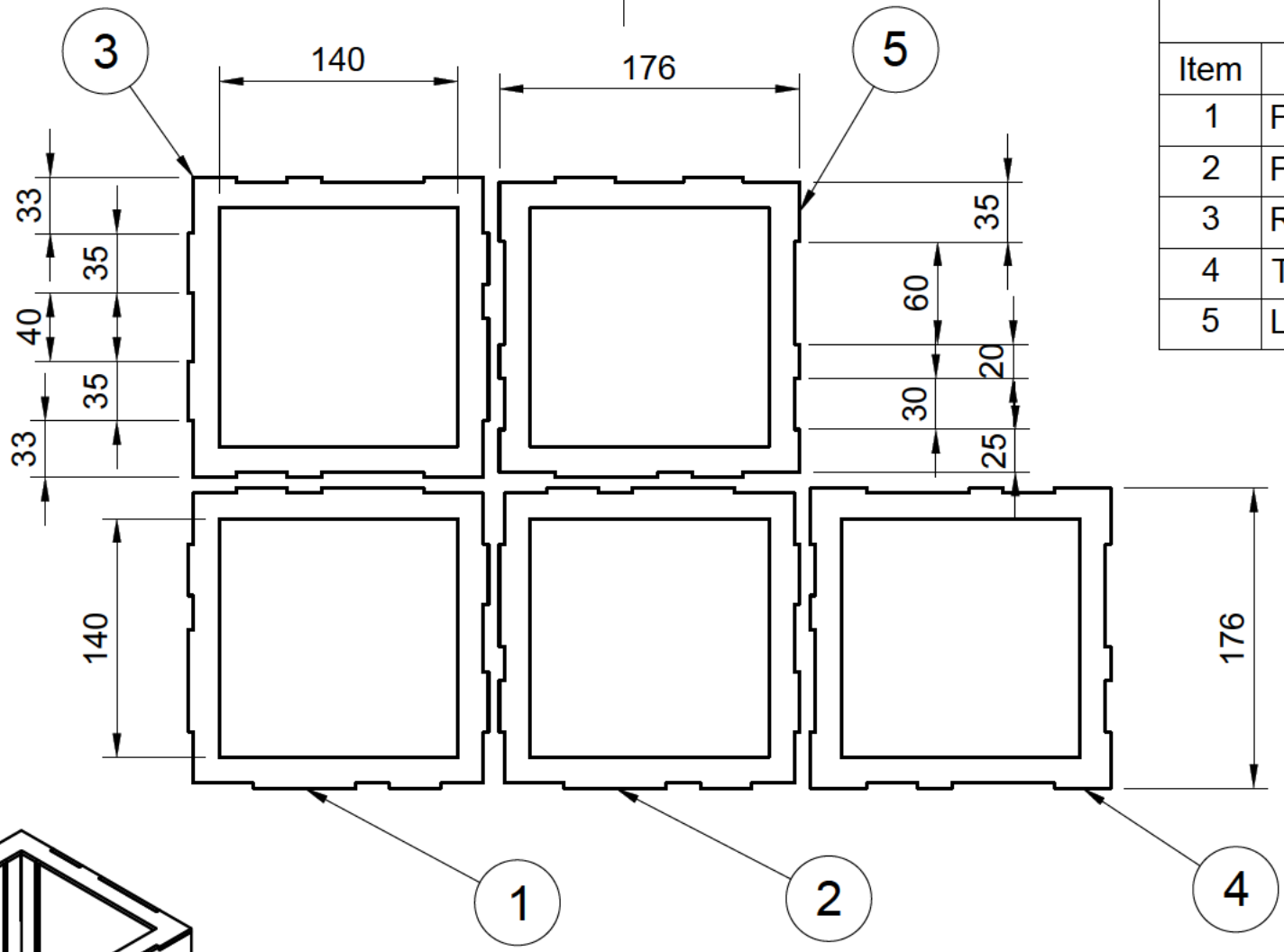

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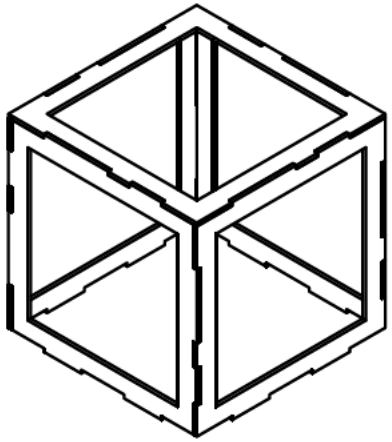
4	Top
5	Left



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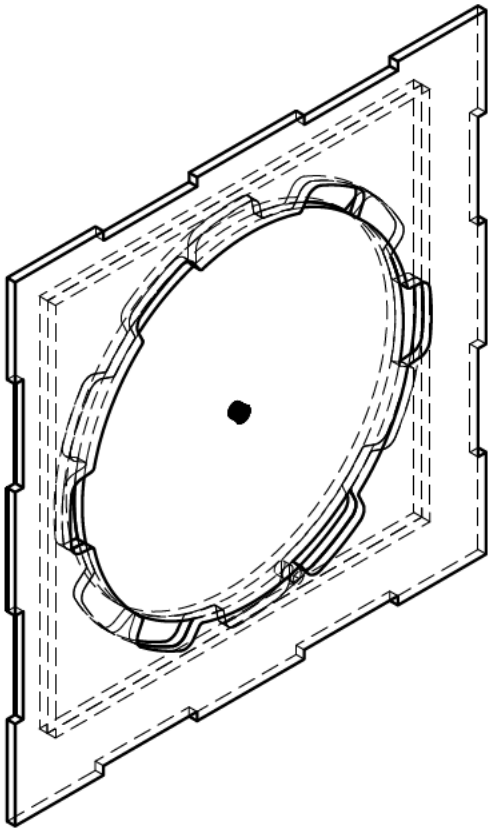

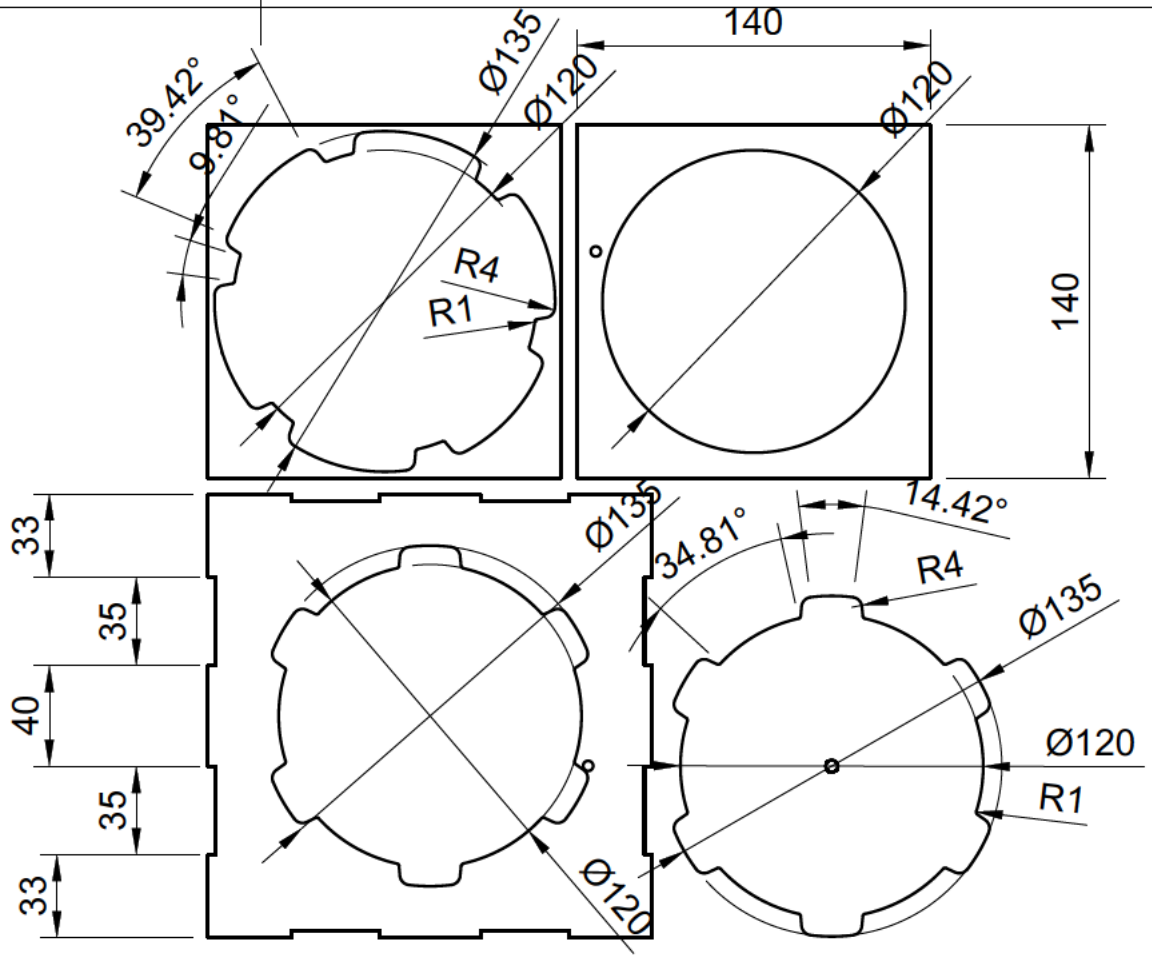

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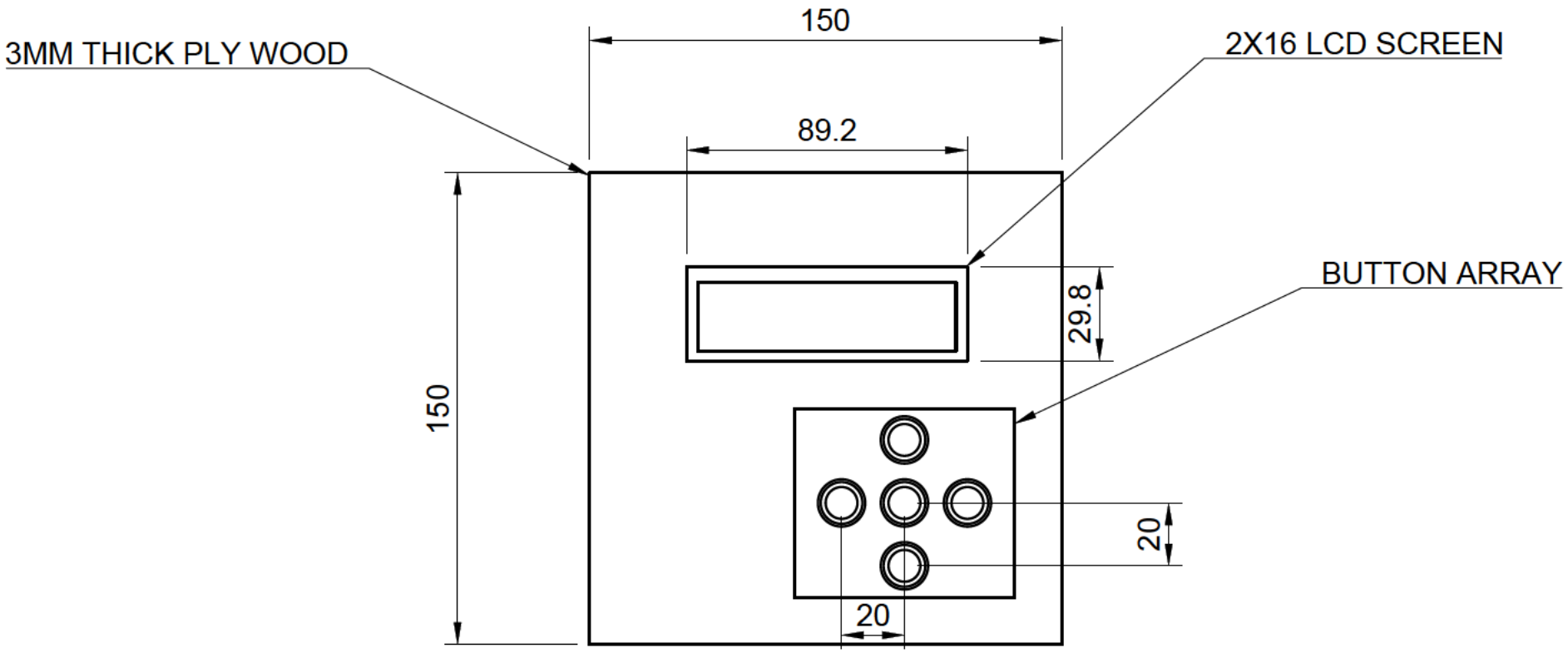

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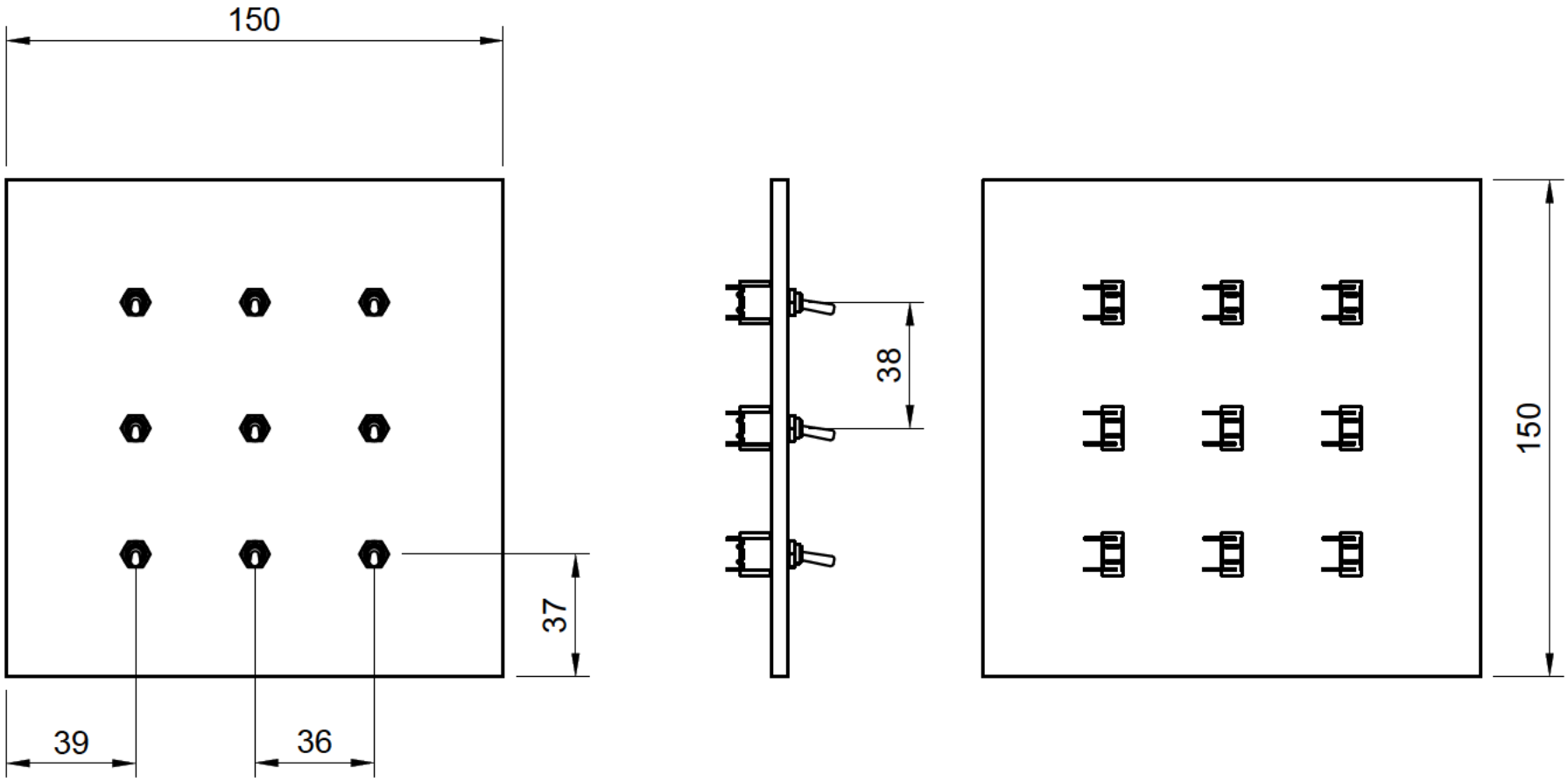

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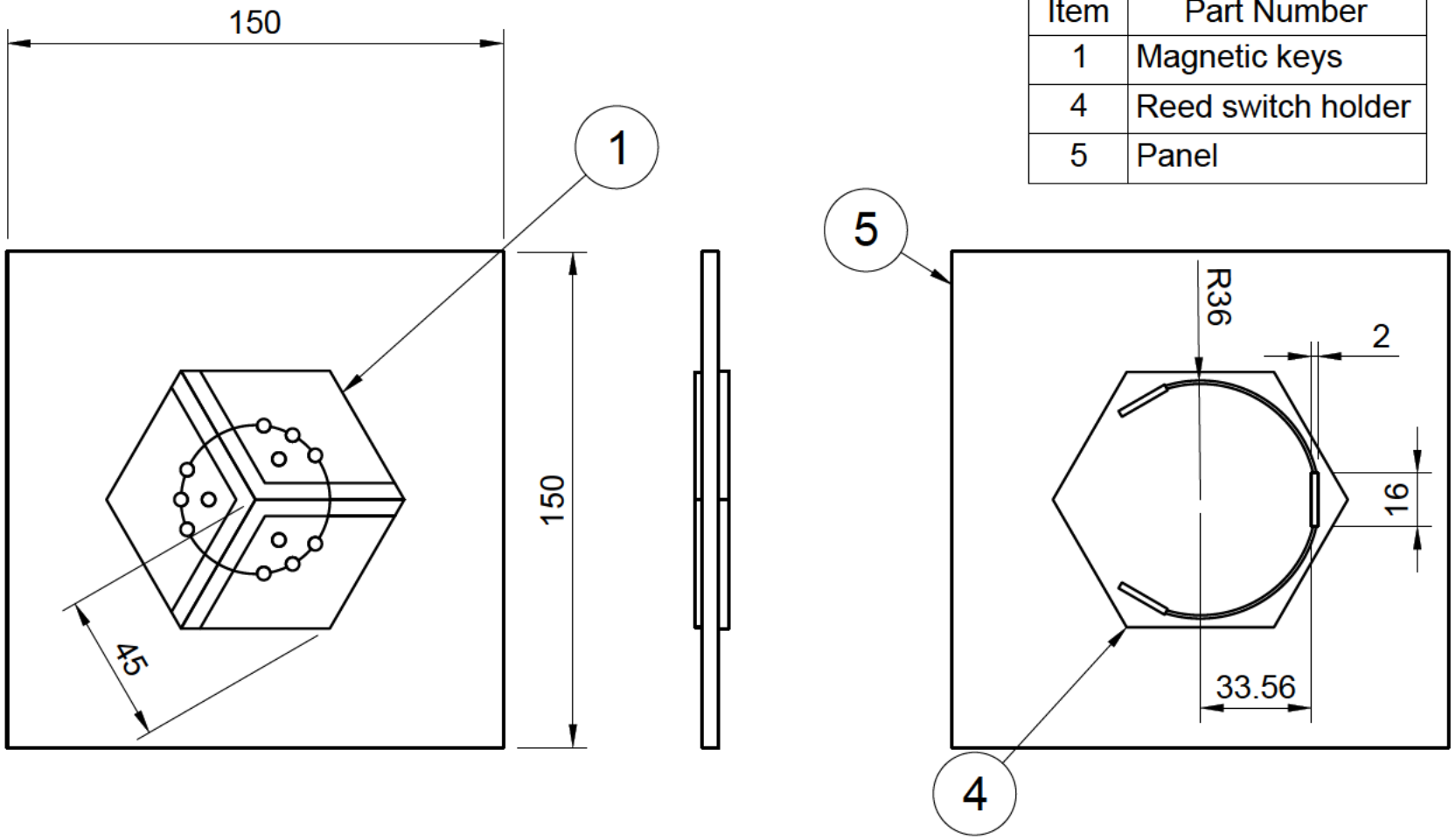
1	Magnetic keys
4	Reed switch holder
5	Panel



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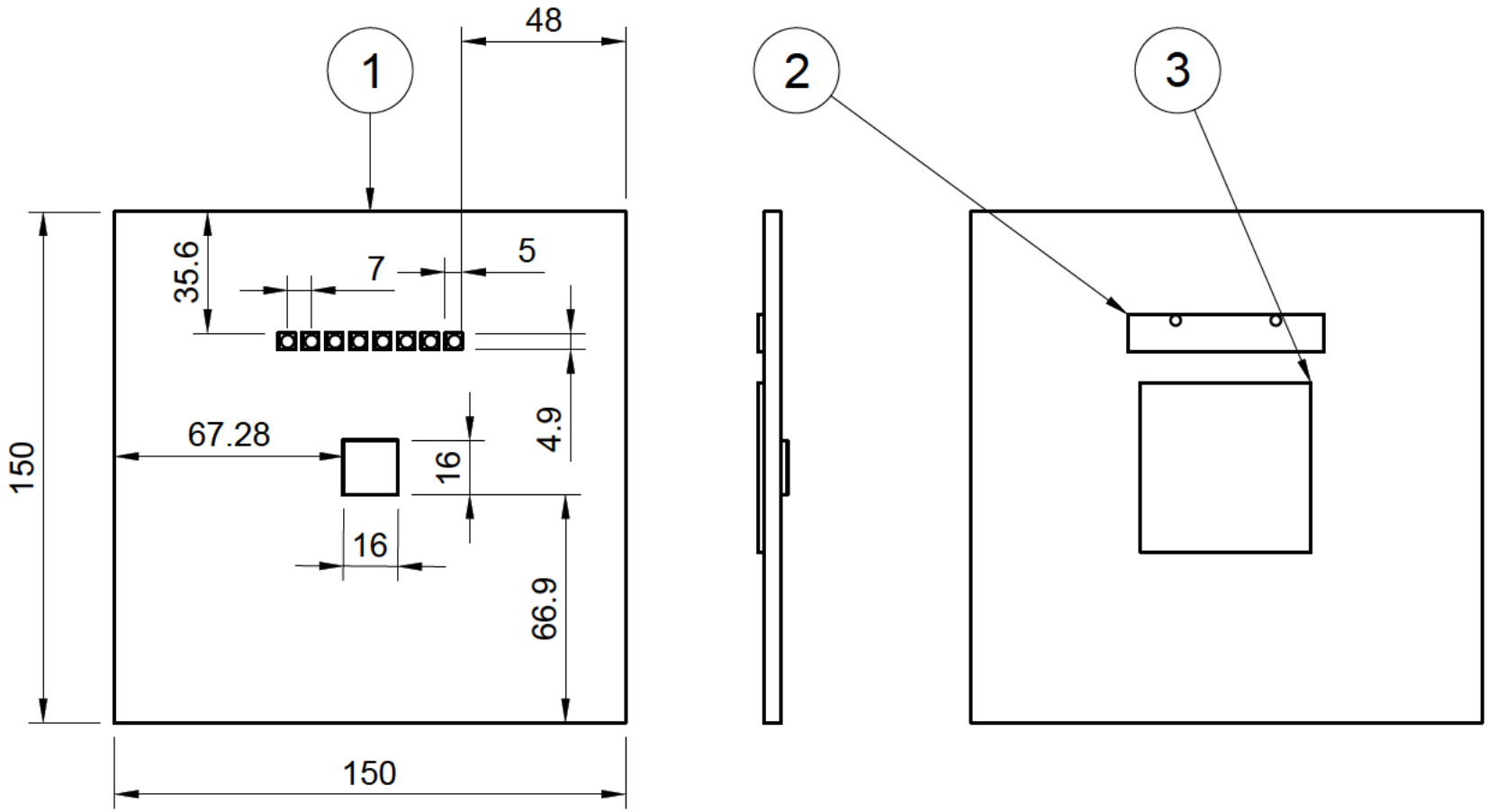

Parts List	
Item	Part Number
1	Pannel (1)
2	Individually Addresable LED strip
3	GPS

Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
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Appendix D

Design Version Two

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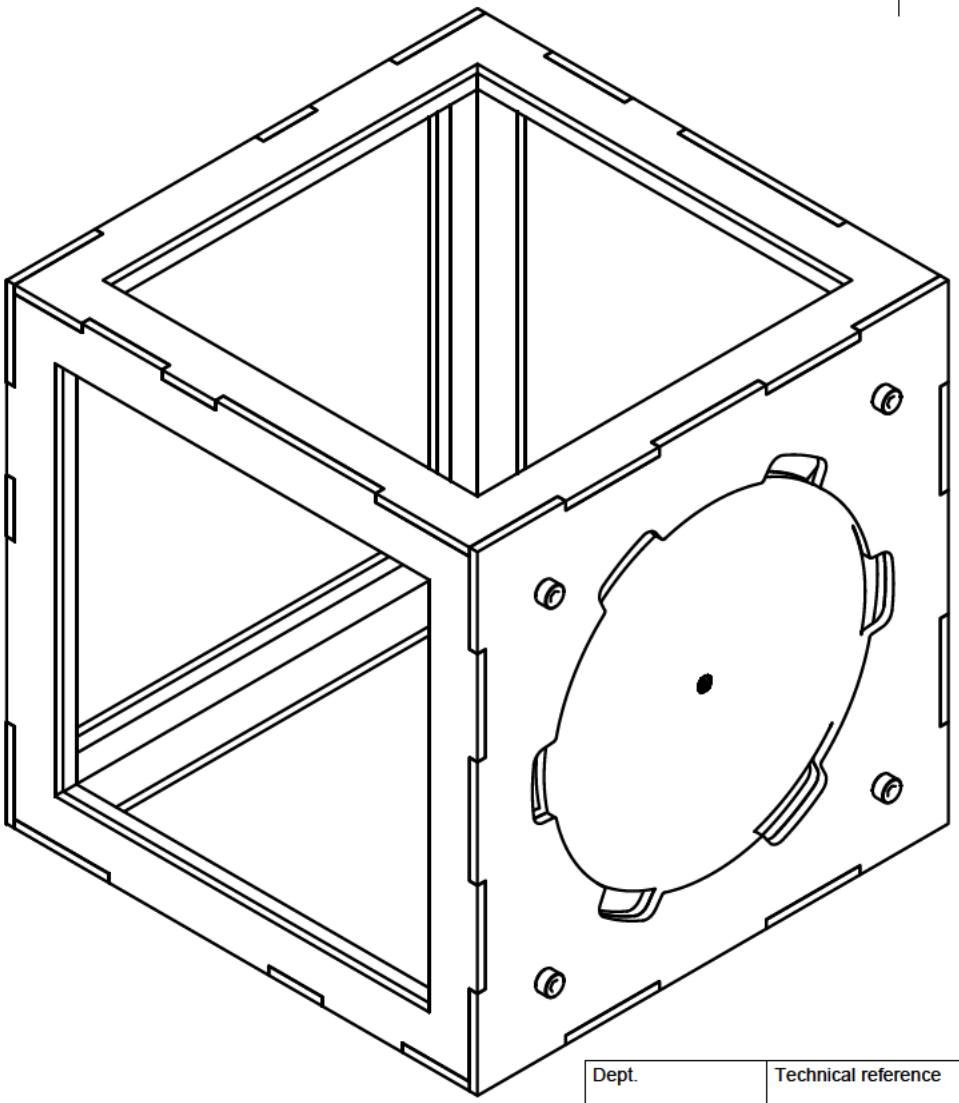

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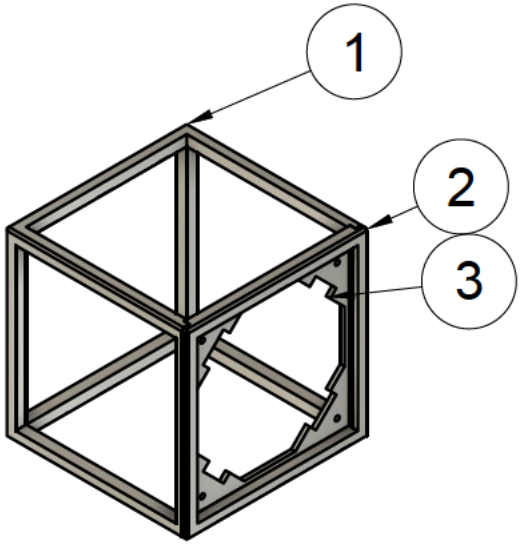
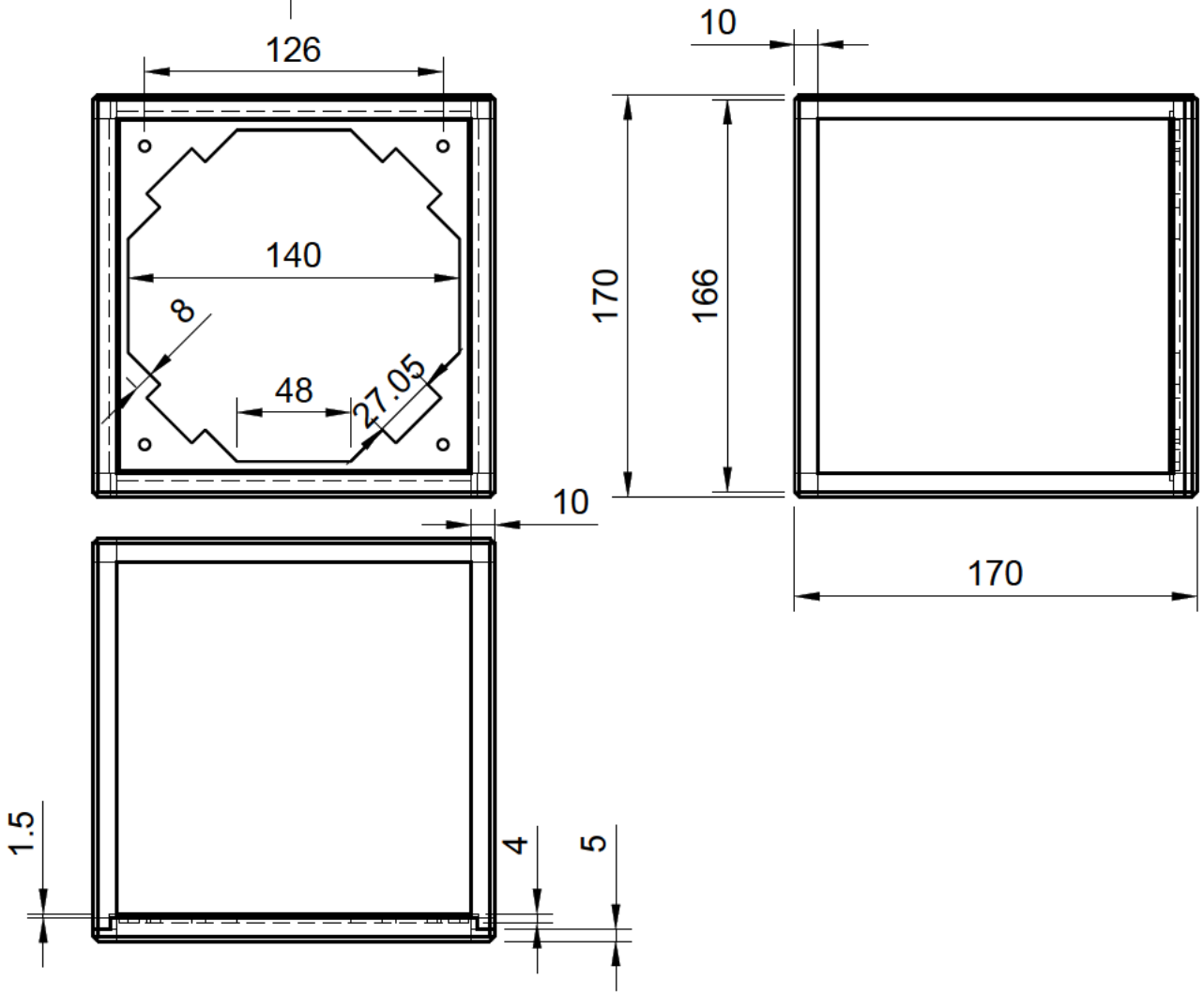
2	Frame top
3	Suspension frame





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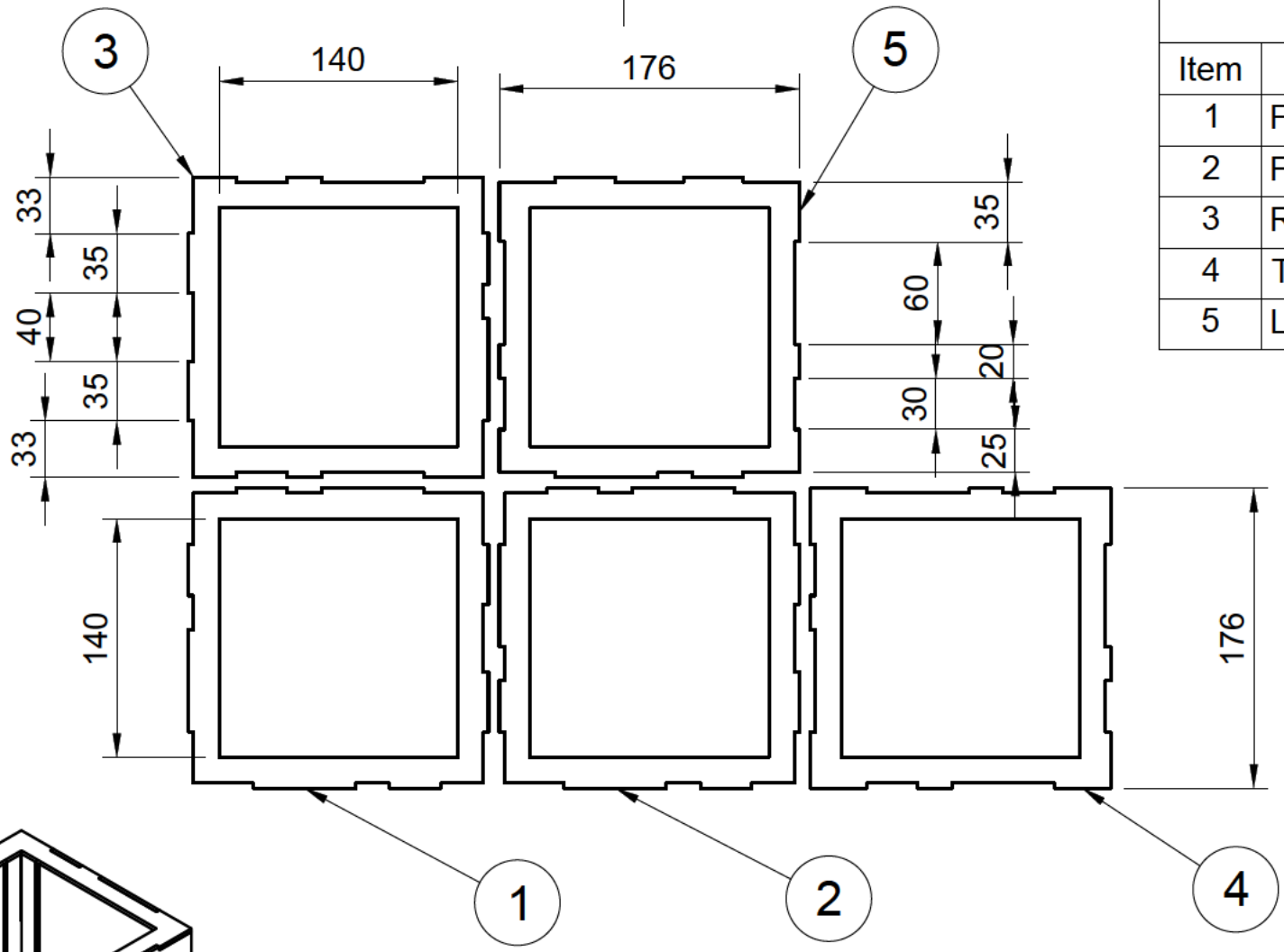

Parts List	
Item	Part Number
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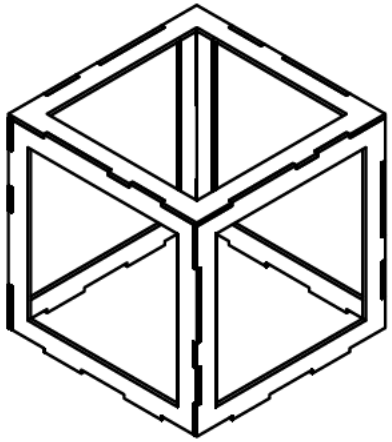
2	Front/Back
3	Right
4	Top
5	Left



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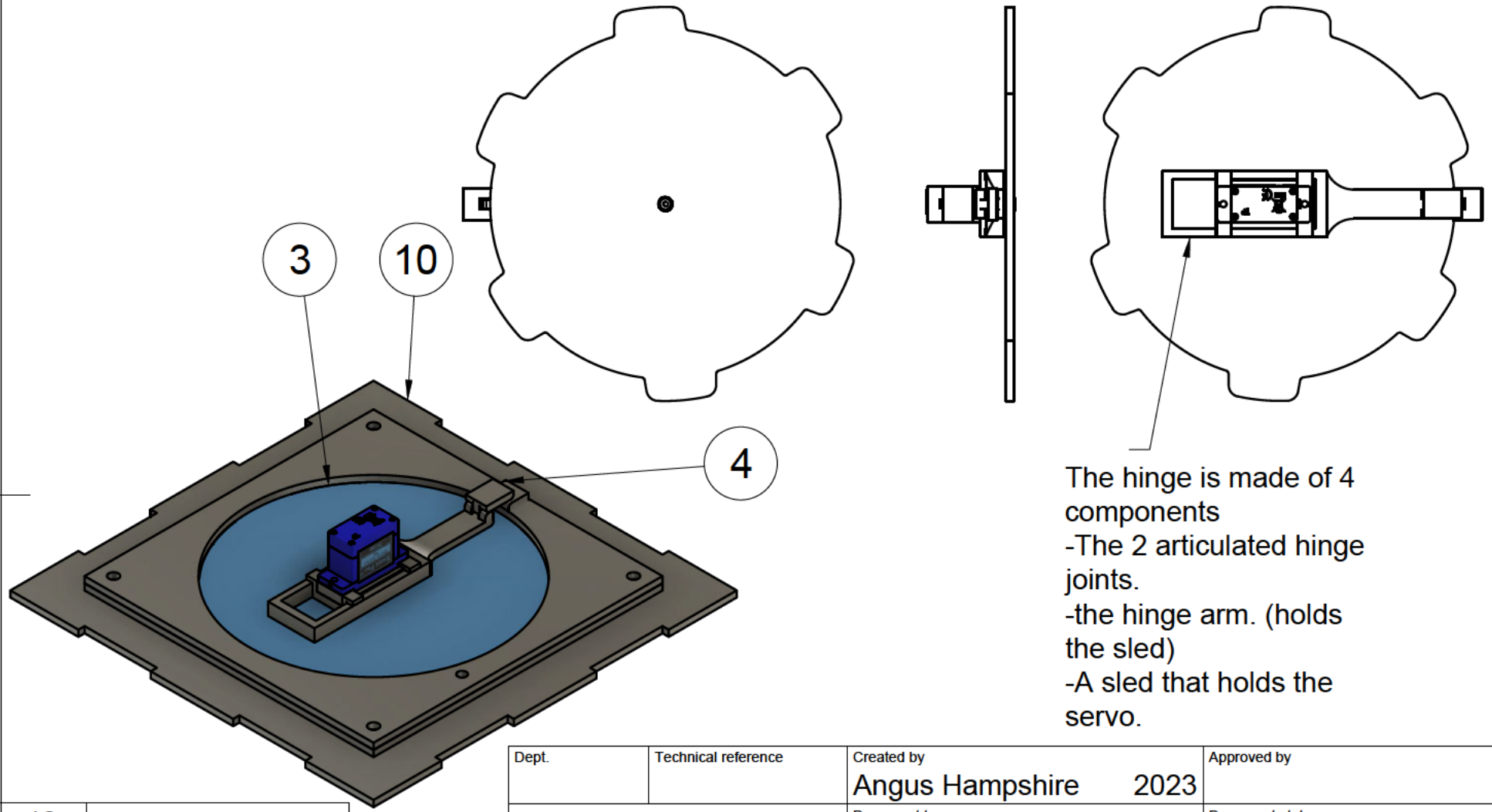

The hinge is made of 4 components
-The 2 articulated hinge joints.
-the hinge arm. (holds the sled)
-A sled that holds the servo.

Item	Part Number
10	Door face
4	Hige
3	Door

Parts List

Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
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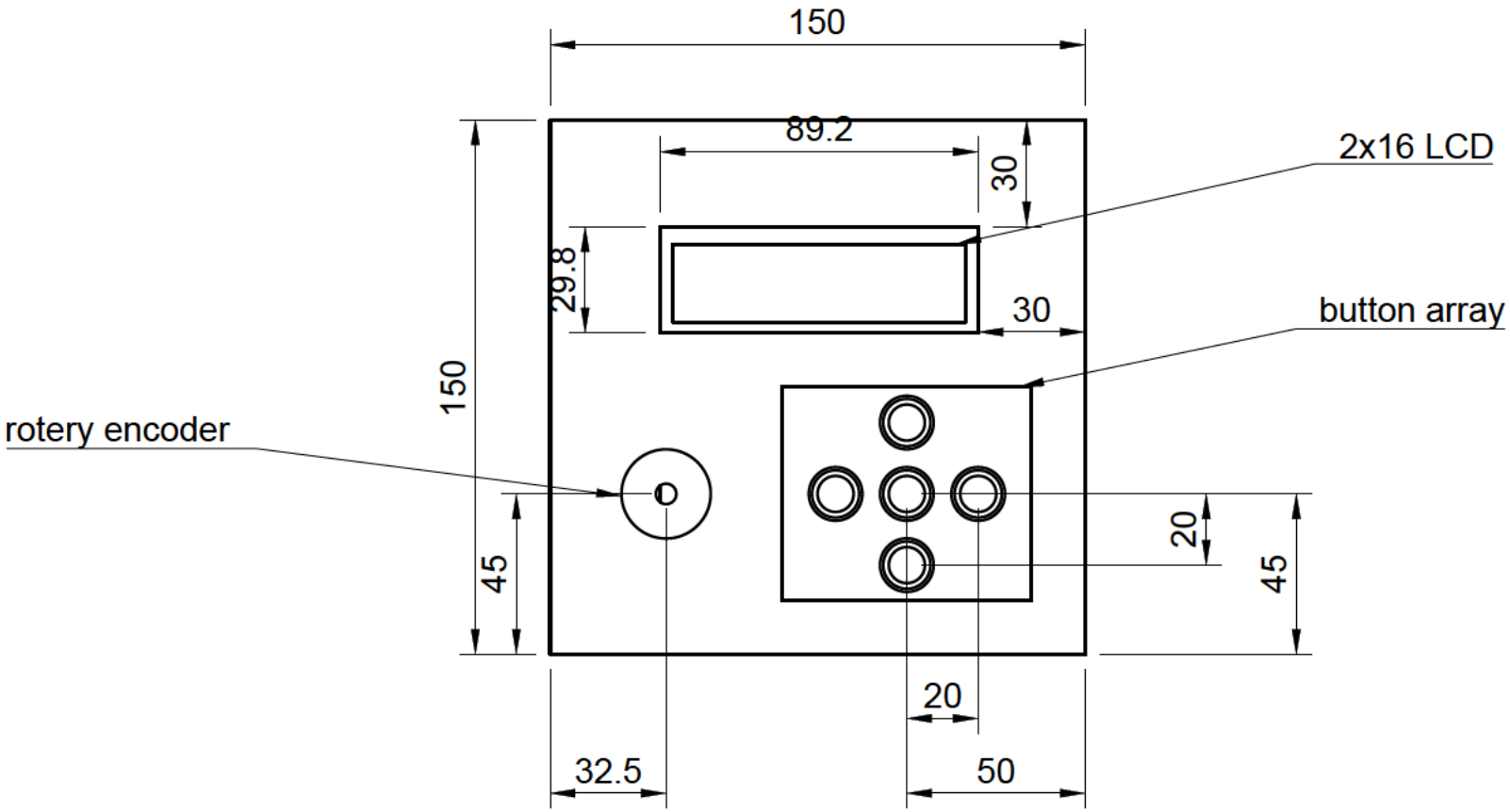

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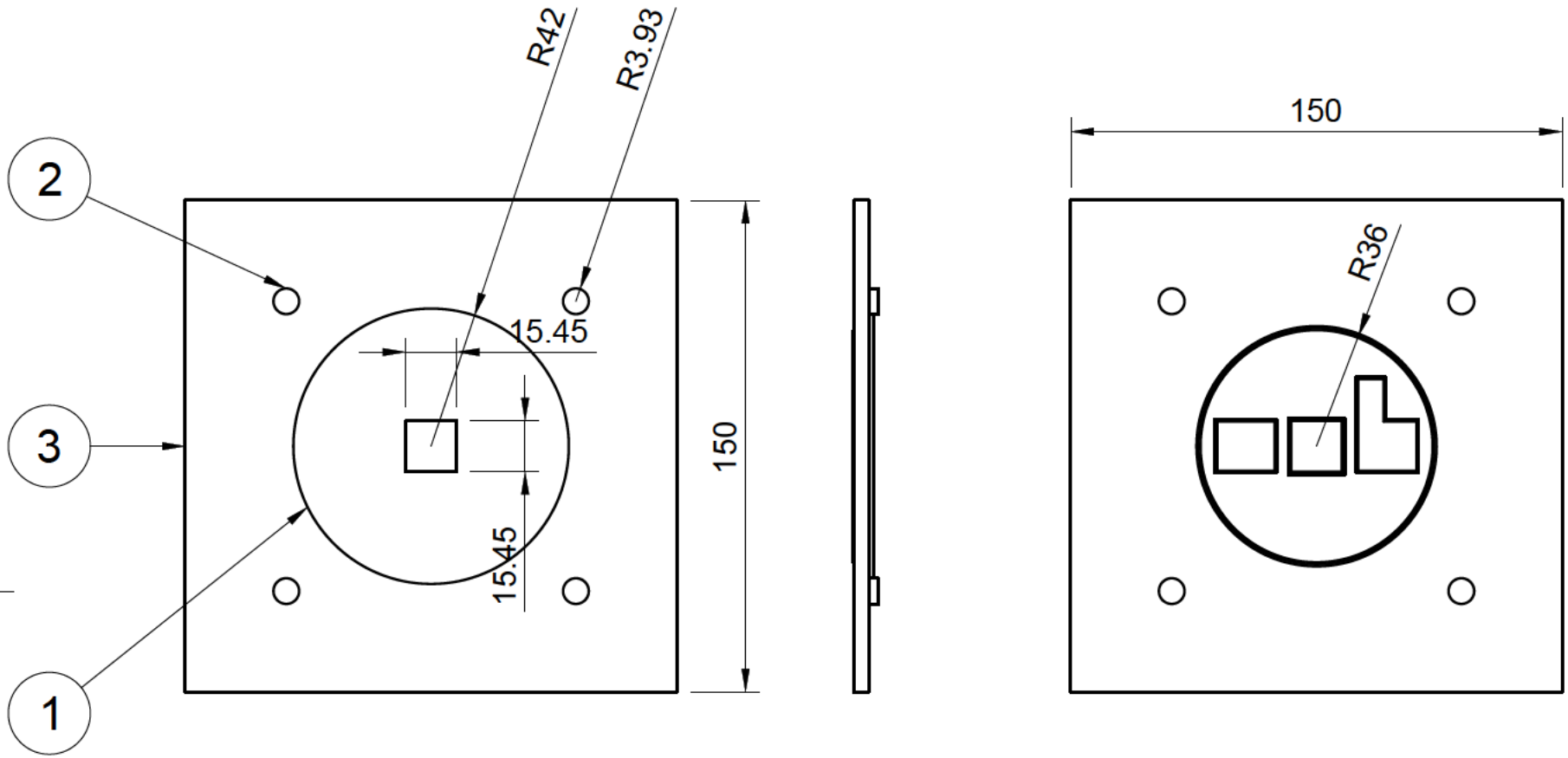

Item	Part Number
3	Panel
2	LED
1	GPS RIM

Parts List

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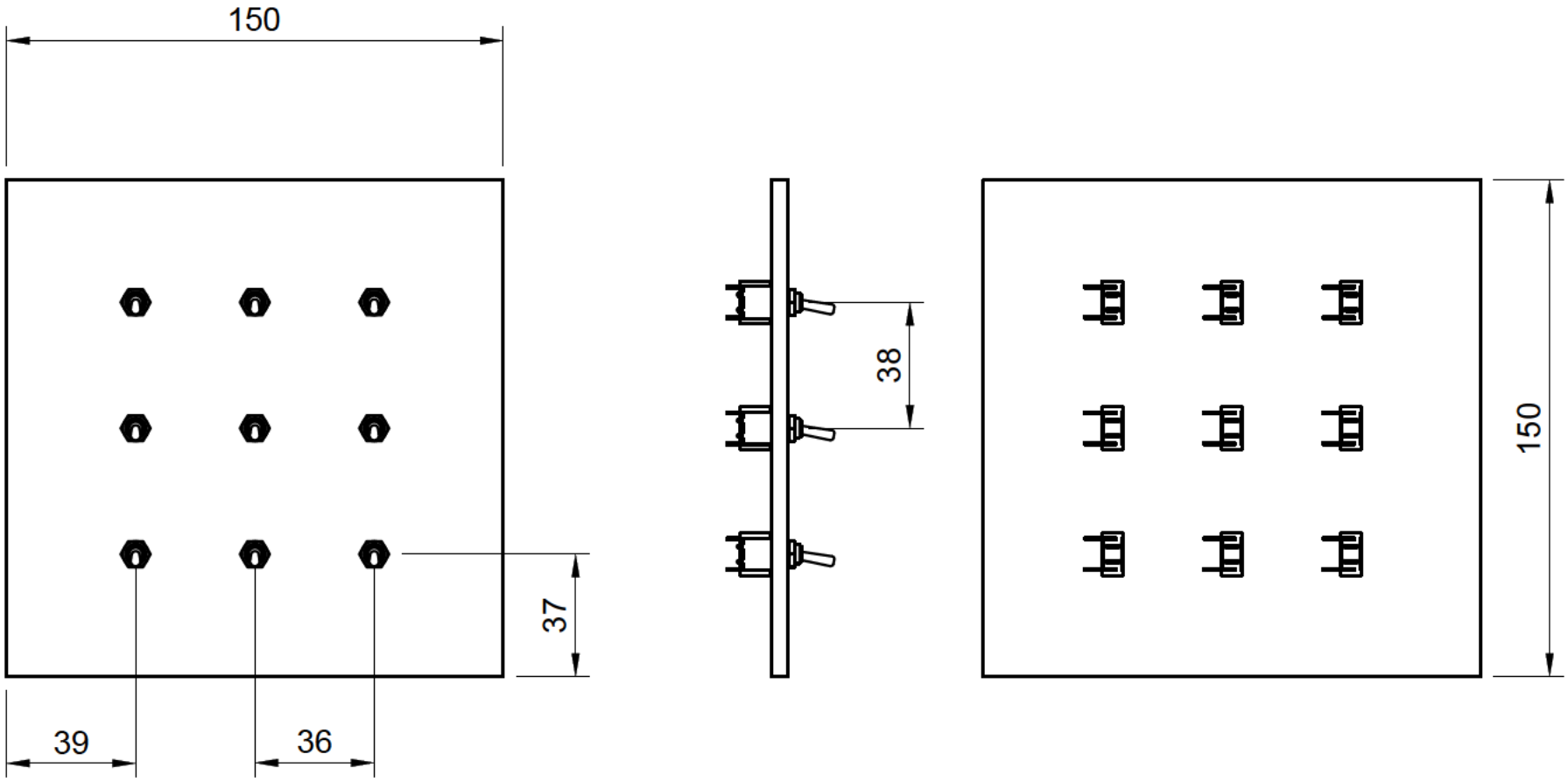

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Parts List	
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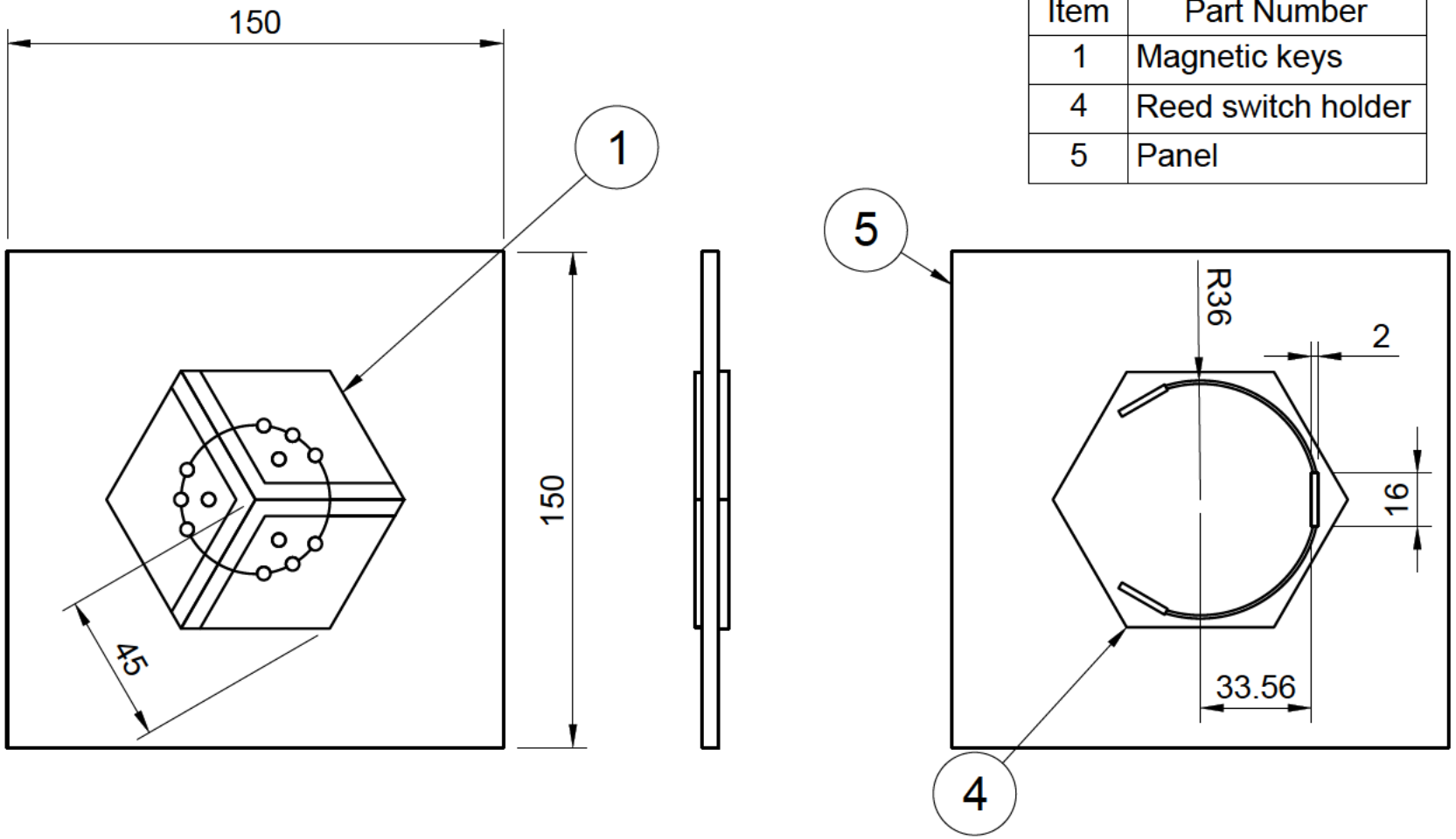
4	Reed switch holder
5	Panel



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Appendix E

Design Version Three

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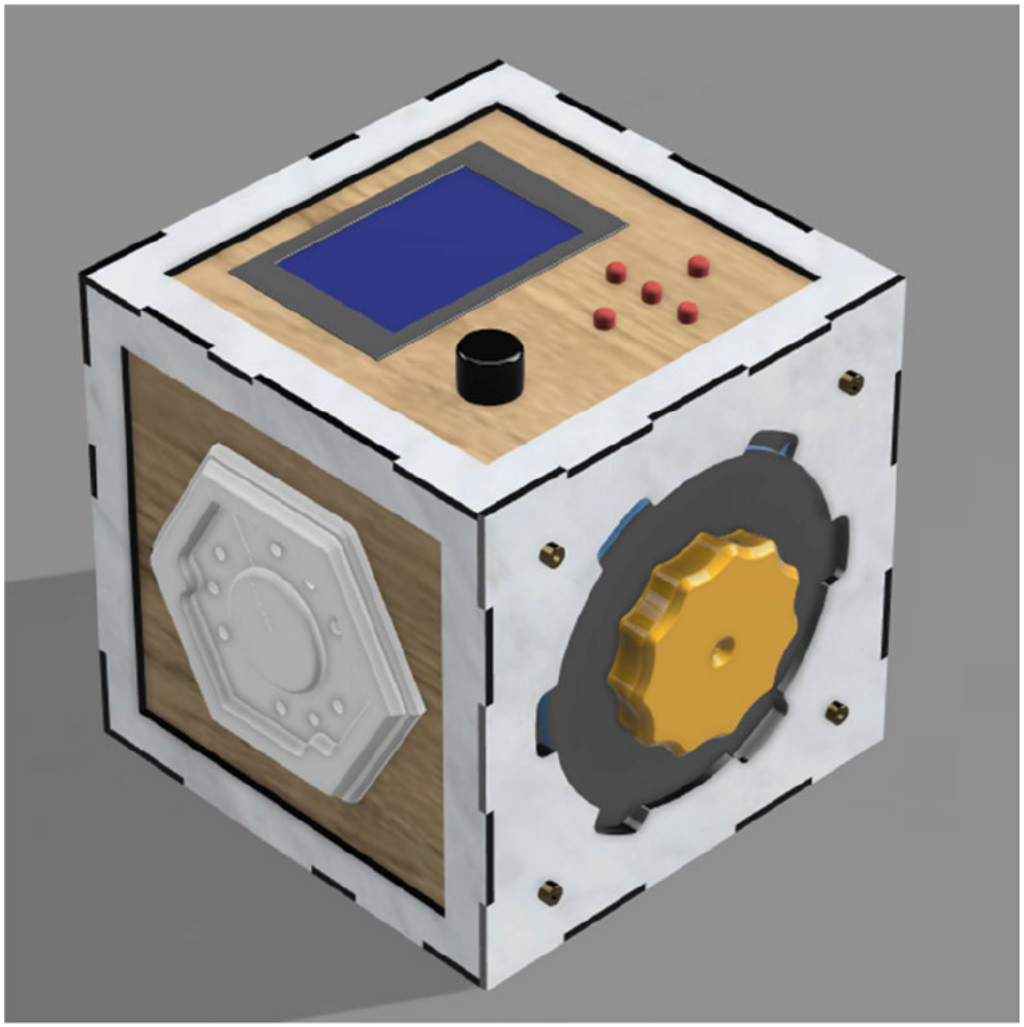
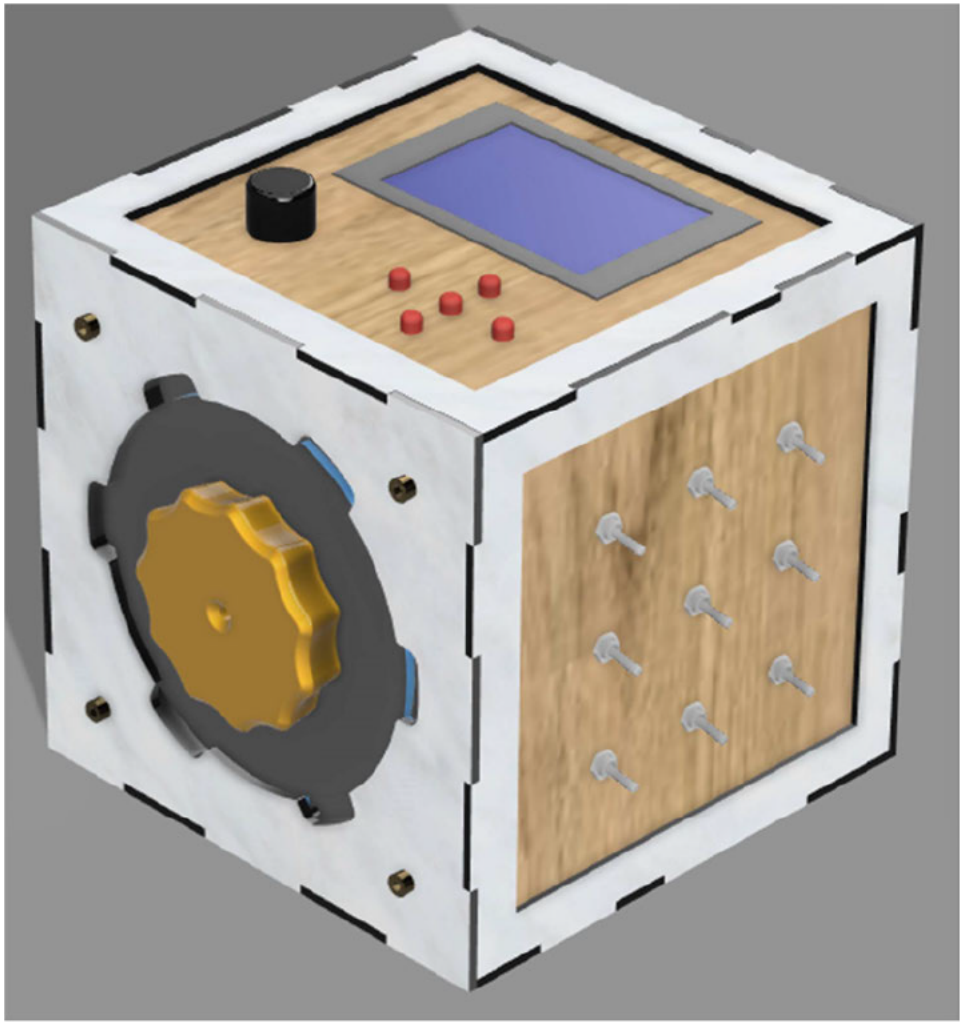
E.1 Images





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		Title Tesseract V3 Rendering	DWG No.
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Figure E.1: The Tesseract

Figure E.2: The Tesseract

Figure E.3: The Tesseract

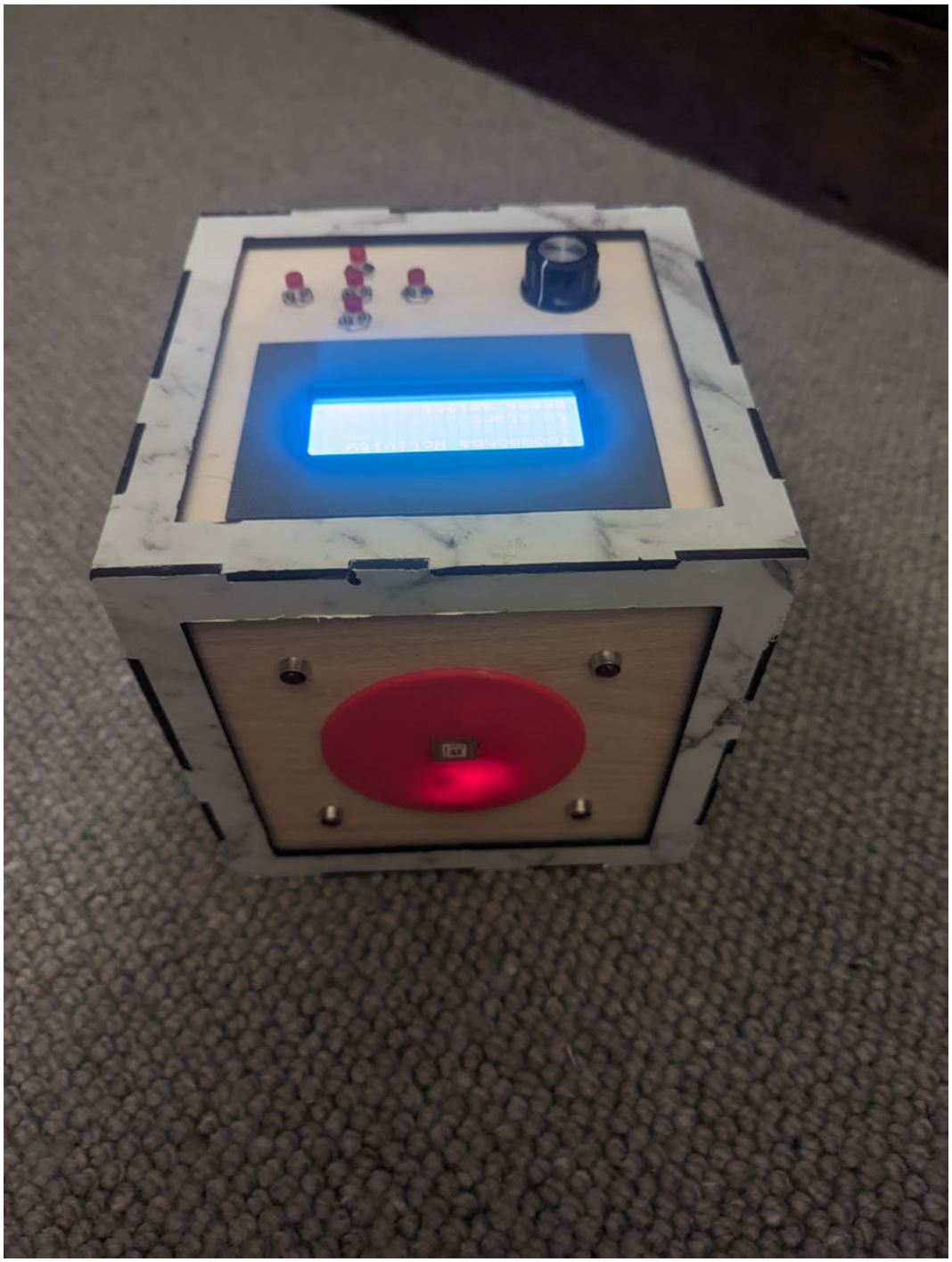
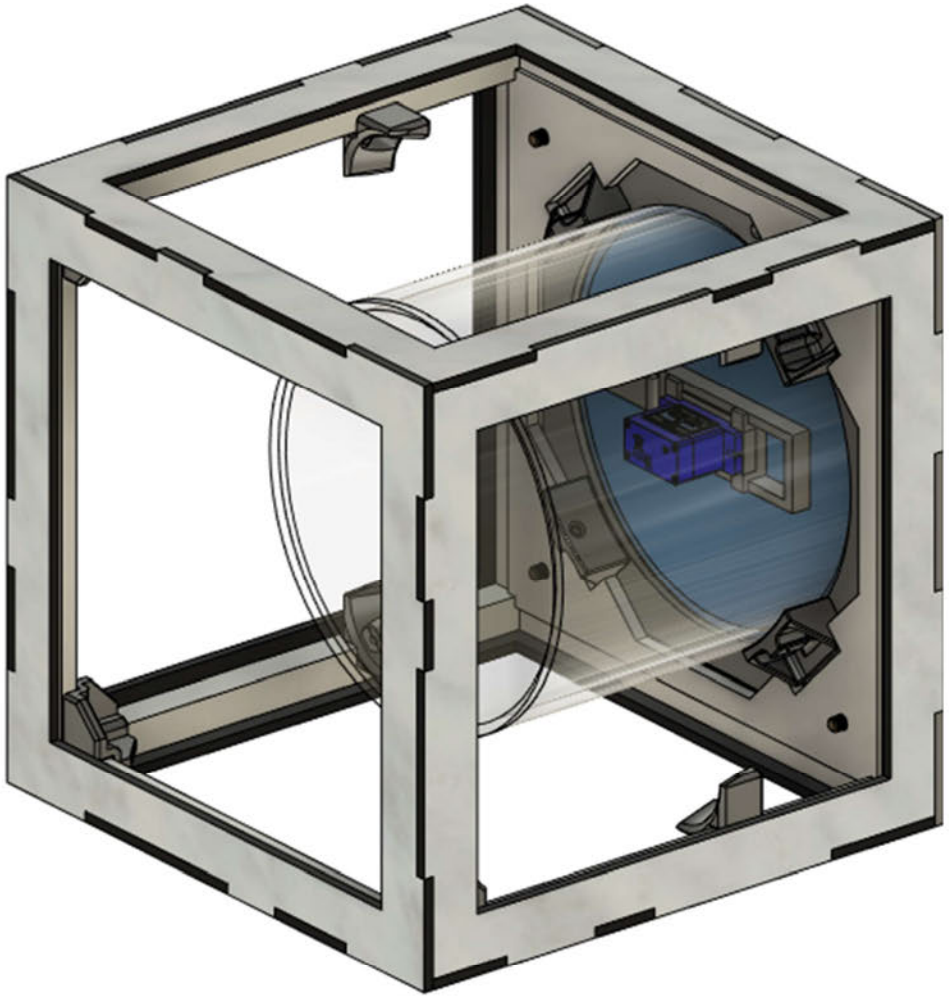


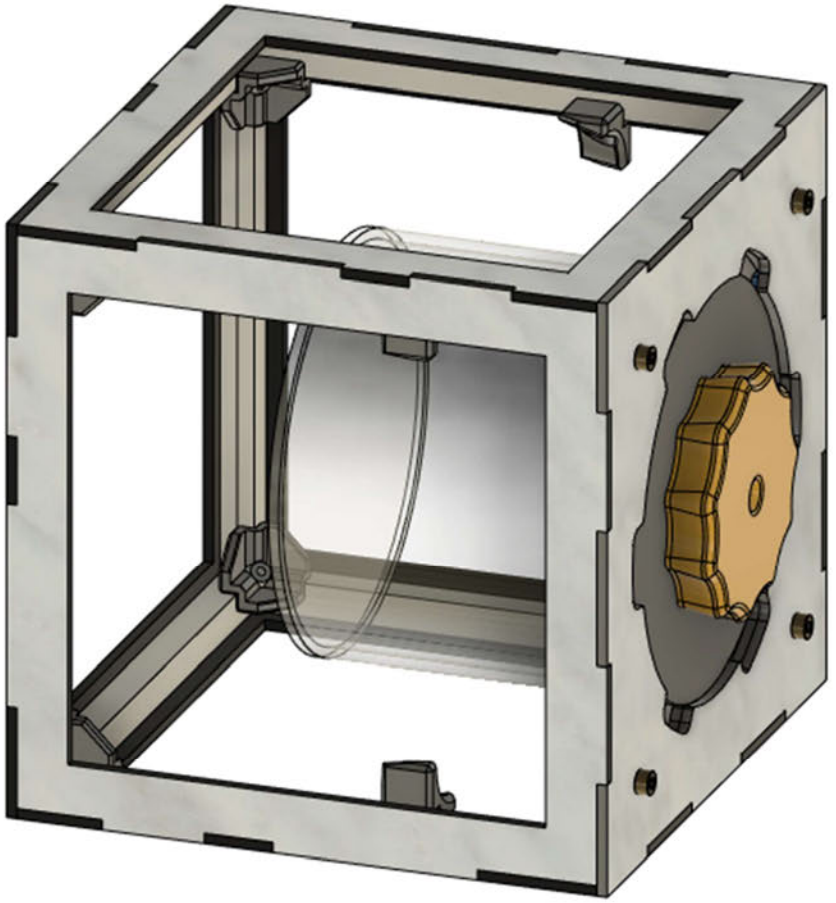
Figure E.5: The Tesseract

Figure E.6: The Tesseract

E.2 Structure

Structure Version 2





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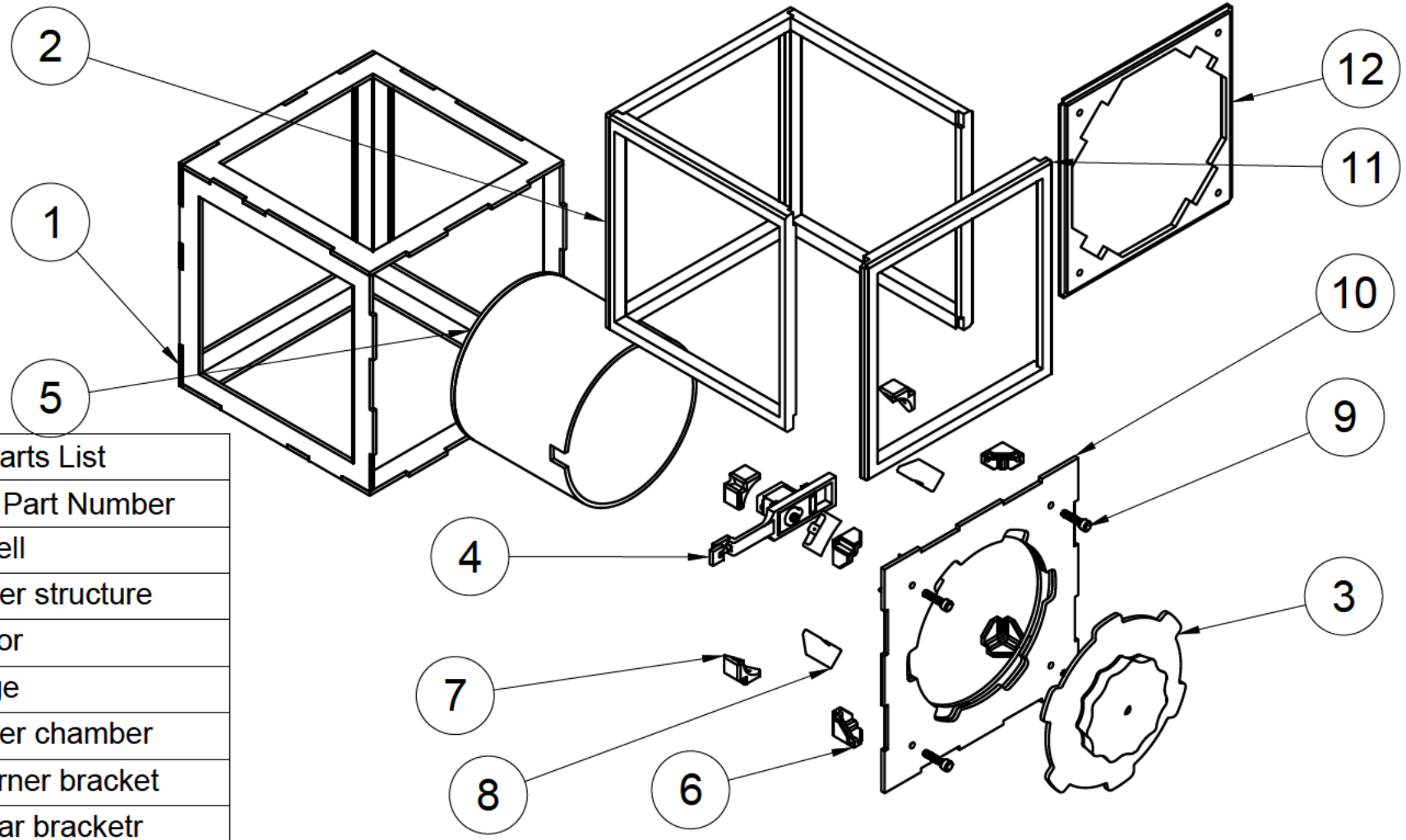

Parts List	
Item	Part Number
1	Shell
2	Inner structure
3	Door
4	Hige
5	Inner chamber
6	Corner bracket
7	Pillar bracketr
8	Inner chamber mount
9	M4 door screw
10	Door Face
11	Door inner frame
12	Suspension frame

Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
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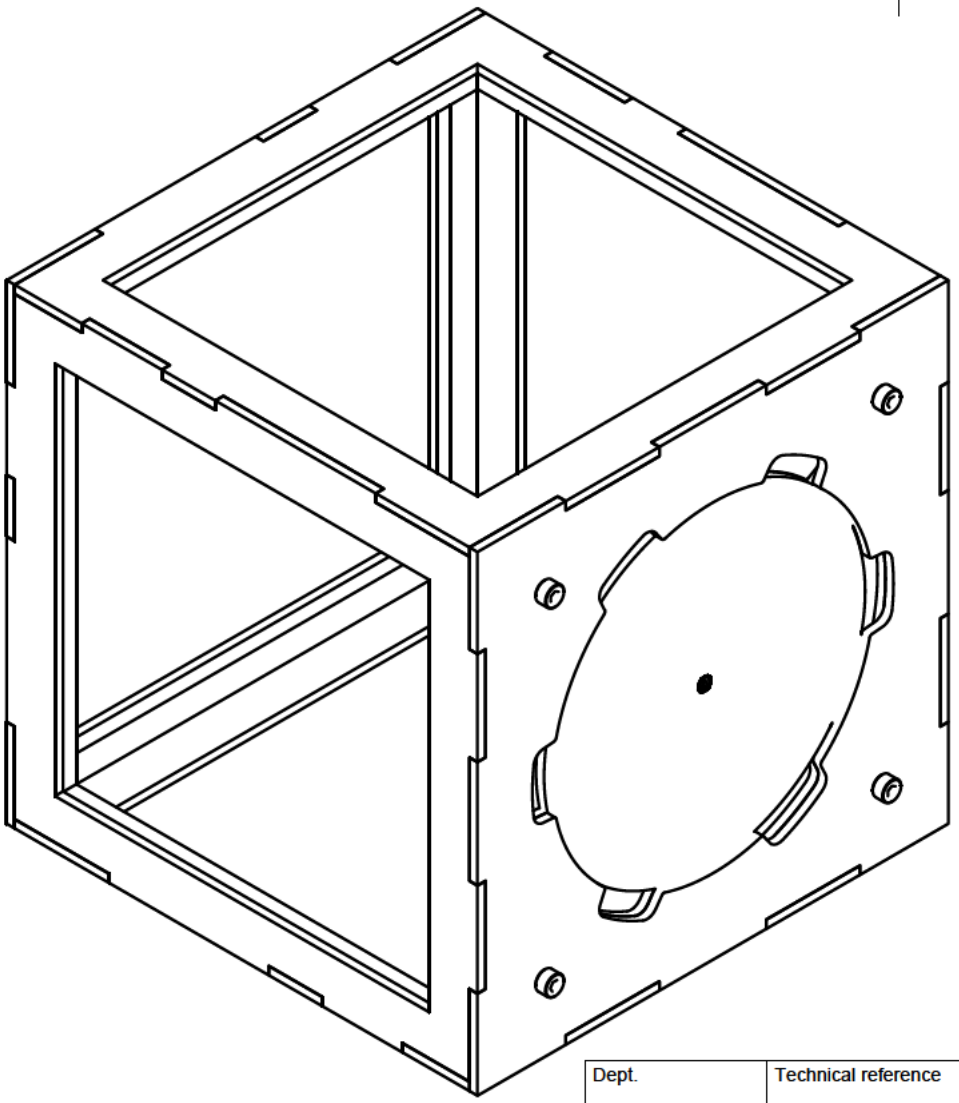

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		Document type	Document status
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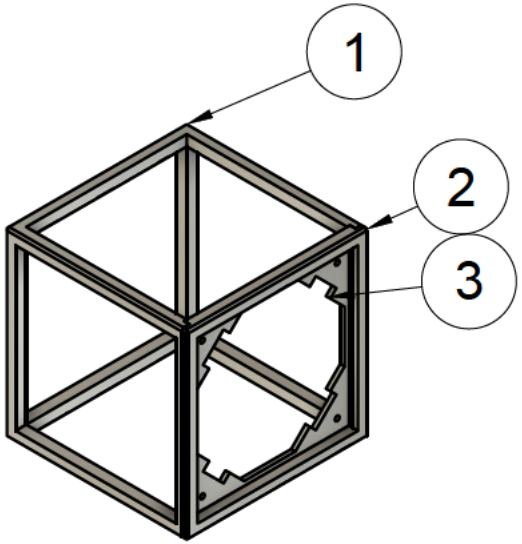
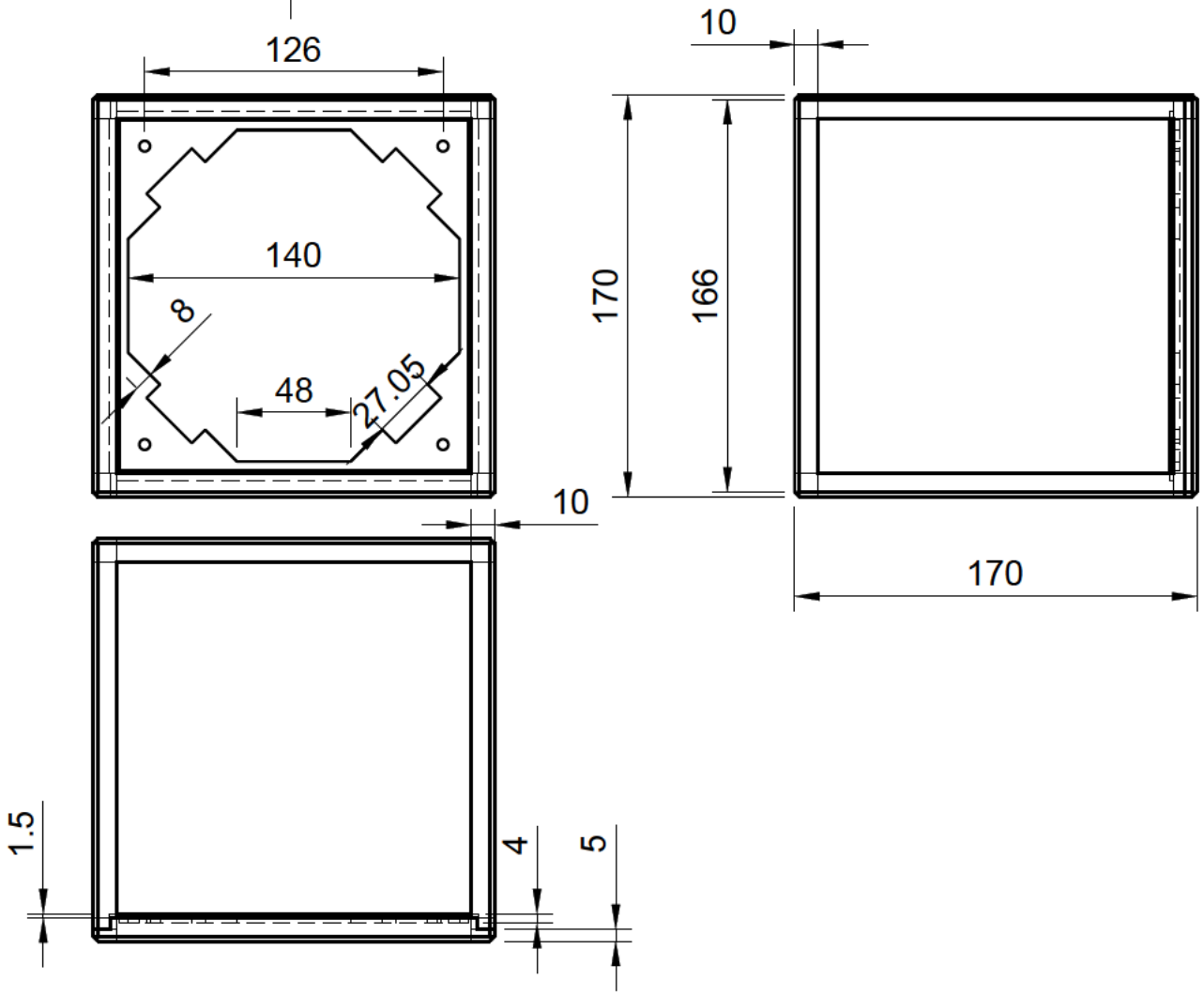
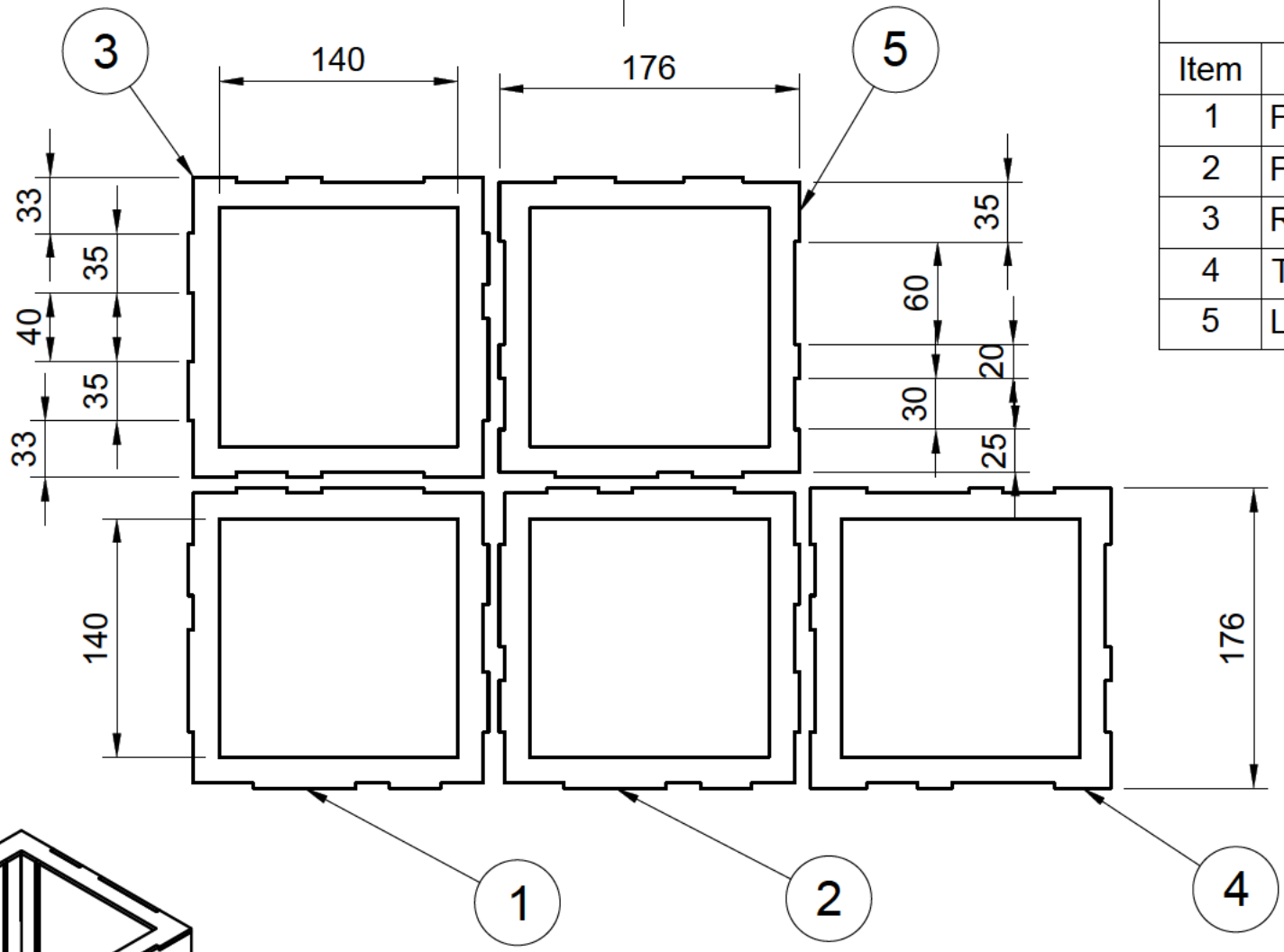
			Rev. / Date of issue / Sheet 1/1

Parts List	
Item	Part Number
1	Frame
2	Frame top
3	Suspension frame

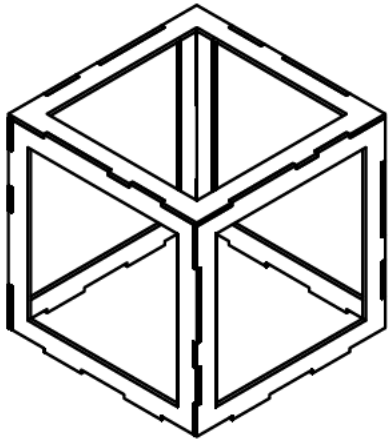




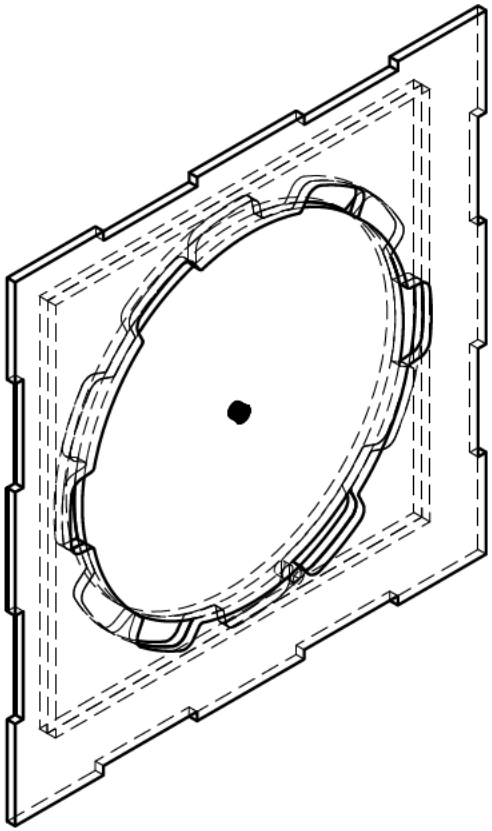
Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title: inner structure v2	DWG No.
			Rev. / Date of issue / Sheet 1/1

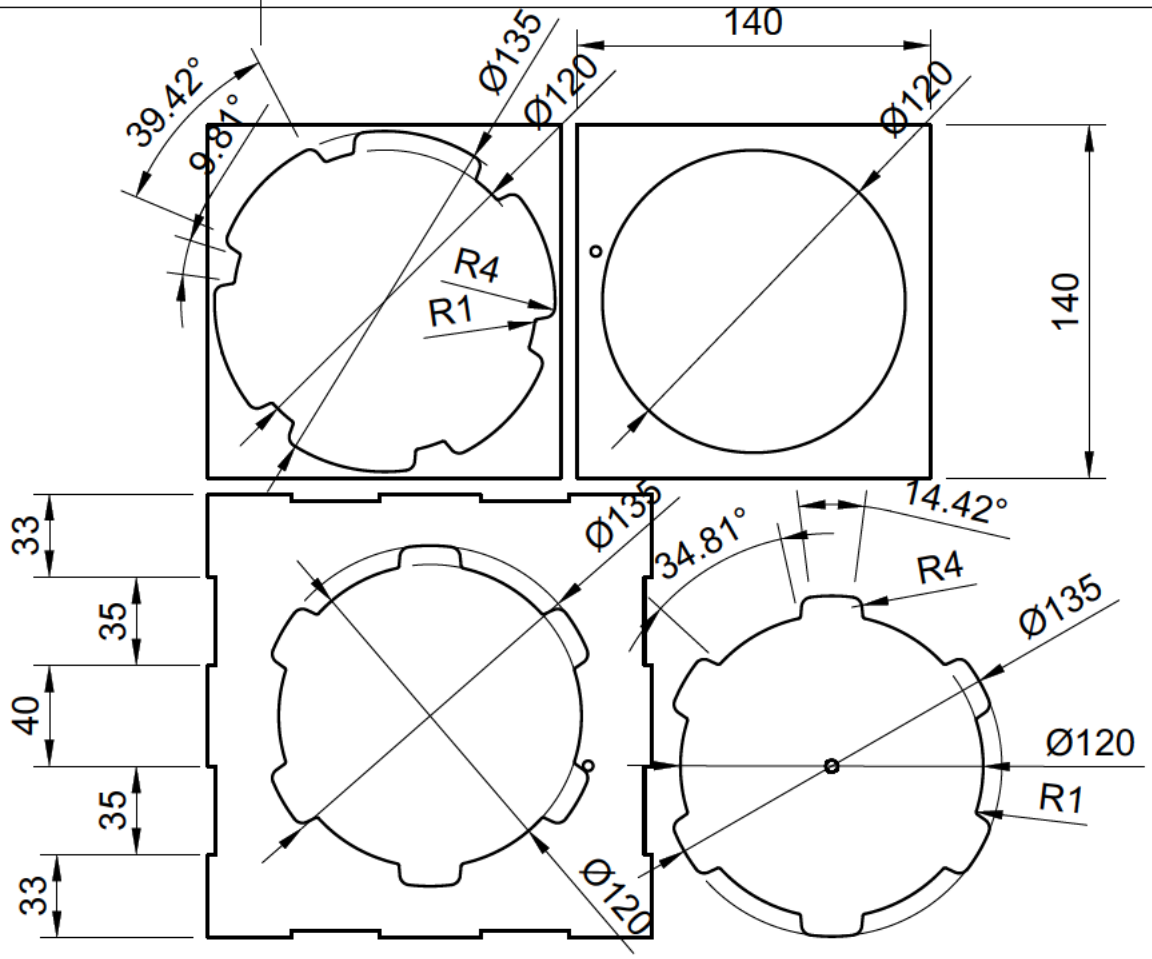


Parts List	
Item	Part Number
1	Front/Back (1)
2	Front/Back
3	Right
4	Top
5	Left

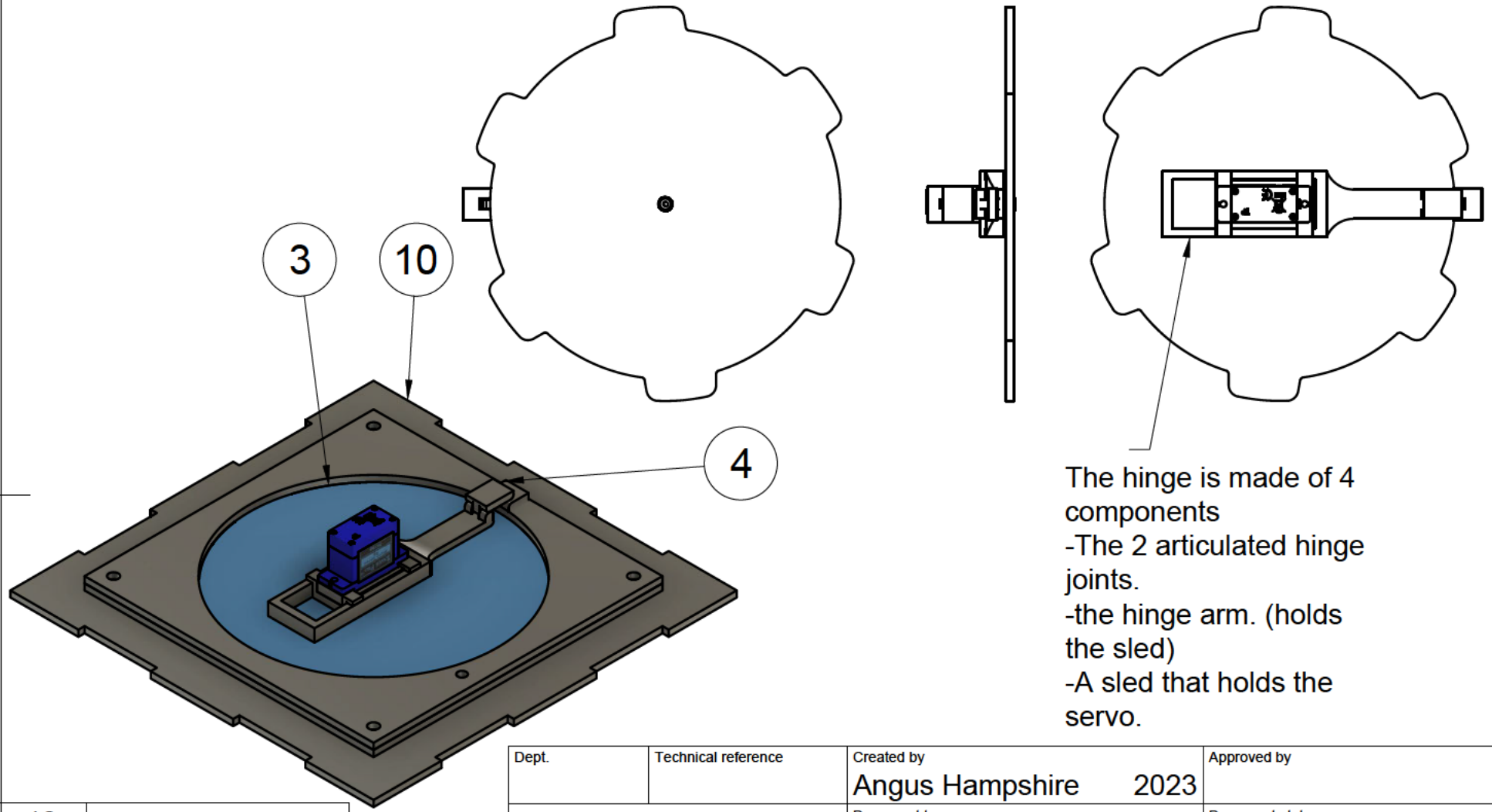


Dept.	Technical reference	Created by Angus Hampshire 21/10/2023	Approved by
		Document type	Document status
		Title SHELL LAYOUT: COMPONENT OF THE TESSERACT	DWG No. 1
			Rev. / Date of issue / Sheet 1/1





Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title DOOR FACE COMPONENT OF THE TESERACT	DWG No.
			Rev. / Date of issue / Sheet 1/1

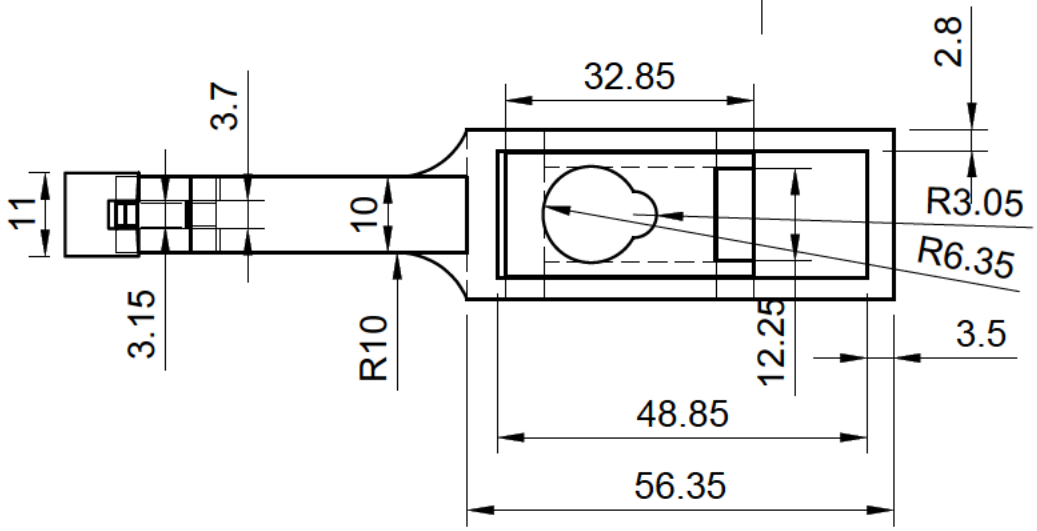


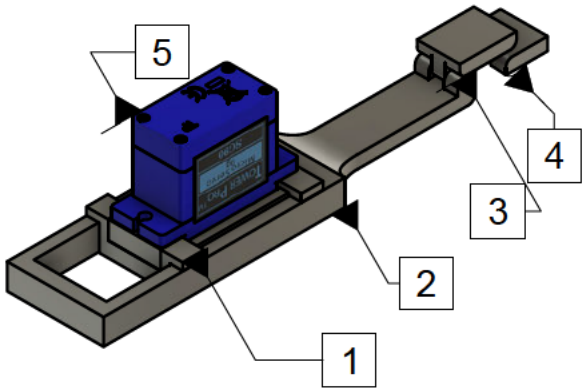
The hinge is made of 4 components
-The 2 articulated hinge joints.
-the hinge arm. (holds the sled)
-A sled that holds the servo.

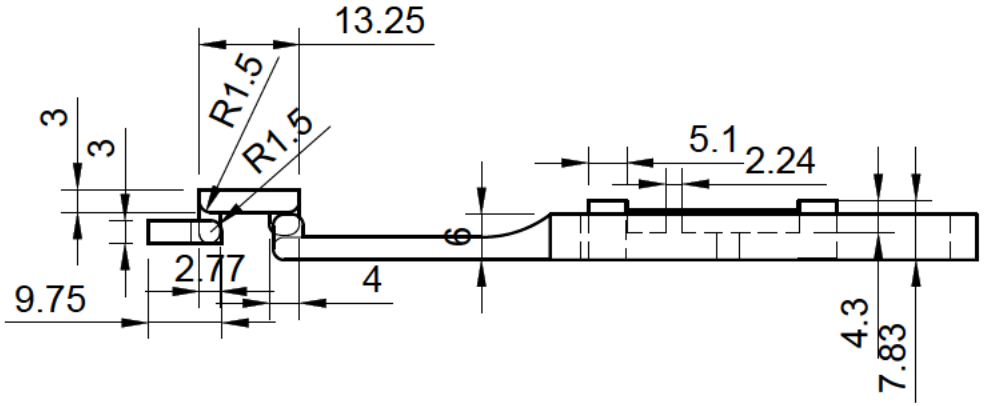
Item	Part Number
10	Door face
4	Hige
3	Door

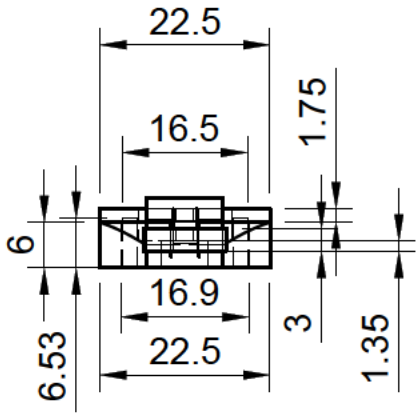
Parts List

Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title: v2 door overview	DWG No.
			Rev. / Date of issue / Sheet 1/1



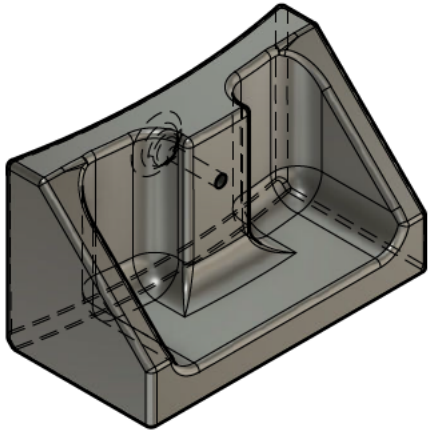


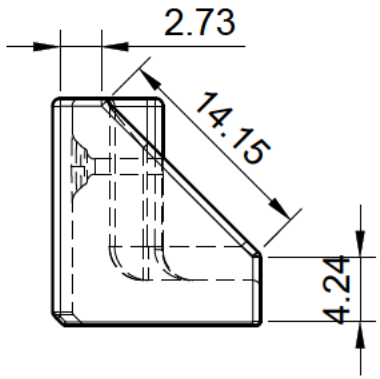


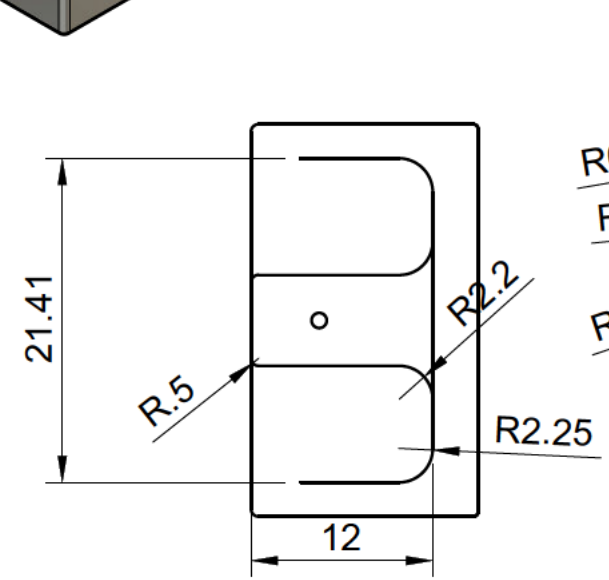


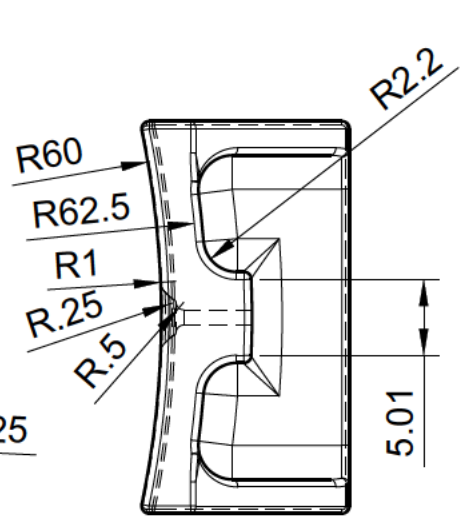
5	5v servo motor
4	Hinge Base
3	Hinge#3
2	Hinge/Rail
1	Servo Sled
PARTS LIST	

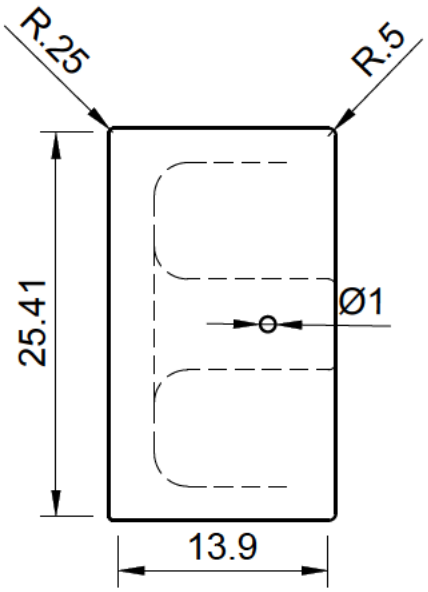
Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title Door Hinge + Servo Sled	DWG No.
			Rev. / Date of issue / Sheet 1/1



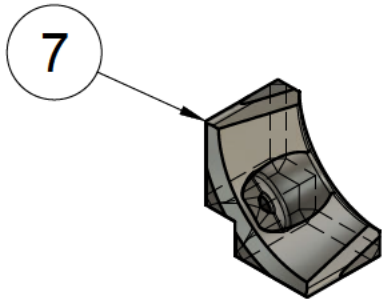


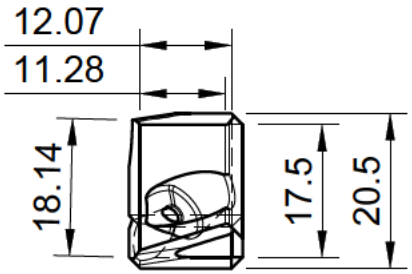


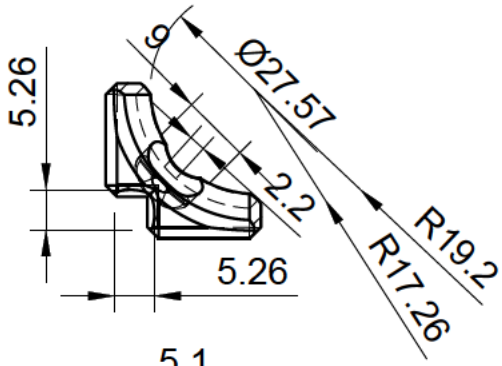


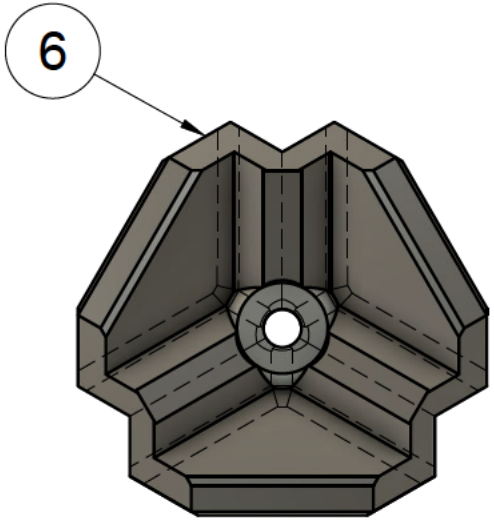


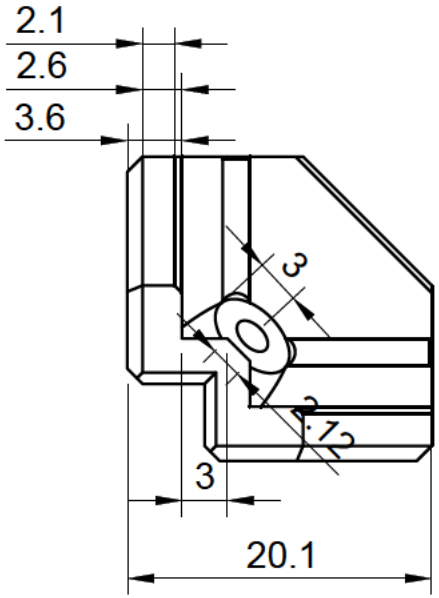
Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title Inner chamber mount x3	DWG No.
			Rev. / Date of issue / Sheet 1/1

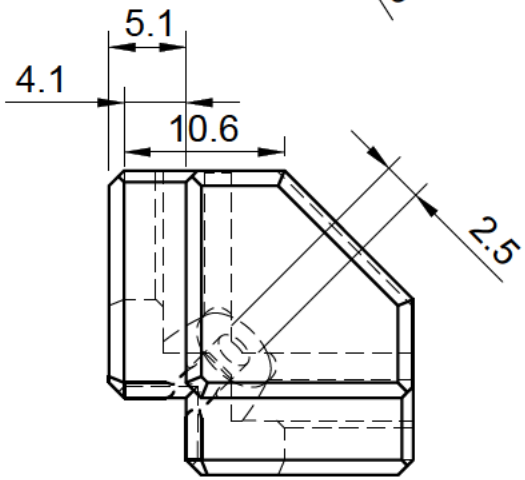












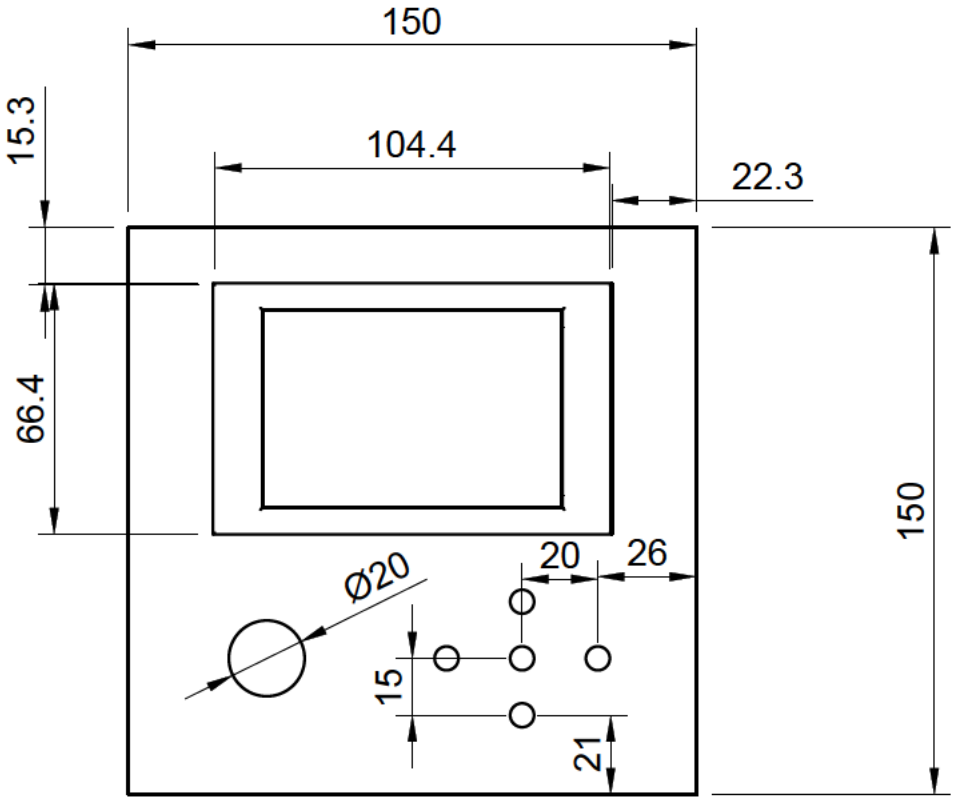
6	Corner Bracket	4
7	Pillar Bracket	4
NUM	NAME	QTY
PARTS LIST		

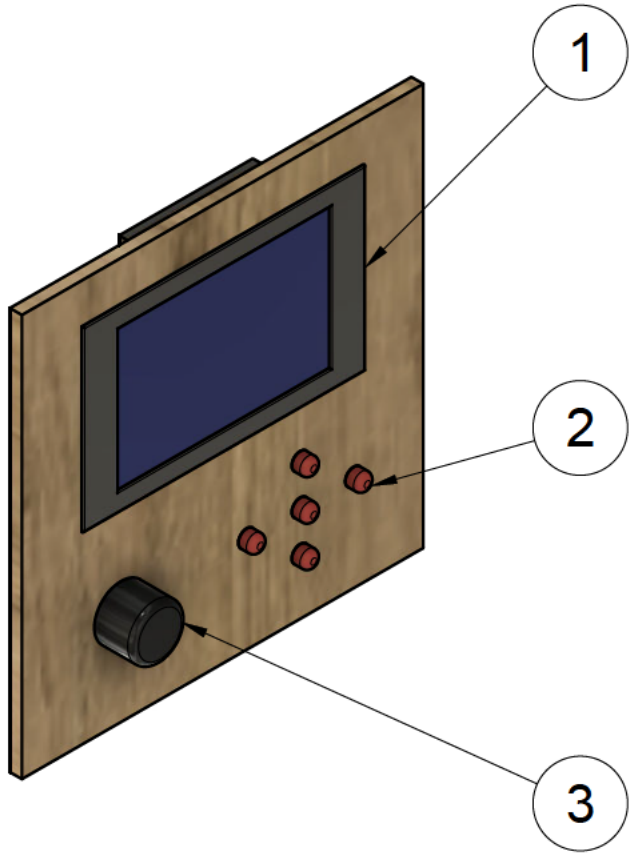
Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title Pannel Mounting Brackets	DWG No.
			Rev. / Date of issue / Sheet 1/1

E.3 Faces

Multi Role IO

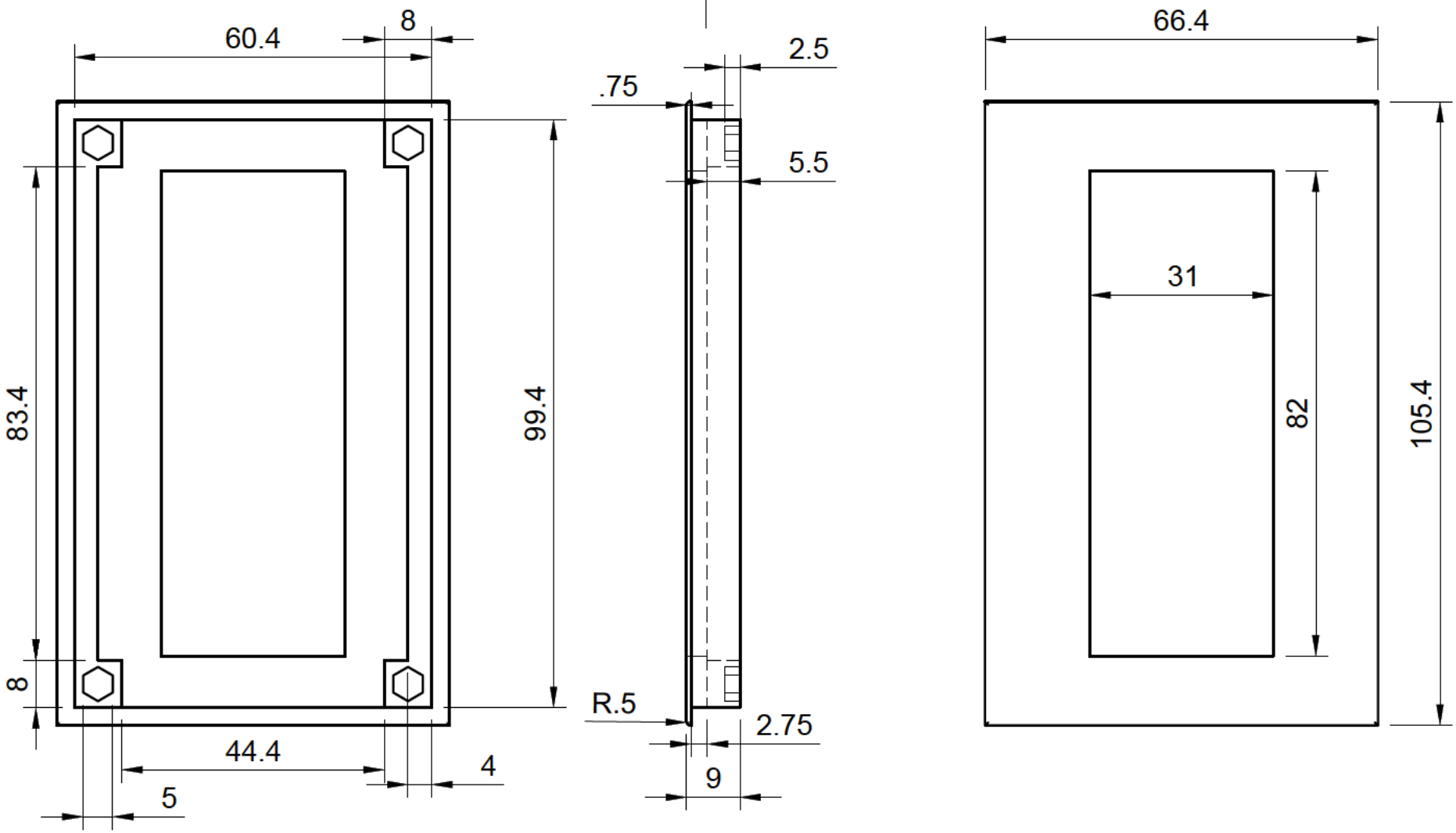
Multi Role IO, Version 3



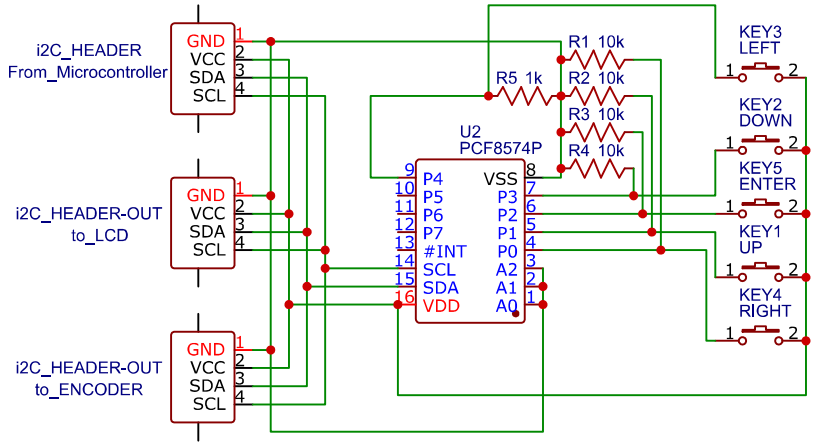


Parts List	
Item	Part Number
1	4x20 LCD
2	Buttons
3	Rotery encoder

Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title Multi Role IO v3	DWG No.
			Rev. / Date of issue / Sheet 1/1



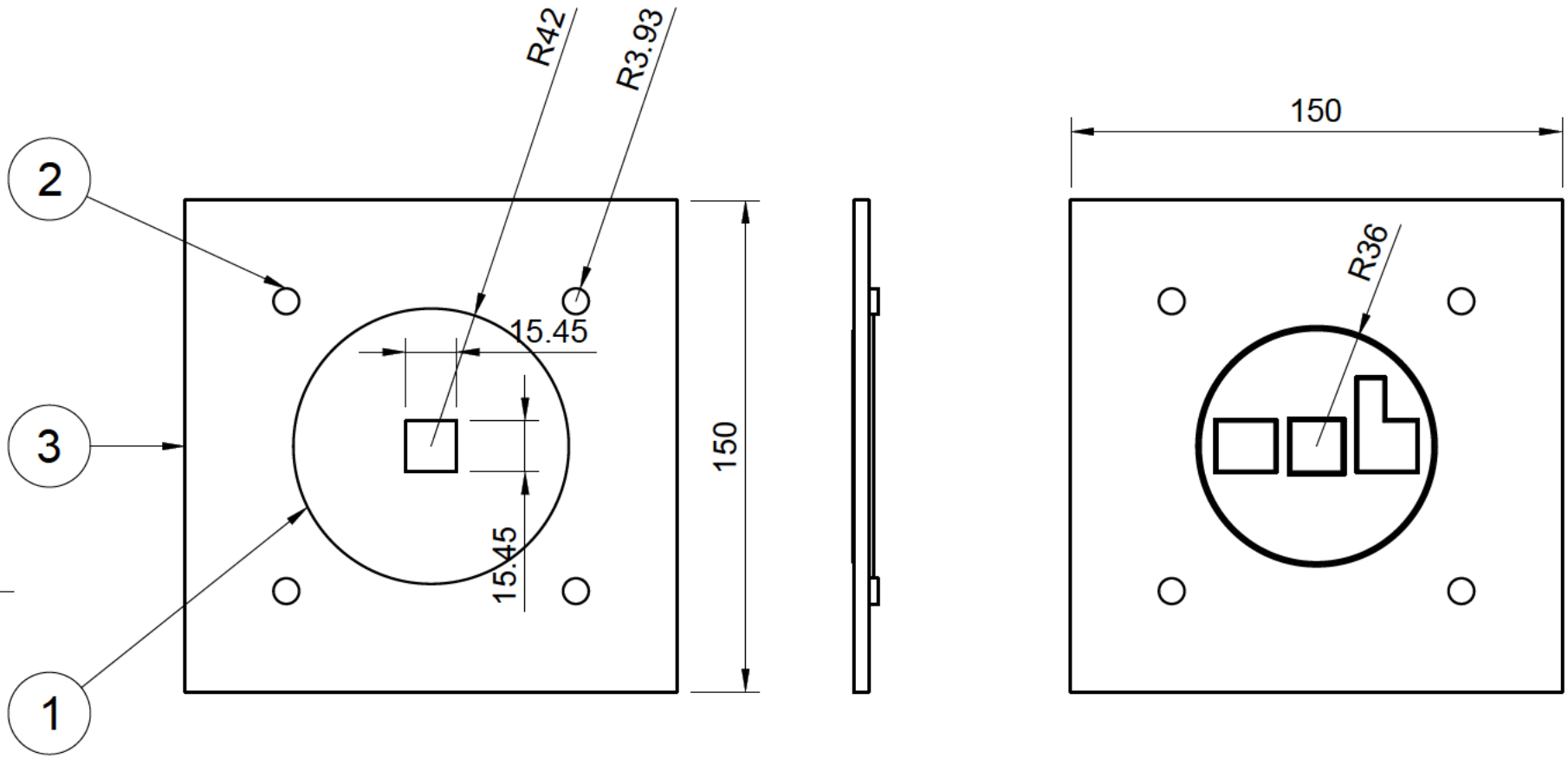
Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title Multi Role IO 4x20 LCD Mount	DWG No.
			Rev. / Date of issue / Sheet 1/1



TITLE: MULTI PURPOSE IO V3		REV: 1.0
EasyEDA	Company: THE TESSERACT	Sheet: 1/1
	Date: 2023	Drawn By: ANGUS HAMPSHIRE

GPS

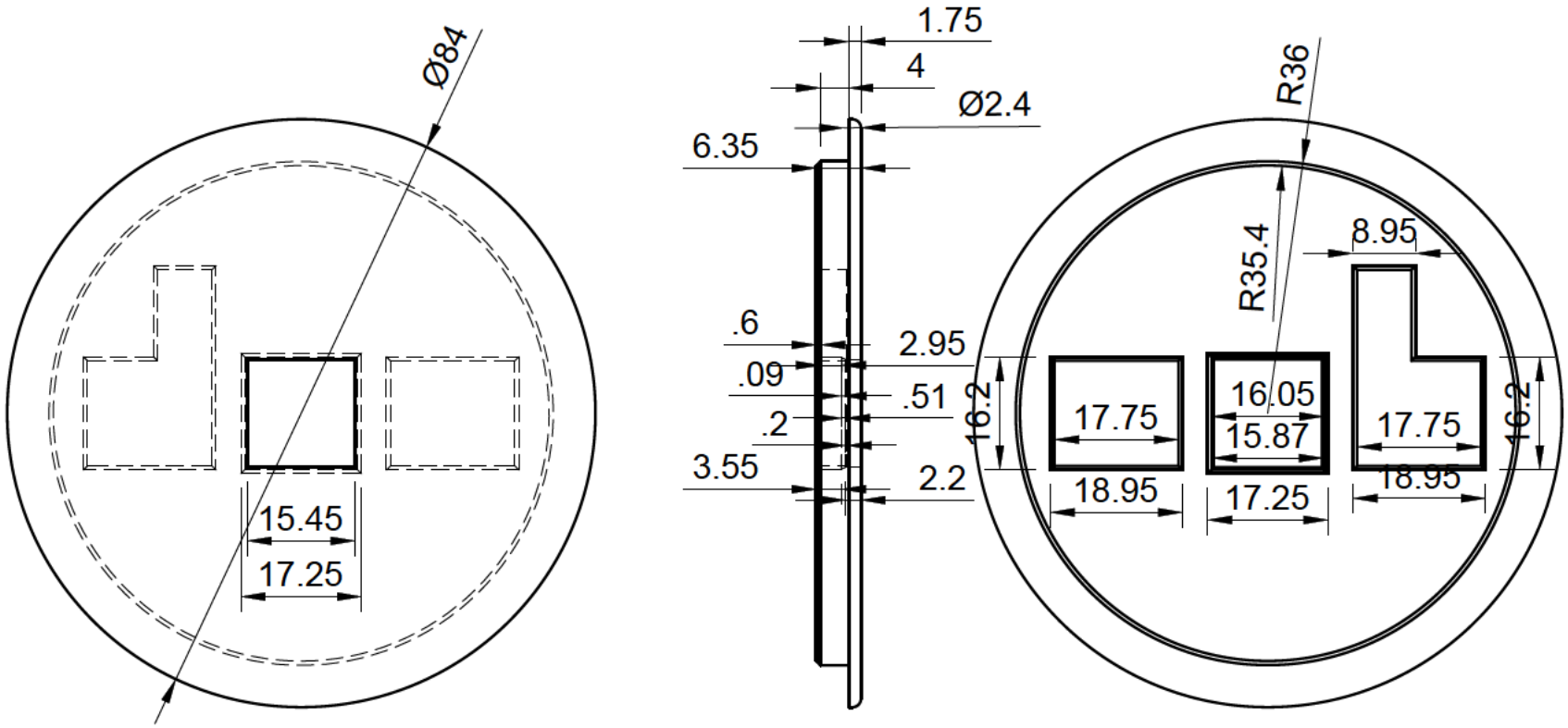
GPS, Version 3



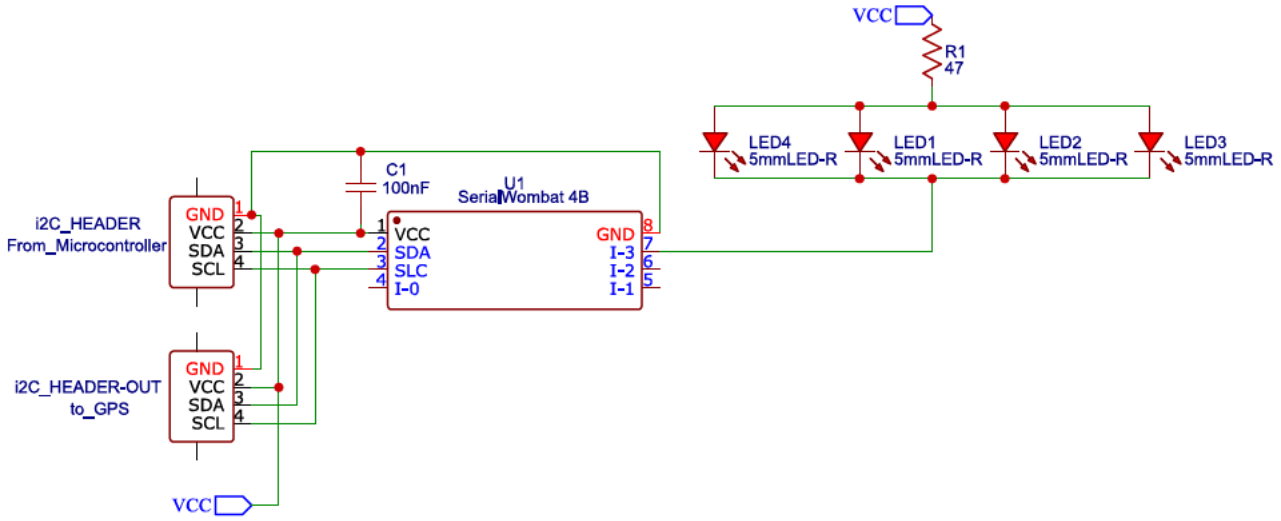
Item	Part Number
3	Panel
2	LED
1	GPS RIM

Parts List

Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title: Gps panel V2l	DWG No.
			Rev. / Date of issue / Sheet 1/1



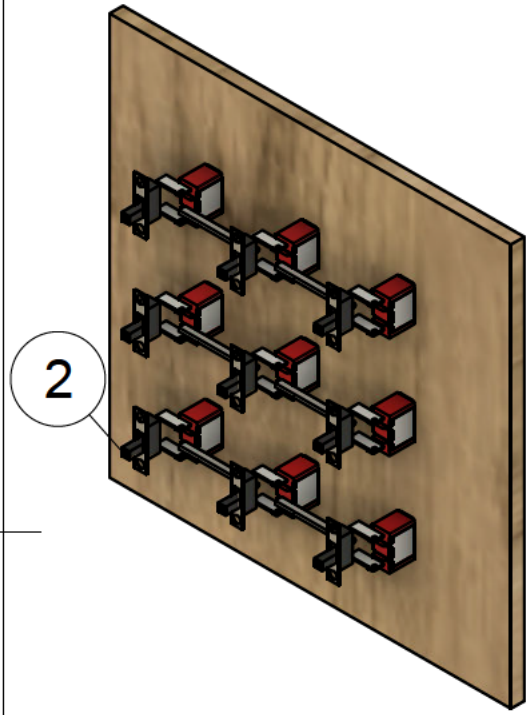
Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title GPS mount	DWG No.
			Rev. / Date of issue / Sheet 1/1

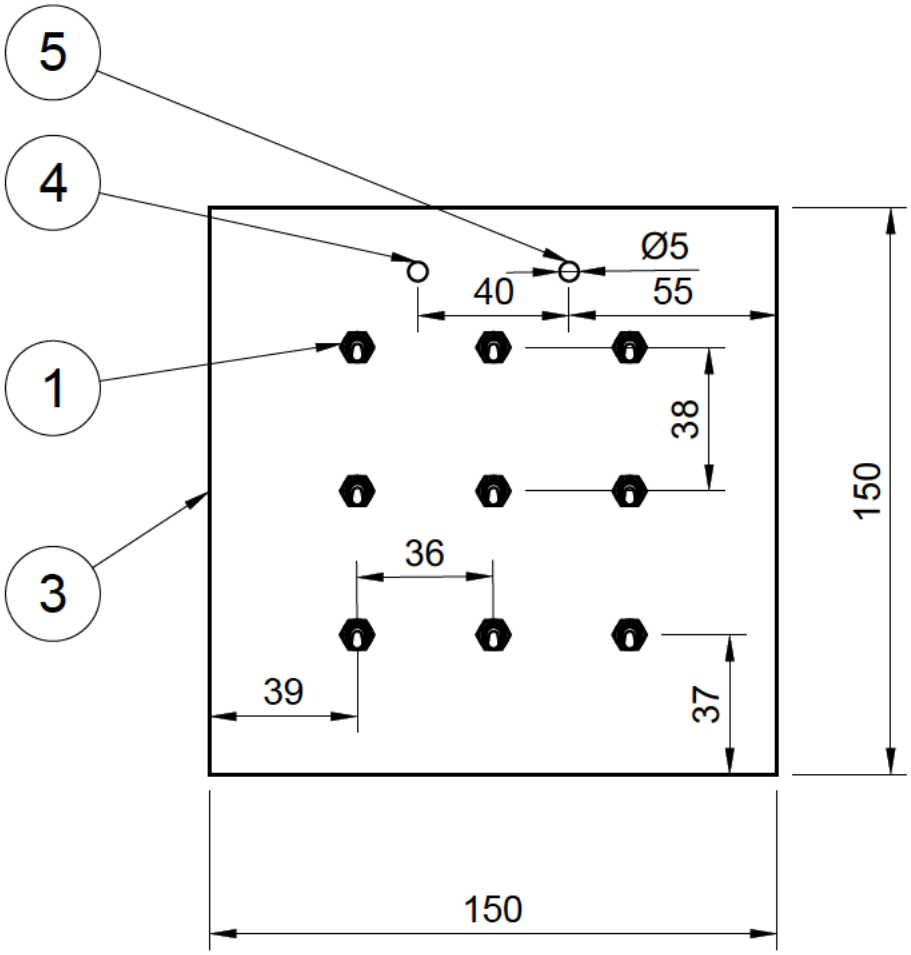


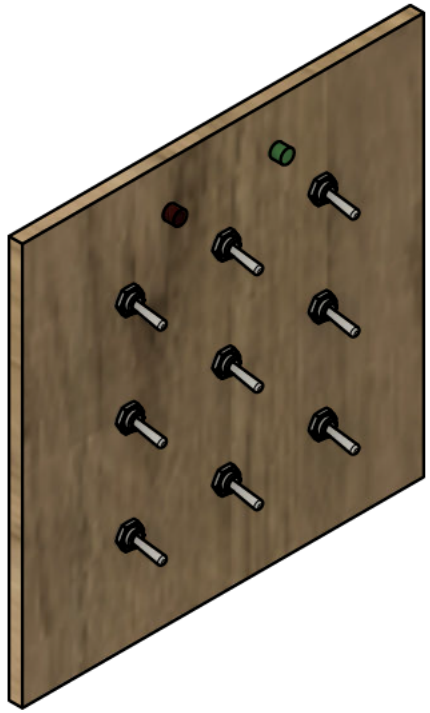
TITLE: GPS PANEL 3		REV: 1.0
EasyEDA	Company: THE TESSERACT	Sheet: 1/1
	Date: 2023	Drawn By: ANGUS HAMPSHIRE

Switch Array

Switch Array, Version 2

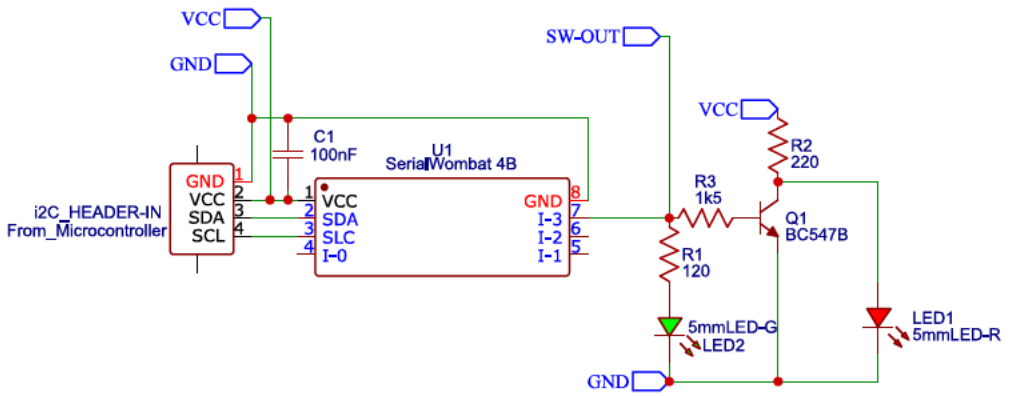


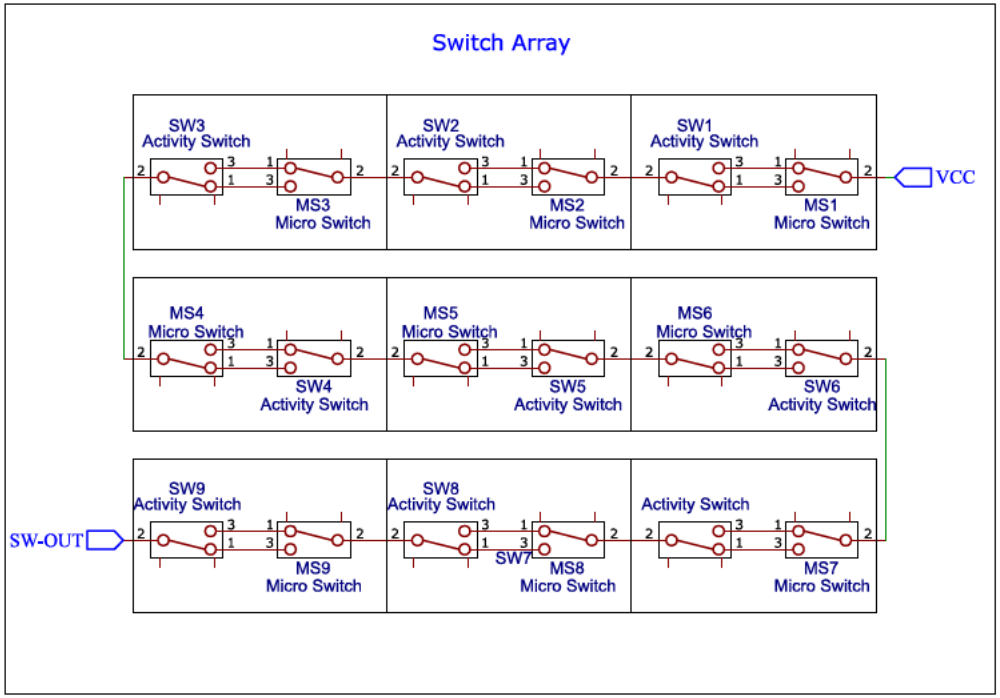




Parts List	
Item	Part Number
1	Switches
2	Microswitches
3	Panel (2)
4	Red LED
5	Green LED

Dept.	Technical reference	Created by Angus Hampshire 21/10/2023	Approved by
		Document type	Document status
		Title switch panel v2	DWG No.
			Rev. / Date of issue / Sheet 1/1

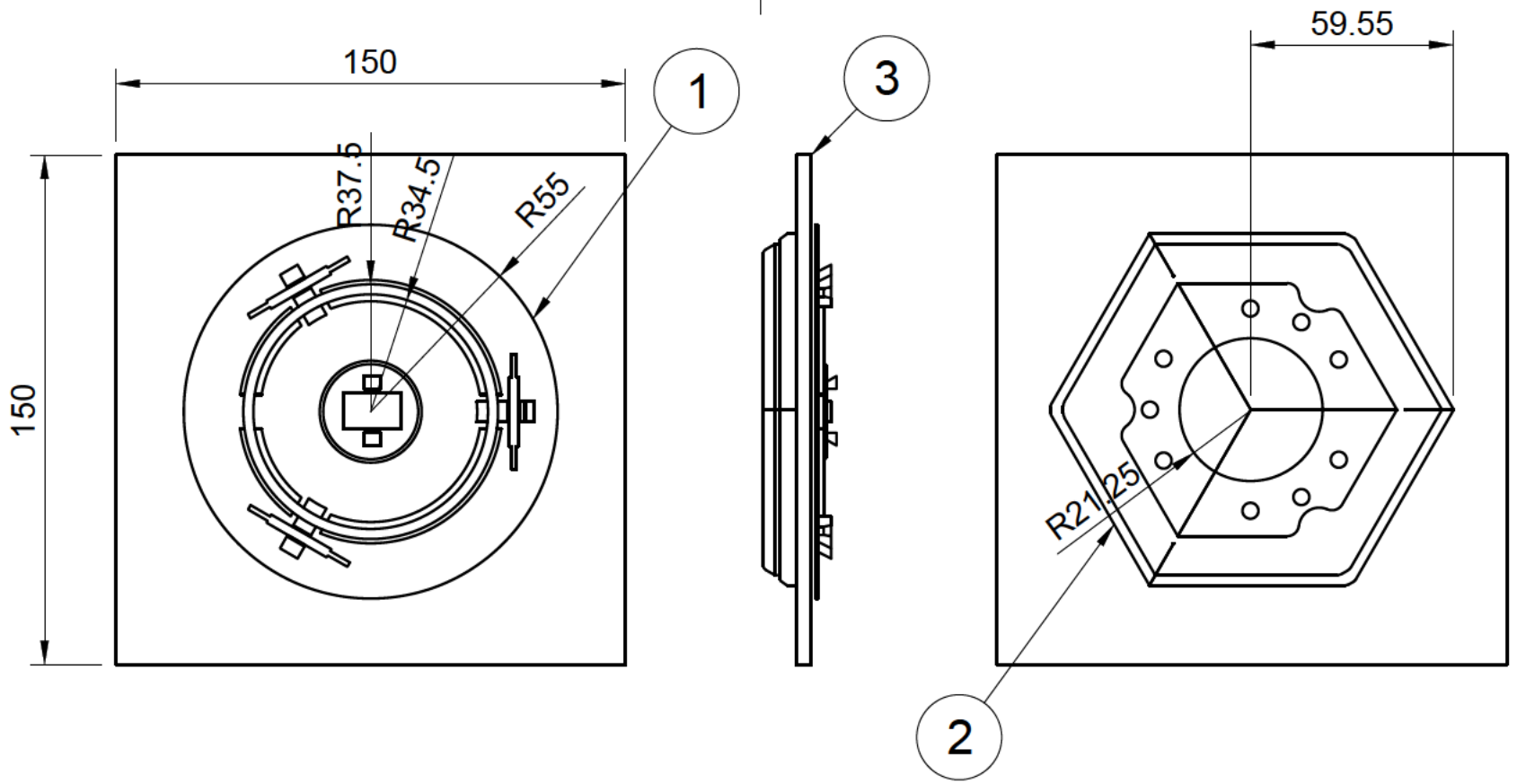




TITLE: SWITCH PANEL V2		REV: 1.0
EasyEDA	Company: THE TESSERACT	Sheet: 1/1
	Date: 2023	Drawn By: ANGUS HAMPSHIRE

Magnetic Key

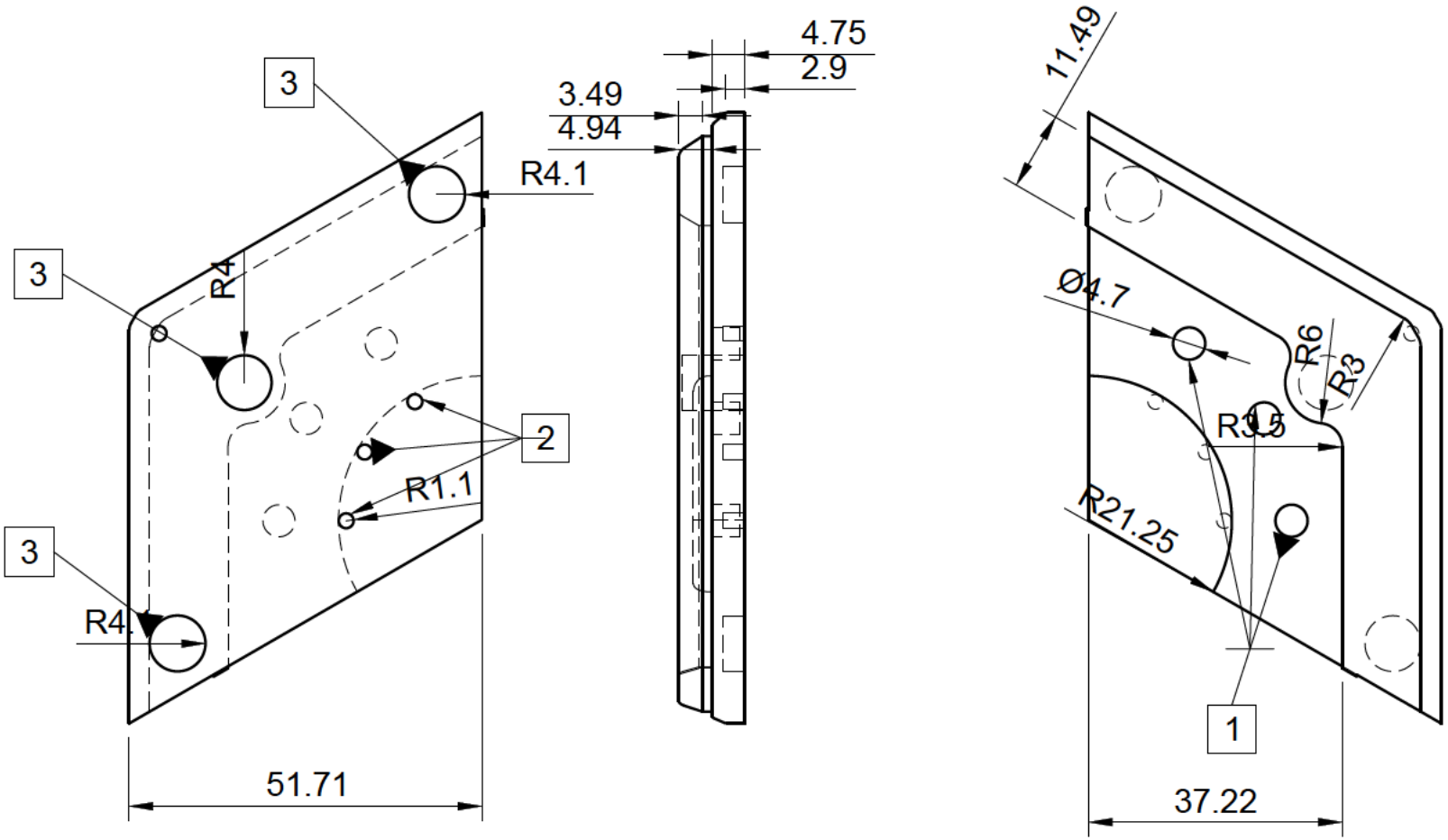
Magnetic Key, Version 2



Item	Part Number
3	Panel (1)
2	Magnetic keys
1	Reed rim

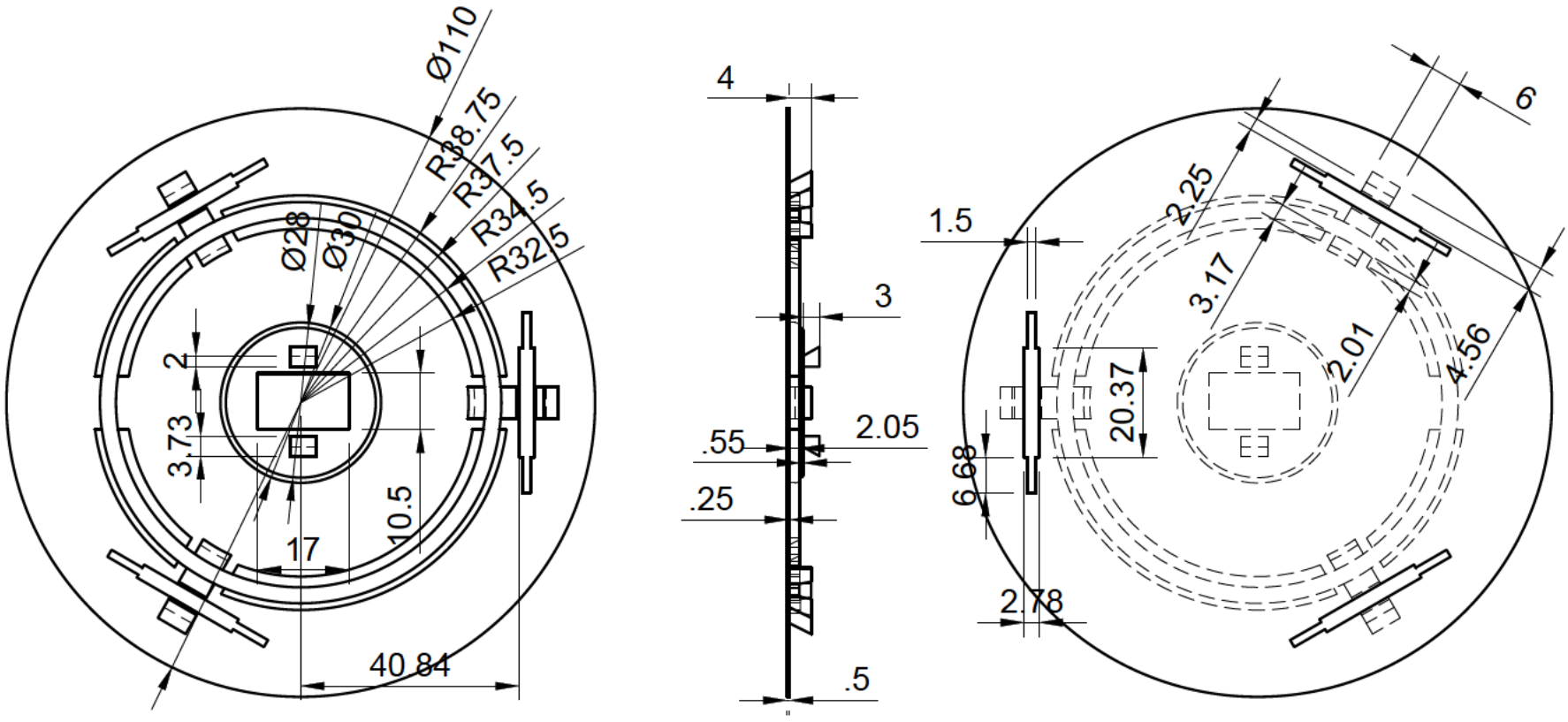
Parts List

Dept.	Technical reference	Created by: Angus Hampshire 2023	Approved by
		Document type	Document status
		Title: Magnetic keys v2	DWG No.
			Rev. / Date of issue / Sheet: 1/1

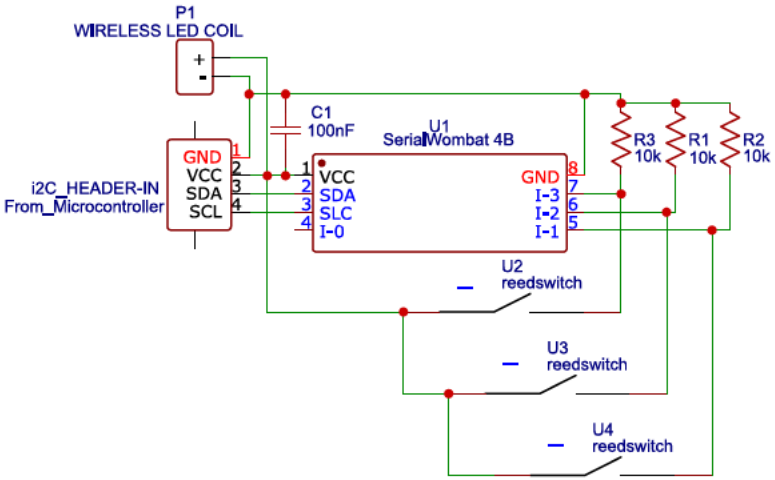


Wireless led	1
small magnet slot	2
magnet slot	3

Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title magnetic key	DWG No.
			Rev. / Date of issue / Sheet 1/1



Dept.	Technical reference	Created by Angus Hampshire 2023	Approved by
		Document type	Document status
		Title magnetic key reed switch holder	DWG No.
			Rev. / Date of issue / Sheet 1/1



TITLE: MAGNETIC KEY PANEL		REV: 1.0
EasyEDA	Company: THE TESSERACT	Sheet: 1/1
	Date: 2023	Drawn By: ANGUS HAMPSHIRE

Appendix F

Cost List

Magnetic Switch Panel			
Item	QTY:	Additional Information	Price
Magnetic key	3	PLA	~
Reed Switch Holder	1	PLA	~
Panel	1	Birch Ply	~
8mm magnet	9		~
1mm magnet	9		~
Wireless LED	9	adafruit ID:5140	$11.35
Wireless LED Coil	1		
SerialWombat 4B	1		$7.75
10K Ohm Resistor	3		~
100nF ceramic Cap	1		~

Switch Array Panel			
Item	QTY:	Additional Information	Price
LED- Green	1		~
LED- Red	1		~
BC547 NPN transistor	1		~
220 Ohm Resistor	1		~
120 Ohm Resistor	1		~
1K5 Ohm Resistor	1		~
SerialWombat 4B	1		$7.75
100nF ceramic Cap	1		~
micro slide switch (spdt)	9	EG1201A	$2.00
togle switch (spdt)	9	jacar: ST0335	$5.00
Panel	1	Birch Ply	~

GPS Panel			
Item	QTY:	Additional Information	Price
LED- Red	1		~
SerialWombat 4B	1		$7.75
100nF ceramic Cap	1		~
47 Ohm Resistor	1		~
SparkFun Ublox GPS	1	SparkFun GPS-21834 (Cheaper options are avalible)	$55
Panel	1	Birch Ply	~
GPS unit mount	1	PLA	~

Multi Role IO			
Item	QTY:	Additional Information	Price
Panel	1	Birch Ply	~
LCD Mount	1	PLA	~
Encoder standoff	1	ABS	~
4x20 LCD	1		$6.41
PCF8574 LCD to I2C adapter	1		
I2C Encoder	1	DF Robot SKU:SEN0502	$9.90
PCF8574 i2c multiplexer			$2
SPST Momentary Button	5	Jaycar: SP0710	$3.00

Door and frame			
Item	QTY:	Additional Information	Price
door	1	Acrylic	~
Shell	1	Acrylic	~
Inner Structure	1	PLA	~
Mounting brackets	12	PLA	~
5v servo moter	1		$5.00

Controll Microcontroller			
Item	QTY:	Additional Information	Price
Microcontroller shield	1		$2.00
SparkFun RedBoard Turbo	1		$48.00

Consumables for all Panels	---	Covers the electronic components, ply wood, fasteners, glue, 3D printing material, and acrylic	$50
Where posible cheaper alternitives where sourced			
		TOTAL	222.91

Appendix G

Test One Test Plan

2023

Test 1: Initial Component Testing

TEST PROCEDURE FOR TEST 1

ANGUS HAMPSHIRE

Trial Procedure_ 16-06-2023

Activity:

The initial testing is intended to confirm the viability of the project and to test the component panels individually in order to ensure that the components function correctly.

Trial Conducted By:

Angus Hampshire.

Trial Participants:

Angus Hampshire

Contents

Situation:

This test will determine the viability of the concept of the Tesseract modular multi role activity platform and to test the component panels individually in order to ensure that the components function correctly.

The testing will consist of an individual assessment of all of the sections of the design:

These will be separated into:
The structure. The inner structure, the shell, and the door assembly.
The modular panels. The multi role IO, the switch array, the magnetic switches, and the GPS.

The Test will consist of:

1. Construction analysis. The physical structure of each component will be assessed to identify weaknesses and improvements to the design.
2. Component operational analysis. Each of the operative components of the device will be tested to ensure that they function and to identify any areas of improvement.
3. A final assessment. After the structural and component assessment, a final assessment will be done to determine whether the device proposed in the project is viable.

Outcomes:

The objective of this testing is to determine the operational status of the device. The testing will be specifically intended to identify if the design is viable.

The secondary objective of the testing is to identify areas of potential improvement to the device design.

Appendix H

Test Two Test Plan

2023

Test 2:
System Testing and Component Analysis

TEST PROCEDURE FOR TEST 2

ANGUS HAMPSHIRE

Trial Procedure_ 08-07-2023

Activity:

The testing is intended to assess the whole system. Testing is being conducted to assess the utility of the design and identify potential modifications.

Trial Conducted By:

Angus Hampshire.

Trial Participants:

Angus Hampshire

Contents

Situation:

This trial is being held to assess the Tesseract multi role platform.

The testing is intender to test the capabilities of the system and to identify areas of potential improvement.

The Test will consist of:

1. Construction of the platform
    a. analysis of the physical device
2. The connection of the modular activity panels to the microcontroller.
    a. analysis of the electrical connections.
3. A thorough operation of each of the components connected to the device
    a. Analysis of each panel and its configuration/operation.

Outcomes:

The objective of this trial is to determine the effectiveness of the device with specific note to the possible improvements that could be made.

Admin and Logistics:

Testing:

The testing will be conducted in a workroom on private property.

The test will be completed by the developer (Angus Hampshire).

Post test Procedure

After each section of the testing an analysis of the previous test will be conducted. Following the completion of the testing the analysis will be reviewed and written into a document.

Appendix I

Test Three Test Plan

2023

Test 3:
Final Independent Tesseract Operation

TEST PROCEDURE FOR TEST 3

ANGUS HAMPSHIRE

Trial Procedure_ 30-08-2023

Activity:

Testing the prototype activity platform through the trial of an orientation activity 'Ingress Room, The Tesseract'.

Trial Conducted By:

Angus Hampshire.

Trial Participants:

Angus Hampshire

Time-table:

13:30-13:45 - Pre-activity checklist
13:45-15:00 - Trial Run Activity 'Ingress Room, The Tesseract'.
15:00-15:30 - Post trial review.

Contents

Situation:

This trial is being held to assess a proposed multipurpose activity platform.

The trial activity is a simulated first-year orientation activity for engineering and surveying students.

The activity will be completed by engineering and surveying academic staff members with an understanding of the orientation process as well as learning-and-teaching methodologies.

The trial will consist of:

1. A pre-activity briefing to discuss:
    a. Safety issues.
    b. The trials purpose and intent.
    c. The bounds of the testing
2. The completion of a trial activity using the proposed activity platform.
3. A post activity presentation of the system and the design choices, covering:
    a. The modularity of the system
    b. The activity panels used and their multiple uses.
4. A post activity review and discussion to.
    a. Gather data from subject matter experts regarding the practicality of the system.
    b. Gather data from subject matter experts regarding the trial activity.

Outcomes:

The objective of this trial is to determine the effectiveness of a proposed learning and teaching device within an education environment.

The outcomes of this trial will be a review of both the activity platform and the trial activity. The intent of these reviews is to:

1. Determine if the concept of the activity platform is useful for educators.
2. Determine what improvements could be made to the activity platform.
3. Determine what improvements could be made to the trial orientation activity.

Admin and Logistics:

The pre activity checklist will be conducted in accordance with the pre-brief checklist in the appendix.

Trial Activity:

The trial activity will begin in F202 (the collaboration space)

The trial will be completed by the developer (Angus Hampshire).

Due to the trial nature of the activity. There are some puzzles where the known answers will be directly entered. This is to avoid disturbing the normal operation of the campus. In these situations the box will still be taken to the approximate location where the knowledge would be found.

Post Brief Procedure

Once the activity is completed a review will be conducted for both the trial activity as well as the activity platform. The review will be in accordance with the review documents Appendix A and B

Appendix

A- Post Activity Review Sheet. (activity)

Assessment- Activity:

Alignment with Orientation Goals:

1. **How well did the activity align with the orientation goals, and how could it be better?**

Please evaluate how well the activity achieved the following orientation goals and provide suggestions for improvement where necessary:

- Introduce students to facilities, services, resources, and the key stakeholders of the UniSQ community.
- Offer clarity around academic culture and the expectations of academic study.
- Encourage a sense of belonging and connectedness with the USQ community and assist them in identifying with their learning institution.
- Provide students with the opportunity to develop their perceived self-efficacy for help-seeking and independent learning.
- Provide students with opportunities to relate the relevance of their study to their career aspirations and employability development.
- Identify specific high-need student cohorts and develop activities to meet their unique needs.
- Evaluate the introduction of key academic staff.
- Assess the effectiveness of the program and recommended enrolment pattern overview.
- Evaluate the introduction to School-specific facilities.
- Reflect on the communication of general expectations of students and what students may expect from staff.
- Assess the opportunities for students to meet their peers.

Activity Assessment:

1. **Did you enjoy the activity?**
    - Where there any parts of the activity that where obscure or where the information/solution did not seem to logically correlate with the activity/puzzle?
    - Did any section drag on?
    - Where there any puzzles that just felt like useless busy work? (eg collect 10 brown leaves)
2. **Would the activity be engaging and enjoyable for the students?**
    - Please share your observations on how engaging and enjoyable the activity would be for the students.
    - Was the information presented in a way such that the students would be actively learning the content?
    - Did the order of the puzzles seem correct to you?

3. **What other information should have been conveyed as part of the activity? (e.g., the location of the car park)**
    - Are there any additional pieces of information or topics that you believe should have been included in the orientation activity?
4. **Was the time allowed for the activity sufficient?**
    - Reflect on the duration of the activity and whether it provided enough time for students to engage with the content and complete the objectives.
5. **Should there have been a short rapid-fire quiz at the end of the activity?**
    - Share your thoughts on whether incorporating a quiz at the end of the activity would have been beneficial for reinforcing key information.

Overall Feedback: 6. **Please provide any additional comments or suggestions you have about the engineering orientation activity.**

- Feel free to offer any further insights, ideas, or recommendations related to the activity or your experience during the trial.

Thank you for your feedback!!

Do you consent to having your anonymised answers to these questions included in a report?

Y/N

B- Post Activity Review sheet (Device)

Assessment- Device:

Device Trial Experience:

1. **What worked well on the device?**
    - Please describe any specific features or functions that you found effective or impressive.
2. **What did not work well?**
    - Please share any aspects of the device that you found problematic or unsatisfactory.
3. **What are some minor changes that could improve the device?**
    - Are there any small adjustments or enhancements that you believe would make the device better?
4. **What are some major changes that could improve the device?**
    - Are there any significant modifications or new features that you think would significantly enhance the device's performance or usability?

Aesthetic and Sensory Feedback: 5. **General aesthetic suggestions:**

- How do you feel about the device's overall appearance and design? Are there any aesthetic improvements you'd recommend?

6. **General sensory suggestions:**
    - Consider the sensory aspects (e.g., sound, touch, feedback) of using the device. Are there any sensory-related improvements or feedback you'd like to provide?

Modularity: 7. **As the device is modular, what are some modules that you believe would be awesome?**

- Think about additional modules or components that could be integrated with the device to expand its capabilities. Please describe your ideas.

Overall Feedback: 8. **Please share any additional comments or suggestions you have about the device.**

- Feel free to provide any further insights, ideas, or recommendations related to the device or your experience during the trial.

Thank you for participating in our device trial!

Do you consent to having your anonymised answers to these questions included in a report?

Y/N

C- Pre-Brief Checklist

Pre brief checklist

- Discuss safety and risk assessment.
    - Appropriate footwear
    - Hats
    - Sunscreen
    - Activity Boundaries
    - Emergency contact information
- Information accessibility
    - No googling (it won't help you)
    - You may speak to/request resources from members of staff.
    - You are given an information booklet.
- The purpose of the trial
    - Testing the device
        - The device is a modular, easy to setup, activity platform.
        - The device is intended to be used as an 'ingress box' in a scavenger hunt.
        - The concept is an inside-out escape room.
        - There are 5 removable sides that can be set up as puzzles, clues, or information panels.
        - Please note the positives and negatives regarding the platform while trailing the activity.
    - Testing the activity
        - The activity is intended as a first-year orientation activity for engineering and surveying students.
        - The puzzles and challenges are intended to cover most of the orientation objectives.

D- Trial Orientation Activity Document

Activity: Trial Orientation Activity

This activity is intended to be conducted using the tesseract activity platform.

Before the Activity:

1. Provide students with a tour of F block (the engineering building), highlighting important information:
    1. Location of fire exits.
    2. Emergency exit maps with the emergency assembly point.
2. Distribute a booklet with general university information including:
    1. Location of the help desk.
    2. Location of the security offices.
    3. Location of the library.
    4. Suggested enrolment patterns for their degrees.
3. Discussion regarding safety, boundaries, personal conduct, and PPE.
4. Introduce the activity. (see resources section on next page)

Puzzle 1: Bridge Crossing (puzzle + answer located at end**)**

- Provide each student with a piece of paper containing the "Bridge Crossing" puzzle.
- Challenge students to find the fastest time for all four students to cross the bridge safely.
- Once they solve the puzzle, and enter the correct answer into the device. They will get the clue for Puzzle 2.

Puzzle 2: Emergency Exit Haiku

- The students will read a haiku clue off the screen.
- The clue directs students to the emergency exit maps for F block, leading them to the emergency assembly point.
- When the student are outside the gps will track their positions and the leds on the gps Pannel will flash faster as they approach the target location.
- Once at the assembly point, the student will unlock the third puzzle.

Puzzle 3: Head of School's Room Number

- The students will be asked to provide the Room Number for the engineering head of school.
- Students should visit the help desk (as mentioned in the booklet) to inquire about the phone extension.
- Once they obtain the extension, they will be given a puzzle piece and provided the next clue.

Puzzle 4: Resistance Challenge

- The students will be given a resistance value and a set of resistors (on the switch Pannel).
- Instruct them to build the specified resistance by connecting resistors in series and parallel.
- Students should visit the library to seek assistance from the librarian, who will provide a sheet explaining resistor values and connections.
- Once they construct the correct resistance, they will be provided with the next clue.

Puzzle 5: Room Access

- The next clue will direct students to enter a locked room that they do not have access to.
- They must approach a member of staff or campus security to request access to the room.
- Once inside, they get the final puzzle.

Puzzle 6: Degree Course Count

- The final puzzle asks students to determine how many individual courses are in their degrees.
- If they don't know the answer, they can find it in the booklet provided before the activity.
- Once they answer correctly, they have completed all challenges.

Reward:

- Reward students with a Lego minifigure for successfully completing all challenges.

This orientation activity encourages teamwork, problem-solving, and familiarity with important campus locations and resources while engaging students in fun puzzles. It offers a great way to welcome first-year engineering students to the university and their degree program.

Resources:

Activity introduction: the weird fun bit.

In a sill American general accent

“

Alright people drop everything and listen up!

We have an emergency. And we need to act fast.

Now the current situation is this.

The evil MegaMind corporation have just enacted their doomsday protocol! In one hour every powerplant on the planet will explode, destroying the power grid, and sending the human race back to the dark ages.
So far, every attempt to disable the protocol has met with total failure!
Now the world needs you! and your unique skills to help us disable it.

Intelligence suggests that the heads of the MegaMind corporation have transformed themselves into tiny living plastic figurines and locked themselves into their secure vault. It seems that they intend to survive the coming cataclysm and set themselves up as rulers in this post-apocalyptic new world.
Now, We suspect that they have taken the doomsday protocol disarm key into that vault with them.

Thanks to our spies inside of the corporation we know that the leader of this conspiracy has locked the vault with a series of challenges that you are all uniquely qualified to handle!

We have received the first clue to the vault and we are sending it through to you now.

Good Luck Team, the world is counting on you!

General Out.

“

Puzzle 1: The Bridge Crossing

Scenario: You have a group of four first-year engineering students who need to cross a bridge at night. They have only one flashlight, and the bridge is too dangerous to cross without it. The bridge can only hold two people at a time. The four students walk at different speeds: one can cross the bridge in 1 minute, another in 2 minutes, another in 5 minutes, and the slowest in 10 minutes. When two students cross the bridge together, they must go at the slower student's pace.

Challenge: Your task is to find the fastest time possible for all four students to cross the bridge safely.

Answer:

1. The two fastest students (1 minute and 2 minutes) cross the bridge together, taking 2 minutes (2 minutes elapsed).
2. The fastest student (1 minute) returns with the flashlight, taking 1 minute (3 minutes elapsed).

3. The two slowest students (5 minutes and 10 minutes) cross the bridge together, taking 10 minutes (13 minutes elapsed).
4. The second-fastest student (2 minutes) returns with the flashlight, taking 2 minutes (15 minutes elapsed).
5. Finally, the two fastest students (1 minute and 2 minutes) cross the bridge together one more time, taking 2 minutes (17 minutes elapsed).

Puzzle 2: Emergency Exit Haiku

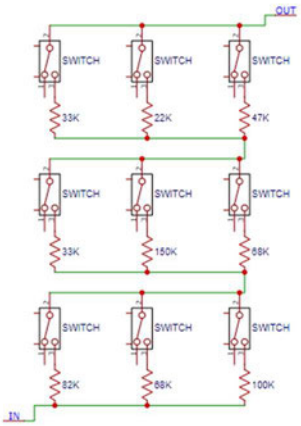
Haiku is as follows:
- *From F block you flee.*
- *To a point of safety*
- *On a map you'll find me.*

The clue will reference the emergency maps leading the students to the emergency assembly point.

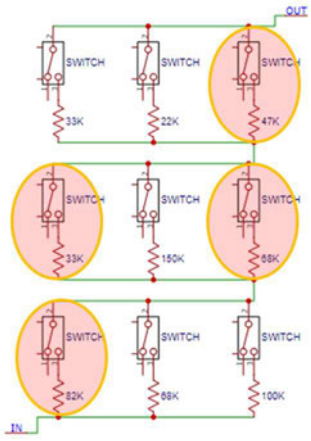
Puzzle 4: Resistance Challenge

The students are given the circuit below and are required to create an resistance of 150k Ω ±%1.

Question,



Answer,



Other:
For this test the 'students' will be given an unofficial orientation booklet rather than an official document. This document will be:

University of Southern Queensland
First Year Orientation Booklet

UniSQ

unisq.edu.au

Welcome to UniSQ

Welcome to the university of southern Queensland! This introductory booklet contains some information on life at UniSQ and the resources available to you as a student.

We Are All Quite Proud Of You!

You have started a university degree.
For many of you this is your first step out of school and for others it is a decision that you have made later in life; in either case you have put in so much effort to be here and you should take some the time to appreciate yourself for the dedication that you have shown to get this far.

No matter what happens in the future, know that you had the determination to get here and that, with resolve and courage, you have the capacity to achieve anything.

iconnect

Your first point of contact for all student enquiries.

At UniSQ, we want our students to feel supported, but realise it isn't always easy knowing where to get help. That's why we launched iconnect.

iconnect helps students find the information they need and can connect them with relevant UniSQ support services. Available by chat, email, phone or face-to-face, we work closely with all areas of the university to ensure you get the answers you need. Our concierges are current UniSQ students, just like you, and are trained to support you through your learning journey.

How to find us

Contact us at:
Phone: +61 7 4631 2285
Toll free calls: 1800 007 252
Email: usq.support@usq.edu.au

Or visit us on campus

UniSQ Toowoomba

Location: Student Central (R Block)
Opening hours: Monday - Friday 8:00am to 5:00pm (AEST)

UniSQ Ipswich

Location: Library (H Block)
Opening hours: Monday - Friday 8:00am to 5:00pm (AEST)

UniSQ Springfield

Location: Atrium (B Block)
Opening hours: Monday - Friday 8:00am to 5:00pm (AEST)

Library

UniSQ Library provides a supportive, connected and intuitive experience that enables:

- students to develop the confidence, resilience and skills required to reach their potential as engaged, informed and productive citizens, and
- staff to access the tools, supports and systems required to reach their potential as world-class teachers, researchers and professionals.

Library Experience

The Library Experience team provides learning spaces, information services, and a premium digital experience for UniSQ students and staff. The team gathers and analyses evidence to improve library services and better understand our students and academic staff.

Content

The Content team provides access to content, advice and support on intellectual property rights, manages UniSQ created learning objects and research outputs, and ensures data quality across our various content systems.

Learning and Research

The Learning and Research team works with academic staff to support their teaching and research, and with students to support them to develop the skills to succeed at University. The Learning and Research team provides peer support, education support, and research support services, as well as co-curricular and entrepreneurship opportunities via the UniSQ Library Makerspace.

Library events

The UniSQ library also hosts a number of events to assist students in both, their study and learning journeys, and connecting with UniSQ community through common interests.

Check out the library events at: https://www.unisq.edu.au/library/unisq-libraries/events

Makerspace

The UniSQ Makerspace is a community space for hands-on making with new digital fabrication technologies and traditional crafts. The Makerspace can be used for class projects, research, personal projects and hardware prototyping. Currently, the Makerspace has 3D Printers, 3D scanner, soldering station, a badge maker, hand tooling, a sewing machine, craft materials and much more.

Opening hours

Our libraries are available for individual and group study. 24-hour computer spaces are available in Ipswich and Springfield libraries, and adjoining the Toowoomba library.

Where is the Library located?

There is a branch of the UniSQ Library located at each of our three campuses:

- Toowoomba Campus Library - Located in B block (Levels 2 & 3) (Toowoomba campus & map)
- Springfield Campus Library - Located in A block (Level 1) (Springfield campus & map)
- Ipswich Campus Library - Located in H block (Level 2) (Ipswich campus & map)

UniSQ Clubs

Clubs and societies are a core part of student life at UniSQ, bringing together vibrant and diverse communities and providing opportunities for current UniSQ students. Each of our clubs has a purpose and it is likely there is one focused on something you are passionate about. By joining even one of the many clubs available, you will not only have the opportunity to create great friendships, capture lasting memories and have a blast, but you can also build skills that will help further your career.

What do you do if you can't find a club you are passionate about? Start your own! With dedicated staff to guide you through the process, and an abundance of resources, it has never been easier to start a club or society. All you need is an idea.

Visit the club website for more information on the clubs available at the university.
https://www.unisq.edu.au/current-students/support/student-clubs/find-a-club

DO NOT USE. NOT OFFICIAL CONTENT. For trial purpose only! 09-23

swipe ID cards.

Manny of the building and rooms in the UniSQ campuses are locked using electronic

As a student you will be issued an ID card. These cards are essential for you as you will need to have them to access certain areas rooms in the university, access out of hours resources (such as computer labs), and to access in person examinations.

If you lose your ID, lock it in a room, or if you don't have the access that you believe that you should, you can contact the UniQS campus security offices to request assistance.

Campus Safety and Security

UniSQ Security assists in providing a safe and secure environment for persons and property. Trained and experienced security guards patrol the Toowoomba, Springfield, and Ipswich campuses 24 hours a day, seven days a week.

Security Office contact details

Please note for all emergencies phone +61 7 4631 2222

Campus	Room	Phone	Email
Toowoomba	Z3 101	+61 7 4631 2871 +61 412 716 838	security@usq.edu.au
Springfield	D112	+61 7 3470 4444 +61 437 229 320	usqsecspringfield@usq.edu.au
Ipswich	H110	+61 7 3812 6060 +61 428 086 790	ipswichsecurityoffice@usq.edu.au

Personal protection services

UniSQ Security provides close personal protection (escorts) to visitors 24 hours, seven days per week, if available. Please contact the Security Office on your campus.

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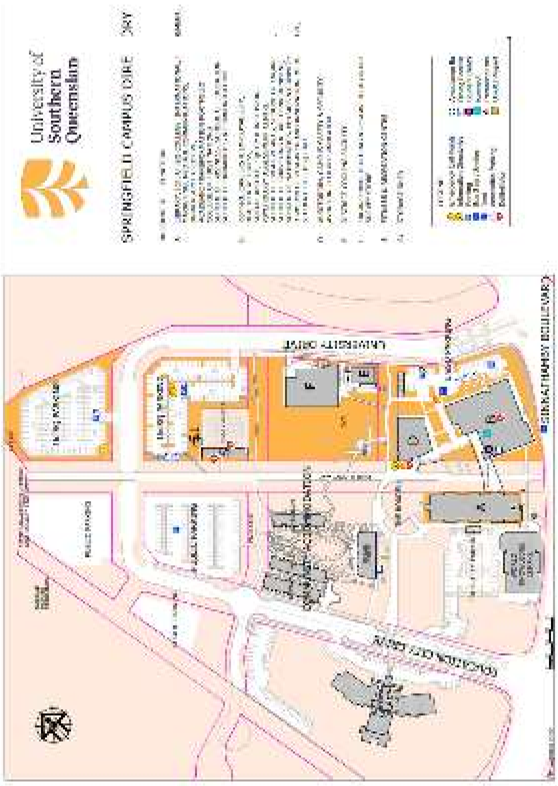

Your Course:

Welcome to the university of southern Queensland! As part of your introductory information, you are provided with the suggested enrolment pattern for you major. This pattern is not compulsory however deviating from it may leave you in an awkward position. Some of the courses have pre-requisites and if you are not careful you can end up in a position where you are unable to take a full load in a semester due to pre-requisite restrictions.

If you ever need assistance with understanding the enrolment pattern, or adapting the enrolment pattern to your unique situation, please feel free to get in contact with the Iconnect team.

Civil Engineering major full-time recommended enrolment pattern (Toowoomba and Springfield campus)

Major Study: Civil Engineering (Major Study Code: [illegible])								
Course	Year of program and semester in which course is normally studied						Residential school	Enrolment requirements
	On-campus (ONC)		External (EXT)		Online (ONL)			
	Year	Sem	Year	Sem	Year	Sem		
Academic Courses Year 1								
ENG1001 Introduction to Engineering and Built Environment Applications	1	1				1,2		
ENM1600 Engineering Mathematics	1	1				1,2		Enrolment is not permitted in ENM1600 if MAT1102 or MAT2402 has been previously completed
ENG1002 Engineering Problem Solving Principles	1	1				1,2		
MEC1201 Engineering Materials	1	1				1,2,3		
ENG1100 Introduction to Engineering Design	1	2				1,2		
CIV1xxx Engineering Statics	1	2				1,2		Pre-requisite: [illegible] or ([illegible] and [illegible]) or Students must be enrolled in one of the following Programs: [illegible] or [illegible] or [illegible]
ENG1003 Technology, Sustainability and Society	1	2				1,2,3		
SVY1500 Spatial Science for Engineers	1	2				1		
Practice Courses Year 1								

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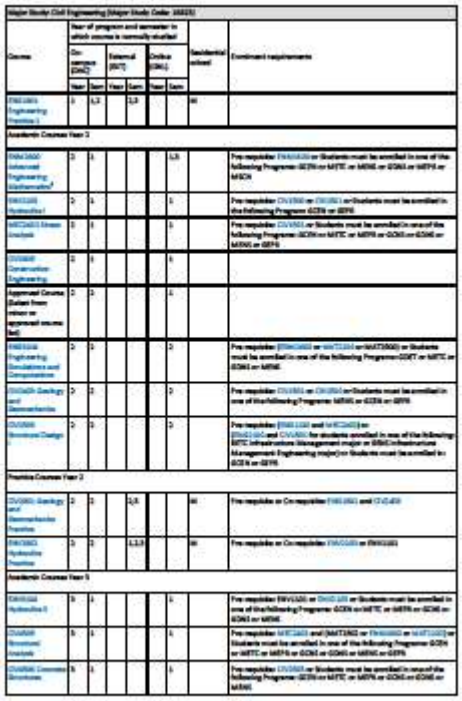

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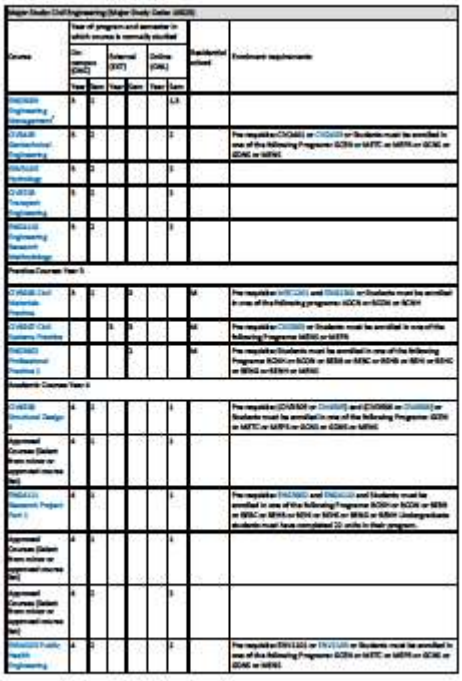

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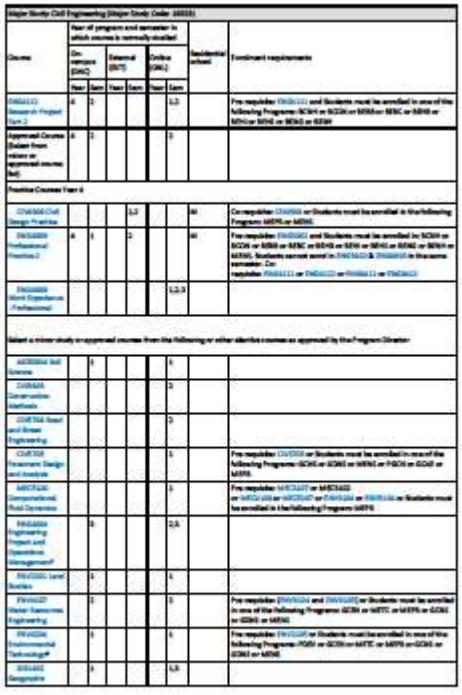

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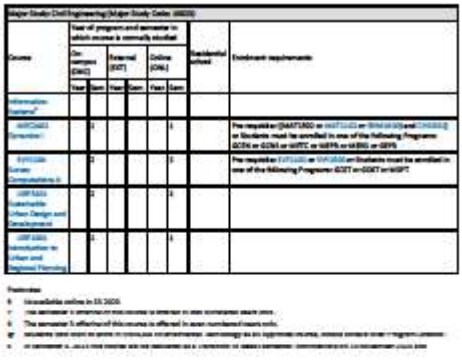

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E- Risk Assessment

RMP

Step 1 (cont)	Step 2	Step 2a	Step 3			Step 4				
Hazards: From step 1 or more if identified	The Risk: What can happen if exposed to the hazard with existing controls in place?	Existing Controls: What are the existing controls that are already in place?	Risk Assessment: (use the Risk Matrix on p3) Consequence x Probability = Risk Level			Additional controls: Enter additional controls if required to reduce the risk level	Risk assessment with additional controls: (use the Risk Matrix on p3 – has the consequence or probability changed?)			Controls Implemented? Yes/No
			Consequence	Probability	Risk Level		Consequence	Probability	Risk Level	
Example										
Working in temperatures over 35° C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	Regular breaks, chilled water available, loose clothing, fatigue management policy.	catastrophic	possible	high	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
During the testing the testing participants will be spending significant time in the testing locationg while focusing on the device.	sun burn	the testers will wear hats and sunscreen.	Minor	Unlikely	Low		Select a consequence	Select a probability	Select a Risk Level	Yes or No
	trip hazard	using small teams of adults, to test the system. as a group they will be able to avoid hazardous terain.	Moderate	Rare	Low		Select a consequence	Select a probability	Select a Risk Level	Yes or No
	walking onto a road or carpark	using small teams of adults, to test the system. They should have the common sense to not walk into trafic.	Catastrophic	Unlikely	Moderate	Having a limited testing area that does not contain any roads or carparks. Ensuring that the participants know the location boundries.	Catastrophic	Rare	Low	Yes or No
interupting campus services	interupting security resulting in a hazardous workplace	the trial coordinator will act as a substitute for any critical staff members to avoid any service interuptions.	Moderate	Unlikely	Moderate		Insignificant	Rare	Low	Yes or No

Step 1 (cont)	Step 2	Step 2a	Step 3			Step 4				
Hazards: From step 1 or more if identified	The Risk: What can happen if exposed to the hazard with existing controls in place?	Existing Controls: What are the existing controls that are already in place?	Risk Assessment: (use the Risk Matrix on p3) Consequence x Probability = Risk Level			Additional controls: Enter additional controls if required to reduce the risk level	Risk assessment with additional controls: (use the Risk Matrix on p3 – has the consequence or probability changed?)			Controls Implemented? Yes/No
			Consequence	Probability	Risk Level		Consequence	Probability	Risk Level	
Example										
Working in temperatures over 35° C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	Regular breaks, chilled water available, loose clothing, fatigue management policy.	catastrophic	possible	high	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
storms and bad weather	higher chances for injury	Appropriate atire for the wheather conditions.	Moderate	Unlikely	Moderate	If there is bad weather the trial can be simulated indoors.	Moderate	Rare	Low	Yes or No
	equipment damage.	the equipment is rouged and inside a case. there is minamal risk of equipment damage.	Moderate	Rare	Low		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Minor	Unlikely	Low		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No

F- Device version specifications

The Testing is to be conducted using the Tesseract V3 the details of this version are listed below:

X2.B2.C2.A3.F.D3 (frame, left panel, right panel, top panel, bottom panel, back panel)

This code describes identifies the version of each panel used as well as the location of the panels on the device.

Appendix J

Test Four Test Plan

2023

Test 4: Functional Tesseract Operation

TEST PROCEDURE FOR TEST 4

ANGUS HAMPSHIRE

Trial Procedure_ 06-09-2023

Activity:

Testing the prototype activity platform through the trial of an orientation activity ‘Ingress Room, The Tesseract’.

Trial Conducted By:

Angus Hampshire.

Trial Participants:

[redacted]

[redacted]

[redacted]

Time-table:

12:00-13:30 - Lunch
13:30-13:45 - Pre-brief
13:45-15:00 - Trial Run Activity ‘Ingress Room, The Tesseract’.
15:00-15:30 - Post trial discussion and review.

Contents

Situation:

This trial is being held to assess a proposed multipurpose activity platform.

The trial activity is a simulated first-year orientation activity for engineering and surveying students.

The activity will be completed by engineering and surveying academic staff members with an understanding of the orientation process as well as learning-and-teaching methodologies.

The trial will consist of:

1. A pre-activity briefing to discuss:
    a. Safety issues.
    b. The trials purpose and intent.
    c. The bounds of the testing
2. The completion of a trial activity using the proposed activity platform.
3. A post activity presentation of the system and the design choices, covering:
    a. The modularity of the system
    b. The activity panels used and their multiple uses.
4. A post activity review and discussion to.
    a. Gather data from subject matter experts regarding the practicality of the system.
    b. Gather data from subject matter experts regarding the trial activity.

Outcomes:

The objective of this trial is to determine the effectiveness of a proposed learning and teaching device within an education environment.

The outcomes of this trial will be comprehensive reviews by subject matter experts on both the activity platform and the trial activity. The intent of these reviews is to:

1. Determine if the concept of the activity platform is useful for educators.
2. Determine what improvements could be made to the activity platform.
3. Determine what improvements could be made to the trial orientation activity.

Admin and Logistics:

The pre brief will be conducted in accordance with the pre-brief checklist in the appendix.

Trial Activity:

The trial activity will begin in F202 (the collaboration space)

The trial should be completed by the participants without assistance from the trial conductor however the Trial Conductor will be accompany the trial party in case of any issues.

Due to the trial nature of the activity. There are some puzzles where the conductor will act as another member of the university staff. This is to avoid disturbing the normal operation of the campus.

Post Brief Procedure

Once the participants have completed the activity, each participant will be given a review document for both the trial activity as well as the activity platform.

Once both documents are completed and collected there will be a group discussion, organised by the conductor, regarding the positives and negatives of both the equipment and activity trialed.

Appendix

A- Post Activity Review Sheet. (activity)

Assessment- Activity:

Alignment with Orientation Goals:

1. **How well did the activity align with the orientation goals, and how could it be better?**

Please evaluate how well the activity achieved the following orientation goals and provide suggestions for improvement where necessary:

- Introduce students to facilities, services, resources, and the key stakeholders of the UniSQ community.
- Offer clarity around academic culture and the expectations of academic study.
- Encourage a sense of belonging and connectedness with the USQ community and assist them in identifying with their learning institution.
- Provide students with the opportunity to develop their perceived self-efficacy for help-seeking and independent learning.
- Provide students with opportunities to relate the relevance of their study to their career aspirations and employability development.
- Identify specific high-need student cohorts and develop activities to meet their unique needs.
- Evaluate the introduction of key academic staff.
- Assess the effectiveness of the program and recommended enrolment pattern overview.
- Evaluate the introduction to School-specific facilities.
- Reflect on the communication of general expectations of students and what students may expect from staff.
- Assess the opportunities for students to meet their peers.

Activity Assessment:

1. **Did you enjoy the activity?**
    - Where there any parts of the activity that where obscure or where the information/solution did not seem to logically correlate with the activity/puzzle?
    - Did any section drag on?
    - Where there any puzzles that just felt like useless busy work? (eg collect 10 brown leaves)
2. **Would the activity be engaging and enjoyable for the students?**
    - Please share your observations on how engaging and enjoyable the activity would be for the students.
    - Was the information presented in a way such that the students would be actively learning the content?
    - Did the order of the puzzles seem correct to you?

3. **What other information should have been conveyed as part of the activity? (e.g., the location of the car park)**
    - Are there any additional pieces of information or topics that you believe should have been included in the orientation activity?
4. **Was the time allowed for the activity sufficient?**
    - Reflect on the duration of the activity and whether it provided enough time for students to engage with the content and complete the objectives.
5. **Should there have been a short rapid-fire quiz at the end of the activity?**
    - Share your thoughts on whether incorporating a quiz at the end of the activity would have been beneficial for reinforcing key information.

Overall Feedback: 6. **Please provide any additional comments or suggestions you have about the engineering orientation activity.**

- Feel free to offer any further insights, ideas, or recommendations related to the activity or your experience during the trial.

Thank you for your feedback!!

Do you consent to having your anonymised answers to these questions included in a report?

Y/N

B- Post Activity Review sheet (Device)

Assessment- Device:

Device Trial Experience:

1. **What worked well on the device?**
    - Please describe any specific features or functions that you found effective or impressive.
2. **What did not work well?**
    - Please share any aspects of the device that you found problematic or unsatisfactory.
3. **What are some minor changes that could improve the device?**
    - Are there any small adjustments or enhancements that you believe would make the device better?
4. **What are some major changes that could improve the device?**
    - Are there any significant modifications or new features that you think would significantly enhance the device's performance or usability?

Aesthetic and Sensory Feedback: 5. **General aesthetic suggestions:**

- How do you feel about the device's overall appearance and design? Are there any aesthetic improvements you'd recommend?

6. **General sensory suggestions:**
    - Consider the sensory aspects (e.g., sound, touch, feedback) of using the device. Are there any sensory-related improvements or feedback you'd like to provide?

Modularity: 7. **As the device is modular, what are some modules that you believe would be awesome?**

- Think about additional modules or components that could be integrated with the device to expand its capabilities. Please describe your ideas.

Overall Feedback: 8. **Please share any additional comments or suggestions you have about the device.**

- Feel free to provide any further insights, ideas, or recommendations related to the device or your experience during the trial.

Thank you for participating in our device trial!

Do you consent to having your anonymised answers to these questions included in a report?

Y/N

C- Pre-Brief Checklist

Pre brief checklist

- Discuss safety and risk assessment.
    - Appropriate footwear
    - Hats
    - Sunscreen
    - Activity Boundaries
    - Emergency contact information
- Information accessibility
    - No googling (it won't help you)
    - You may speak to/request resources from members of staff.
    - You are given an information booklet.
- The purpose of the trial
    - Testing the device
        - The device is a modular, easy to setup, activity platform.
        - The device is intended to be used as an 'ingress box' in a scavenger hunt.
        - The concept is an inside-out escape room.
        - There are 5 removable sides that can be set up as puzzles, clues, or information panels.
        - Please note the positives and negatives regarding the platform while trailing the activity.
    - Testing the activity
        - The activity is intended as a first-year orientation activity for engineering and surveying students.
        - The puzzles and challenges are intended to cover most of the orientation objectives.

D- Trial Orientation Activity Document

Activity: Trial Orientation Activity

This activity is intended to be conducted using the tesseract activity platform.

Before the Activity:

1. Provide students with a tour of F block (the engineering building), highlighting important information:
    1. Location of fire exits.
    2. Emergency exit maps with the emergency assembly point.
2. Distribute a booklet with general university information including:
    1. Location of the help desk.
    2. Location of the security offices.
    3. Location of the library.
    4. Suggested enrolment patterns for their degrees.
3. Discussion regarding safety, boundaries, personal conduct, and PPE.
4. Introduce the activity. (see resources section on next page)

Puzzle 1: Bridge Crossing (puzzle + answer located at end**)**

- Provide each student with a piece of paper containing the "Bridge Crossing" puzzle.
- Challenge students to find the fastest time for all four students to cross the bridge safely.
- Once they solve the puzzle, and enter the correct answer into the device. They will get the clue for Puzzle 2.

Puzzle 2: Emergency Exit Haiku

- The students will read a haiku clue off the screen.
- The clue directs students to the emergency exit maps for F block, leading them to the emergency assembly point.
- When the student are outside the gps will track their positions and the leds on the gps Pannel will flash faster as they approach the target location.
- Once at the assembly point, the student will unlock the third puzzle.

Puzzle 3: Head of School's Room Number

- The students will be asked to provide the Room Number for the engineering head of school.
- Students should visit the help desk (as mentioned in the booklet) to inquire about the phone extension.
- Once they obtain the extension, they will be given a puzzle piece and provided the next clue.

Puzzle 4: Resistance Challenge

- The students will be given a resistance value and a set of resistors (on the switch Pannel).
- Instruct them to build the specified resistance by connecting resistors in series and parallel.
- Students should visit the library to seek assistance from the librarian, who will provide a sheet explaining resistor values and connections.
- Once they construct the correct resistance, they will be provided with the next clue.

Puzzle 5: Room Access

- The next clue will direct students to enter a locked room that they do not have access to.
- They must approach a member of staff or campus security to request access to the room.
- Once inside, they get the final puzzle.

Puzzle 6: Degree Course Count

- The final puzzle asks students to determine how many individual courses are in their degrees.
- If they don't know the answer, they can find it in the booklet provided before the activity.
- Once they answer correctly, they have completed all challenges.

Reward:

- Reward students with a Lego minifigure for successfully completing all challenges.

This orientation activity encourages teamwork, problem-solving, and familiarity with important campus locations and resources while engaging students in fun puzzles. It offers a great way to welcome first-year engineering students to the university and their degree program.

Resources:

Activity introduction: the weird fun bit.

In a sill American general accent

“

Alright people drop everything and listen up!

We have an emergency. And we need to act fast.

Now the current situation is this.

The evil MegaMind corporation have just enacted their doomsday protocol! In one hour every powerplant on the planet will explode, destroying the power grid, and sending the human race back to the dark ages.
So far, every attempt to disable the protocol has met with total failure!
Now the world needs you! and your unique skills to help us disable it.

Intelligence suggests that the heads of the MegaMind corporation have transformed themselves into tiny living plastic figurines and locked themselves into their secure vault. It seems that they intend to survive the coming cataclysm and set themselves up as rulers in this post-apocalyptic new world.
Now, We suspect that they have taken the doomsday protocol disarm key into that vault with them.

Thanks to our spies inside of the corporation we know that the leader of this conspiracy has locked the vault with a series of challenges that you are all uniquely qualified to handle!

We have received the first clue to the vault and we are sending it through to you now.

Good Luck Team, the world is counting on you!

General Out.

“

Puzzle 1: The Bridge Crossing

Scenario: You have a group of four first-year engineering students who need to cross a bridge at night. They have only one flashlight, and the bridge is too dangerous to cross without it. The bridge can only hold two people at a time. The four students walk at different speeds: one can cross the bridge in 1 minute, another in 2 minutes, another in 5 minutes, and the slowest in 10 minutes. When two students cross the bridge together, they must go at the slower student's pace.

Challenge: Your task is to find the fastest time possible for all four students to cross the bridge safely.

Answer:

1. The two fastest students (1 minute and 2 minutes) cross the bridge together, taking 2 minutes (2 minutes elapsed).
2. The fastest student (1 minute) returns with the flashlight, taking 1 minute (3 minutes elapsed).

3. The two slowest students (5 minutes and 10 minutes) cross the bridge together, taking 10 minutes (13 minutes elapsed).
4. The second-fastest student (2 minutes) returns with the flashlight, taking 2 minutes (15 minutes elapsed).
5. Finally, the two fastest students (1 minute and 2 minutes) cross the bridge together one more time, taking 2 minutes (17 minutes elapsed).

Puzzle 2: Emergency Exit Haiku

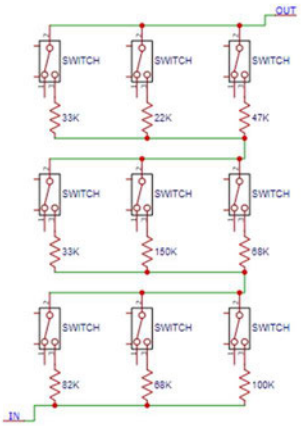
Haiku is as follows:
- *From F block you flee.*
- *To a point of safety*
- *On a map you'll find me.*

The clue will reference the emergency maps leading the students to the emergency assembly point.

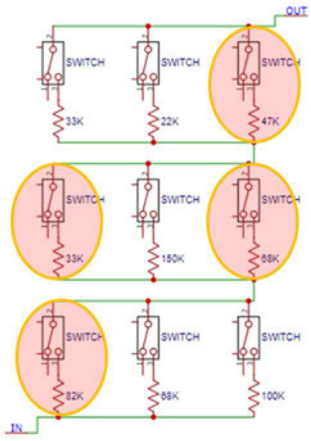
Puzzle 4: Resistance Challenge

The students are given the circuit below and are required to create an resistance of 150k Ω ±%1.

Question,



Answer,



Other:
For this test the 'students' will be given an unofficial orientation booklet rather than an official document. This document will be:

University of Southern Queensland
First Year Orientation Booklet

UniSQ

unisq.edu.au

Welcome to UniSQ

Welcome to the university of southern Queensland! This introductory booklet contains some information on life at UniSQ and the resources available to you as a student.

We Are All Quite Proud Of You!

You have started a university degree.
For many of you this is your first step out of school and for others it is a decision that you have made later in life; in either case you have put in so much effort to be here and you should take some the time to appreciate yourself for the dedication that you have shown to get this far.

No matter what happens in the future, know that you had the determination to get here and that, with resolve and courage, you have the capacity to achieve anything.

iconnect

Your first point of contact for all student enquiries.

At UniSQ, we want our students to feel supported, but realise it isn't always easy knowing where to get help. That's why we launched iconnect.

iconnect helps students find the information they need and can connect them with relevant UniSQ support services. Available by chat, email, phone or face-to-face, we work closely with all areas of the university to ensure you get the answers you need. Our concierges are current UniSQ students, just like you, and are trained to support you through your learning journey.

How to find us

Contact us at:
Phone: +61 7 4631 2285
Toll free calls: 1800 007 252
Email: usq.support@usq.edu.au

Or visit us on campus

UniSQ Toowoomba

Location: Student Central (R Block)
Opening hours: Monday - Friday 8:00am to 5:00pm (AEST)

UniSQ Ipswich

Location: Library (H Block)
Opening hours: Monday - Friday 8:00am to 5:00pm (AEST)

UniSQ Springfield

Location: Atrium (B Block)
Opening hours: Monday - Friday 8:00am to 5:00pm (AEST)

Library

UniSQ Library provides a supportive, connected and intuitive experience that enables:

- students to develop the confidence, resilience and skills required to reach their potential as engaged, informed and productive citizens, and
- staff to access the tools, supports and systems required to reach their potential as world-class teachers, researchers and professionals.

Library Experience

The Library Experience team provides learning spaces, information services, and a premium digital experience for UniSQ students and staff. The team gathers and analyses evidence to improve library services and better understand our students and academic staff.

Content

The Content team provides access to content, advice and support on intellectual property rights, manages UniSQ created learning objects and research outputs, and ensures data quality across our various content systems.

Learning and Research

The Learning and Research team works with academic staff to support their teaching and research, and with students to support them to develop the skills to succeed at University. The Learning and Research team provides peer support, education support, and research support services, as well as co-curricular and entrepreneurship opportunities via the UniSQ Library Makerspace.

Library events

The UniSQ library also hosts a number of events to assist students in both, their study and learning journeys, and connecting with UniSQ community through common interests.

Check out the library events at: https://www.unisq.edu.au/library/unisq-libraries/events

Makerspace

The UniSQ Makerspace is a community space for hands-on making with new digital fabrication technologies and traditional crafts. The Makerspace can be used for class projects, research, personal projects and hardware prototyping. Currently, the Makerspace has 3D Printers, 3D scanner, soldering station, a badge maker, hand tooling, a sewing machine, craft materials and much more.

Opening hours

Our libraries are available for individual and group study. 24-hour computer spaces are available in Ipswich and Springfield libraries, and adjoining the Toowoomba library.

Where is the Library located?

There is a branch of the UniSQ Library located at each of our three campuses:

- Toowoomba Campus Library - Located in B block (Levels 2 & 3) (Toowoomba campus & map)
- Springfield Campus Library - Located in A block (Level 1) (Springfield campus & map)
- Ipswich Campus Library - Located in H block (Level 2) (Ipswich campus & map)

UniSQ Clubs

Clubs and societies are a core part of student life at UniSQ, bringing together vibrant and diverse communities and providing opportunities for current UniSQ students. Each of our clubs has a purpose and it is likely there is one focused on something you are passionate about. By joining even one of the many clubs available, you will not only have the opportunity to create great friendships, capture lasting memories and have a blast, but you can also build skills that will help further your career.

What do you do if you can't find a club you are passionate about? Start your own! With dedicated staff to guide you through the process, and an abundance of resources, it has never been easier to start a club or society. All you need is an idea.

Visit the club website for more information on the clubs available at the university.
https://www.unisq.edu.au/current-students/support/student-clubs/find-a-club

swipe ID cards.

Manny of the building and rooms in the UniSQ campuses are locked using electronic

As a student you will be issued an ID card. These cards are essential for you as you will need to have them to access certain areas rooms in the university, access out of hours resources (such as computer labs), and to access in person examinations.

If you lose your ID, lock it in a room, or if you don't have the access that you believe that you should, you can contact the UniQS campus security offices to request assistance.

Campus Safety and Security

UniSQ Security assists in providing a safe and secure environment for persons and property. Trained and experienced security guards patrol the Toowoomba, Springfield, and Ipswich campuses 24 hours a day, seven days a week.

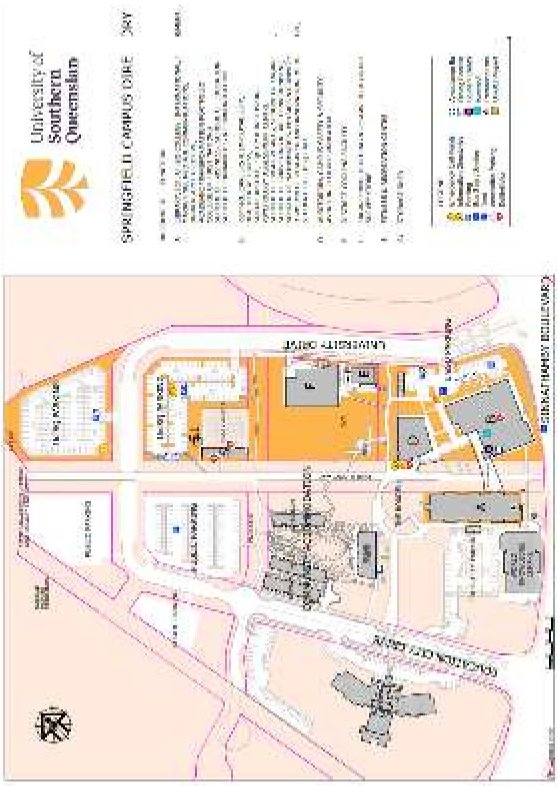
Security Office contact details

Please note for all emergencies phone +61 7 4631 2222

Campus	Room	Phone	Email
Toowoomba	Z3 101	+61 7 4631 2871 +61 412 716 838	security@usq.edu.au
Springfield	D112	+61 7 3470 4444 +61 437 229 320	usqsecspringfield@usq.edu.au
Ipswich	H110	+61 7 3812 6060 +61 428 086 790	ipswichsecurityoffice@usq.edu.au

Personal protection services

UniSQ Security provides close personal protection (escorts) to visitors 24 hours, seven days per week, if available. Please contact the Security Office on your campus.



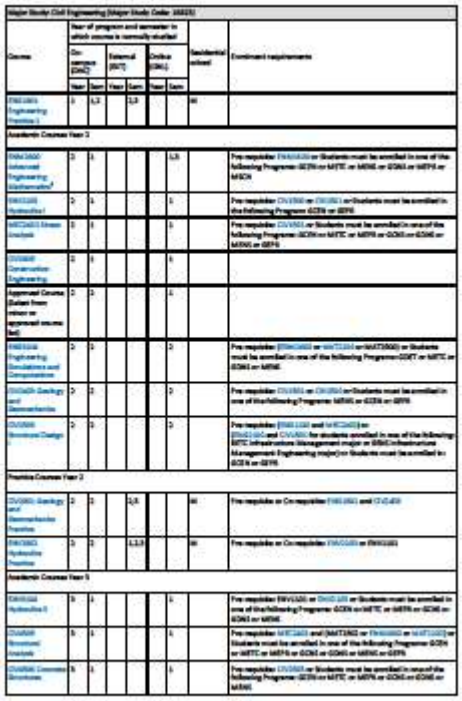
Your Course:

Welcome to the university of southern Queensland! As part of your introductory information, you are provided with the suggested enrolment pattern for you major. This pattern is not compulsory however deviating from it may leave you in an awkward position. Some of the courses have pre-requisites and if you are not careful you can end up in a position where you are unable to take a full load in a semester due to pre-requisite restrictions.

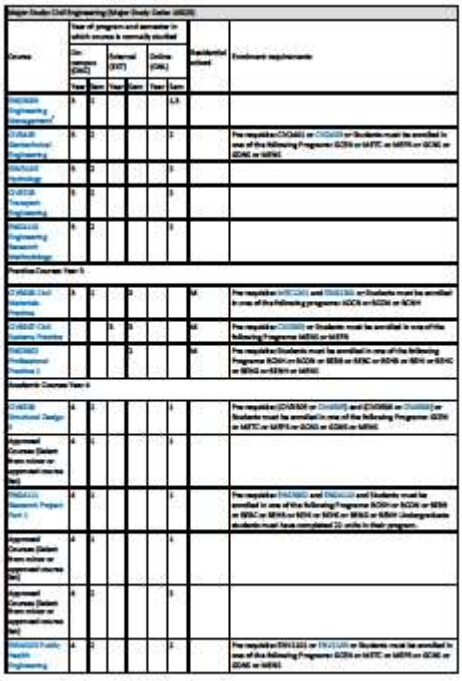
If you ever need assistance with understanding the enrolment pattern, or adapting the enrolment pattern to your unique situation, please feel free to get in contact with the Iconnect team.

Civil Engineering major full-time recommended enrolment pattern (Toowoomba and Springfield campus)

Major Study: Civil Engineering (Major Study Code: [illegible])								
Course	Year of program and semester in which course is normally studied						Residential school	Enrolment requirements
	On campus (ONC)		External (EXT)		Online (ONL)			
	Year	Sem	Year	Sem	Year	Sem		
Academic Courses Year 1								
ENG1101 Introduction to Engineering and Built Environment Applications	1	1				1,2		
ENM1600 Engineering Mathematics	1	1				1,2		Enrolment is not permitted in ENM1600 if MAT1102 or MAT1502 has been previously completed
ENG1002 Engineering Problem Solving Principles	1	1				1,2		
MEC1201 Engineering Materials	1	1				1,2,3		
ENG1102 Introduction to Engineering Design	1	2				1,2		
CIV1500 Engineering Statics	1	2				1,3		Pre-requisite: ENM1600 or (ENM1500 and CIV1500) or Students must be enrolled in one of the following Programs: BEPH or BEPS or BEPA
ENG1003 Technology, Sustainability and Society	1	2				1,2,3		
SVY1500 Spatial Science for Engineers	1	2				1		
Practice Courses Year 1								



DO NOT USE. NOT OFFICIAL CONTENT. For trial purpose only! 09-23



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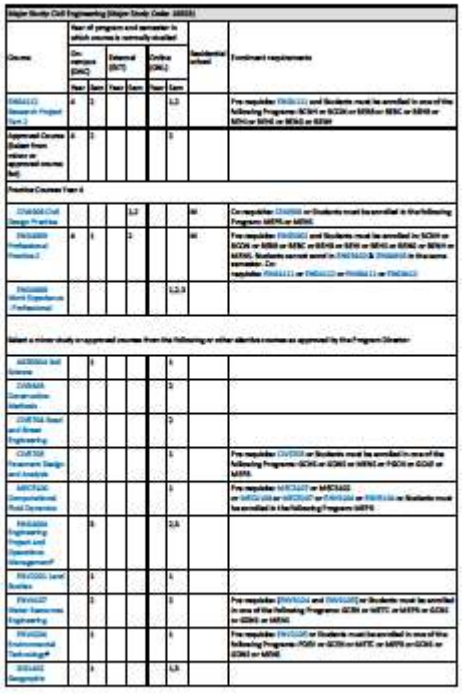

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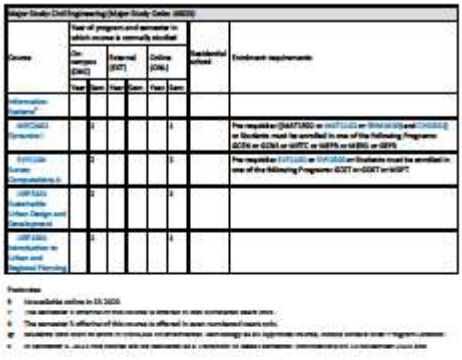

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E- Risk Assessment

RMP

Step 1 (cont)	Step 2	Step 2a	Step 3			Step 4				
Hazards: From step 1 or more if identified	**The Risk:** What can happen if exposed to the hazard with existing controls in place?	**Existing Controls:** What are the existing controls that are already in place?	**Risk Assessment:** (use the Risk Matrix on p3) Consequence x Probability = Risk Level			**Additional controls:** Enter additional controls if required to reduce the risk level	**Risk assessment with additional controls:** (use the Risk Matrix on p3 – has the consequence or probability changed?)			**Controls Implemented? Yes/No**
			Consequence	Probability	Risk Level		Consequence	Probability	Risk Level	
Example										
Working in temperatures over 35° C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	Regular breaks, chilled water available, loose clothing, fatigue management policy.	catastrophic	possible	high	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
During the testing the testing participants will be spending significant time in the testing locationg while focusing on the device.	sun burn	the testers will wear hats and sunscreen.	Minor	Unlikely	Low		Select a consequence	Select a probability	Select a Risk Level	Yes or No
	trip hazard	using small teams of adults, to test the system. as a group they will be able to avoid hazardous terain.	Moderate	Rare	Low		Select a consequence	Select a probability	Select a Risk Level	Yes or No
	walking onto a road or carpark	using small teams of adults, to test the system. They should have the common sense to not walk into trafic.	Catastrophic	Unlikely	Moderate	Having a limited testing area that does not contain any roads or carparks. Ensuring that the participants know the location boundries.	Catastrophic	Rare	Low	Yes or No
interupting campus services	interupting security resulting in a hazardous workplace	the trial coordinator will act as a substitute for any critical staff members to avoid any service interuptions.	Moderate	Unlikely	Moderate		Insignificant	Rare	Low	Yes or No

Step 1 (cont)	Step 2	Step 2a	Step 3			Step 4				
Hazards: From step 1 or more if identified	**The Risk:** What can happen if exposed to the hazard with existing controls in place?	**Existing Controls:** What are the existing controls that are already in place?	**Risk Assessment:** (use the Risk Matrix on p3) Consequence x Probability = Risk Level			**Additional controls:** Enter additional controls if required to reduce the risk level	**Risk assessment with additional controls:** (use the Risk Matrix on p3 – has the consequence or probability changed?)			**Controls Implemented? Yes/No**
			Consequence	Probability	Risk Level		Consequence	Probability	Risk Level	
Example										
Working in temperatures over 35° C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	Regular breaks, chilled water available, loose clothing, fatigue management policy.	catastrophic	possible	high	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
storms and bad weather	higher chances for injury	Appropriate atire for the wheather conditions.	Moderate	Unlikely	Moderate	If there is bad weather the trial can be simulated indoors.	Moderate	Rare	Low	Yes or No
	equipment damage.	the equipment is rouged and inside a case. there is minamal risk of equipment damage.	Moderate	Rare	Low		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Minor	Unlikely	Low		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No
			Select a consequence	Select a probability	Select a Risk Level		Select a consequence	Select a probability	Select a Risk Level	Yes or No

F- Device version specifications

The Testing is to be conducted using the Tesseract V3 the details of this version are listed below:

X2.B2.C2.A3.F.D3 (frame, left panel, right panel, top panel, bottom panel, back panel)

This code describes identifies the version of each panel used as well as the location of the panels on the device.

Appendix K

Test Four Example Student Orientation Booklet

University of Southern Queensland

First Year Orientation Booklet

UniSQ

unisq.edu.au

Welcome to UniSQ

Welcome to the university of southern Queensland! This introductory booklet contains some information on life at UniSQ and the resources available to you as a student.

We Are All Quite Proud Of You!

You have started a university degree.
For many of you this is your first step out of school and for others it is a decision that you have made later in life; in either case you have put in so much effort to be here and you should take some the time to appreciate yourself for the dedication that you have shown to get this far.

No matter what happens in the future, know that you had the determination to get here and that, with resolve and courage, you have the capacity to achieve anything.

iconnect

Your first point of contact for all student enquiries.

At UniSQ, we want our students to feel supported, but realise it isn't always easy knowing where to get help. That's why we launched iconnect.

iconnect helps students find the information they need and can connect them with relevant UniSQ support services. Available by chat, email, phone or face-to-face, we work closely with all areas of the university to ensure you get the answers you need. Our concierges are current UniSQ students, just like you, and are trained to support you through your learning journey.

How to find us

Contact us at:
Phone: +61 7 4631 2285
Toll free calls: 1800 007 252
Email: **usq.support@usq.edu.au**

Or visit us on campus

UniSQ Toowoomba

Location: Student Central (R Block)
Opening hours: Monday - Friday 8:00am to 5:00pm (AEST)

UniSQ Ipswich

Location: Library (H Block)
Opening hours: Monday - Friday 8:00am to 5:00pm (AEST)

UniSQ Springfield

Location: Atrium (B Block)
Opening hours: Monday - Friday 8:00am to 5:00pm (AEST)

Library

UniSQ Library provides a supportive, connected and intuitive experience that enables:

- students to develop the confidence, resilience and skills required to reach their potential as engaged, informed and productive citizens, and
- staff to access the tools, supports and systems required to reach their potential as world-class teachers, researchers and professionals.

Library Experience

The Library Experience team provides learning spaces, information services, and a premium digital experience for UniSQ students and staff. The team gathers and analyses evidence to improve library services and better understand our students and academic staff.

Content

The Content team provides access to content, advice and support on intellectual property rights, manages UniSQ created learning objects and research outputs, and ensures data quality across our various content systems.

Learning and Research

The Learning and Research team works with academic staff to support their teaching and research, and with students to support them to develop the skills to succeed at University. The Learning and Research team provides peer support, education support, and research support services, as well as co-curricular and entrepreneurship opportunities via the UniSQ Library Makerspace.

Library events

The UniSQ library also hosts a number of events to assist students in both, their study and learning journeys, and connecting with UniSQ community through common interests.

Check out the library events at: **https://www.unisq.edu.au/library/unisq-libraries/events**

Makerspace

The UniSQ Makerspace is a community space for hands-on making with new digital fabrication technologies and traditional crafts. The Makerspace can be used for class projects, research, personal projects and hardware prototyping. Currently, the Makerspace has 3D Printers, 3D scanner, soldering station, a badge maker, hand tooling, a sewing machine, craft materials and much more.

Opening hours

Our libraries are available for individual and group study. 24-hour computer spaces are available in Ipswich and Springfield libraries, and adjoining the Toowoomba library.

Where is the Library located?

There is a branch of the UniSQ Library located at each of our three campuses:

- Toowoomba Campus Library - Located in **R** block (Levels 2 & 3) (Toowoomba campus & map)
- Springfield Campus Library - Located in **A** block (Level 1) (Springfield campus & map)
- Ipswich Campus Library - Located in **H** block (Level 2) (Ipswich campus & map)

UniSQ Clubs

Clubs and societies are a core part of student life at UniSQ, bringing together vibrant and diverse communities and providing opportunities for current UniSQ students. Each of our clubs has a purpose and it is likely there is one focused on something you are passionate about. By joining even one of the many clubs available, you will not only have the opportunity to create great friendships, capture lasting memories and have a blast, but you can also build skills that will help further your career.

What do you do if you can't find a club you are passionate about? Start your own! With dedicated staff to guide you through the process, and an abundance of resources, it has never been easier to start a club or society. All you need is an idea.

Visit the club website for more information on the clubs available at the university.
https://www.unisq.edu.au/current-students/support/student-clubs/find-a-club

swipe ID cards.

Manny of the building and rooms in the UniSQ campuses are locked using electronic

As a student you will be issued an ID card. These cards are essential for you as you will need to have them to access certain areas rooms in the university, access out of hours resources (such as computer labs), and to access in person examinations.

If you lose your ID, lock it in a room, or if you don't have the access that you believe that you should, you can contact the UniQS campus security offices to request assistance.

Campus Safety and Security

UniSQ Security assists in providing a safe and secure environment for persons and property. Trained and experienced security guards patrol the Toowoomba, Springfield, and Ipswich campuses 24 hours a day, seven days a week.

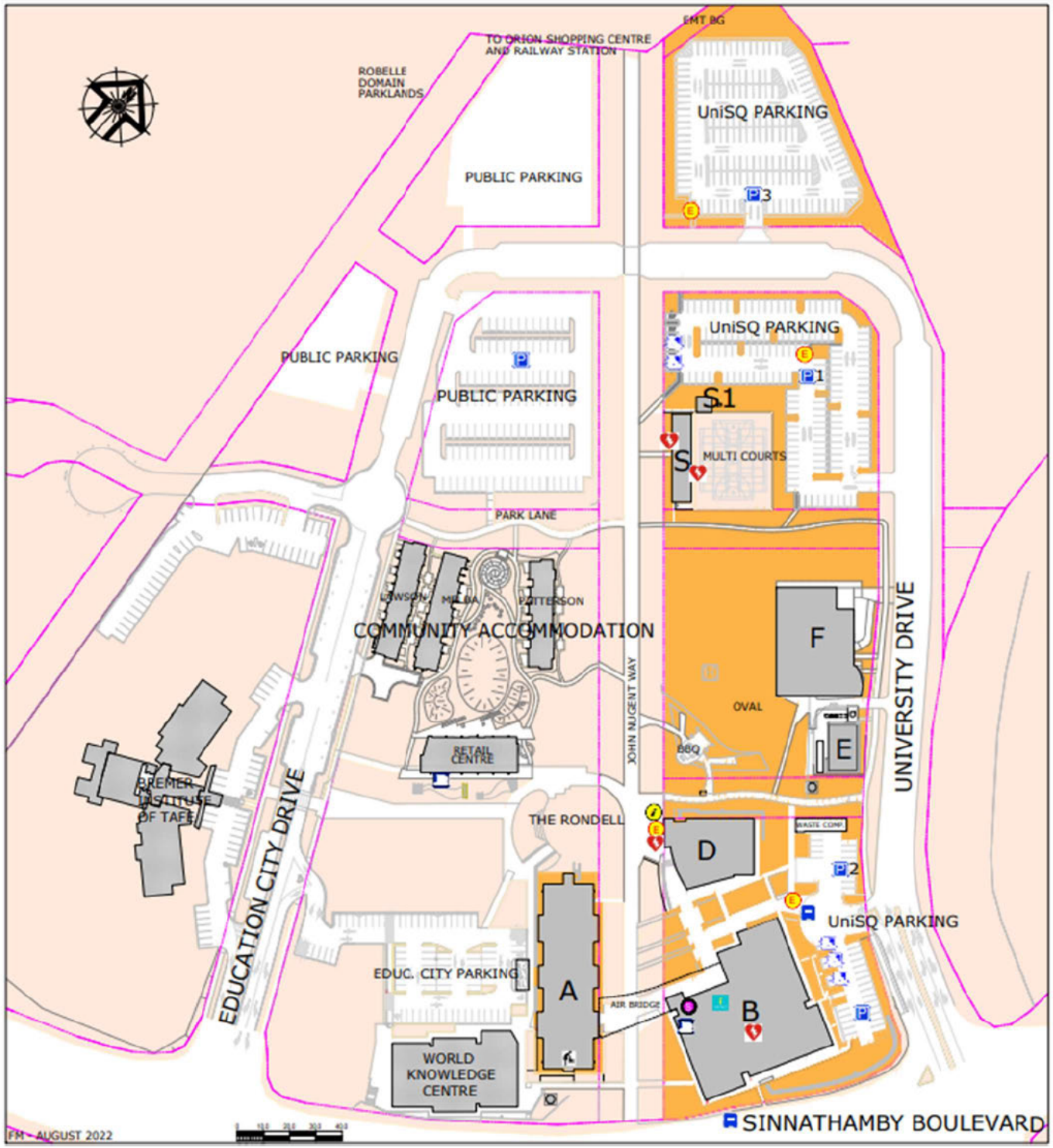
Security Office contact details

Please note **for all emergencies phone +61 7 4631 2222**

Campus	Room	Phone	Email
Toowoomba	Z3 101	+61 7 4631 2871 +61 412 716 838	security@usq.edu.au
Springfield	D112	+61 7 3470 4444 +61 437 229 320	usqsecspringfield@usq.edu.au
Ipswich	H110	+61 7 3812 6060 +61 428 086 790	ipswichsecurityoffice@usq.edu.au

Personal protection services

UniSQ Security provides close personal protection (escorts) to visitors 24 hours, seven days per week, if available. Please contact the Security Office on your campus.



University of Southern Queensland

SPRINGFIELD CAMPUS DIRE ORY

BUILDING ID	FUNCTION
A	LIBRARY, ICT, UniSQ COLLEGE, INTERNATIONAL, E GEMENT, MARKETING, MEDIA & COMMUNICATIONS, UNIVERSITY EXECUTIVE, ACADEMIC TRANSFORMATION PORTFOLIO COLLEGE OF FIRST NATIONS SCHOOL OF BUSINESS, SCHOOL OF EDUCATION, SCHOOL OF HUMANITIES & COMMUNICATION
B	iconnect, CAREERS & EMPLOYABILITY, HEALTH & WELLNESS, SOCIAL JUSTICE, EQUITY & INCLUSION, PSYCHOLOGY ASSESSMENT CENTRE SCHOOL OF CREATIVE ARTS, SCHOOL OF ENGINEE ;, SCHOOL OF SURVEYING & BUILT ENVIRONMENT, SCHOOL OF MATHEMATICS, PHYSICS & COMPUTIN DIVISION OF RESEARCH AND INNOVATION, MEDIA ITRE, STUDENT LIFE, USQ CAFE
D	AUDITORIUM, CAMPUS SAFETY & SECURITY AVIATION - FLIGHT SIMULATOR
E	DISTRICT COOLING FACILITY
F	ENGINEERING TEACHING & RESEARCH LABORATOI SURVEY STORE
S	FITNESS & RECREATION CENTRE
S1	STORAGE SHED

LEGEND

- Emergency Call Points
- Information Directories
- Parking
- Bus Stop / Shelter
- Taxi
- Accessible Parking
- Defibrillator
- Ambulance Bay
- Dining Facilities
- Student Centre
- iconnect
- Parenting Roor
- UniSQ Property

Your Course:

Welcome to the university of southern Queensland! As part of your introductory information, you are provided with the suggested enrolment pattern for you major. This pattern is not compulsory however deviating from it may leave you in an awkward position. Some of the courses have pre-requisites and if you are not careful you can end up in a position where you are unable to take a full load in a semester due to pre-requisite restrictions.

If you ever need assistance with understanding the enrolment pattern, or adapting the enrolment pattern to your unique situation, please feel free to get in contact with the Iconnect team.

Civil Engineering major full-time recommended enrolment pattern (Toowoomba and Springfield campus)

Major Study: Civil Engineering (Major Study Code: 16923)								
Course	Year of program and semester in which course is normally studied						Residential school	Enrolment requirements
	On-campus (ONC)		External (EXT)		Online (ONL)			
	Year	Sem	Year	Sem	Year	Sem		
Academic Courses Year 1								
ENG1002 Introduction to Engineering and Built Environment Applications	1	1				1,2		
ENM1600 Engineering Mathematics	1	1				1,2		Enrolment is not permitted in ENM1600 if MAT1102 or MAT1502 has been previously completed
ENG1004 Engineering Problem Solving Principles	1	1				1,2		
MEC1201 Engineering Materials	1	1				1,2,3		
ENG1100 Introduction to Engineering Design	1	2				1,2		
CIV1501 Engineering Statics	1	2				2,3		Pre-requisite: ENM1600 or (ENM1500 and CIV1500) or Students must be enrolled in one of the following Programs: MEPR or GCEN or GEPR
ENG2002 Technology, Sustainability and Society	1	2				1,2,3		
SVY1500 Spatial Science for Engineers	1	2				2		
Practice Courses Year 1								

Major Study: Civil Engineering (Major Study Code: 16923)								
Course	Year of program and semester in which course is normally studied						Residential school	Enrolment requirements
	On-campus (ONC)		External (EXT)		Online (ONL)			
	Year	Sem	Year	Sem	Year	Sem		
ENG1901 Engineering Practice 1	1	1,2		2,3			M	
Academic Courses Year 2								
ENM2600 Advanced Engineering Mathematics[§]	2	1				1,3		Pre-requisite: ENM1600 or Students must be enrolled in one of the following Programs: GCEN or METC or MENS or GDNS or MEPR or MSCN
ENV2103 Hydraulics I	2	1				1		Pre-requisite: CIV1500 or CIV1501 or Students must be enrolled in the following Program: GCEN or GEPR
MEC2402 Stress Analysis	2	1				1		Pre-requisite: CIV1501 or Students must be enrolled in one of the following Programs: GCEN or METC or MEPR or GCNS or GDNS or MENS or GEPR
CIV2605 Construction Engineering	2	1				1		
Approved Course (Select from minor or approved course list)	2	2				1		
ENG3104 Engineering Simulations and Computations	2	2				2		Pre-requisite: (ENM2600 or MAT2100 or MAT2500) or Students must be enrolled in one of the following Programs: GDET or METC or GDNS or MENS
CIV2403 Geology and Geomechanics	2	2				2		Pre-requisite: CIV1501 or CIV1500 or Students must be enrolled in one of the following Programs: MENS or GCEN or GEPR
CIV2503 Structural Design I	2	2				2		Pre-requisite: (ENG1100 and MEC2402) or (ENG1100 and CIV1501 for students enrolled in one of the following: BETC Infrastructure Management major or BENS Infrastructure Management Engineering major) or Students must be enrolled in: GCEN or GEPR
Practice Courses Year 2								
CIV2901 Geology and Geomechanics Practice	2	2		2,3			M	Pre-requisite or Co-requisite: ENG1901 and CIV2403
ENV2902 Hydraulics Practice	2	2		1,2,3			M	Pre-requisite or Co-requisite: ENV2103 or ENV1101
Academic Courses Year 3								
ENV3104 Hydraulics II	3	1				1		Pre-requisite: ENV1101 or ENV2103 or Students must be enrolled in one of the following Programs: GCEN or METC or MEPR or GCNS or GDNS or MENS
CIV4505 Structural Analysis	3	1				1		Pre-requisite: MEC2402 and (MAT1502 or ENM1600 or MAT1102) or Students must be enrolled in one of the following Programs: GCEN or METC or MEPR or GCNS or GDNS or MENS or GEPR
CIV4506 Concrete Structures	3	1				1		Pre-requisite: CIV2503 or Students must be enrolled in one of the following Programs: GCEN or METC or MEPR or GCNS or GDNS or MENS

Major Study: Civil Engineering (Major Study Code: 16923)								
Course	Year of program and semester in which course is normally studied						Residential school	Enrolment requirements
	On-campus (ONC)		External (EXT)		Online (ONL)			
	Year	Sem	Year	Sem	Year	Sem		
ENG3003 Engineering Management[‡]	3	1				1,3		
CIV3403 Geotechnical Engineering	3	2				2		Pre-requisite: CIV2401 or CIV2403 or Students must be enrolled in one of the following Programs: GCEN or METC or MEPR or GCNS or GDNS or MENS
ENV3105 Hydrology	3	2				2		
CIV3703 Transport Engineering	3	2				2		
ENG4110 Engineering Research Methodology	3	2				2		
Practice Courses Year 3								
CIV3906 Civil Materials Practice	3	1		3			M	Pre-requisite: MEC1201 and ENG1901 or Students must be enrolled in one of the following programs: ADCN or BCON or BCNH
CIV3907 Civil Systems Practice			3	3			M	Pre-requisite: CIV2503 or Students must be enrolled in one of the following Programs: MENS or MEPR
ENG3902 Professional Practice 1				2			M	Pre-requisite: Students must be enrolled in one of the following Programs: BCNH or BCON or BEBB or BEBC or BEHB or BEHI or BEHS or BENG or BENH or MENS
Academic Courses Year 4								
CIV4508 Structural Design II	4	1				1		Pre-requisite: (CIV3505 or CIV4505) and (CIV3506 or CIV4506) or Students must be enrolled in one of the following Programs: GCEN or METC or MEPR or GCNS or GDNS or MENS
Approved Courses (Select from minor or approved course list)	4	1				1		
ENG4111 Research Project Part 1	4	1				1		Pre-requisite: ENG3902 and ENG4110 and Students must be enrolled in one of the following Programs: BCNH or BCON or BEBB or BEBC or BEHB or BEHI or BEHS or BENG or BENH Undergraduate students must have completed 22 units in their program.
Approved Courses (Select from minor or approved course list)	4	1				1		
Approved Courses (Select from minor or approved course list)	4	2				2		
ENV4203 Public Health Engineering	4	2				2		Pre-requisite: ENV1101 or ENV2103 or Students must be enrolled in one of the following Programs: GCEN or METC or MEPR or GCNS or GDNS or MENS

Major Study: Civil Engineering (Major Study Code: 16923)								
Course	Year of program and semester in which course is normally studied						Residential school	Enrolment requirements
	On-campus (ONC)		External (EXT)		Online (ONL)			
	Year	Sem	Year	Sem	Year	Sem		
ENG4112 Research Project Part 2	4	2				1,2		Pre-requisite: ENG4111 and Students must be enrolled in one of the following Programs: BCNH or BCON or BEBB or BEBC or BEHB or BEHI or BEHS or BENG or BENH
Approved Course (Select from minor or approved course list)	4	2				2		
Practice Courses Year 4								
CIV4908 Civil Design Practice				1,2			M	Co-requisite: CIV4508 or Students must be enrolled in the following Program: MEPR or MENS
ENG4903 Professional Practice 2	4	1		2			M	Pre-requisite: ENG3902 and Students must be enrolled in: BCNH or BCON or BEBB or BEBC or BEHB or BEHI or BEHS or BENG or BENH or MENS. Students cannot enrol in ENG3902 & ENG4903 in the same semester. Co-requisite: ENG4111 or ENG4112 or ENG8411 or ENG8412
ENG4909 Work Experience - Professional						1,2,3		
Select a minor study or approved courses from the following or other elective courses as approved by the Program Director								
AGR3304 Soil Science		1				1		
CIV3603 Construction Methods						2		
CIV5704 Road and Street Engineering						2		
CIV5705 Pavement Design and Analysis						1		Pre-requisite: CIV3703 or Students must be enrolled in one of the following Programs: GCNS or GDNS or MENS or PGCN or GCAE or MEPR
MEC5100 Computational Fluid Dynamics						1		Pre-requisite: MEC3107 or MEC3102 or MEC4108 or MEC5107 or ENV3104 or ENV5104 or Students must be enrolled in the following Program: MEPR
ENG4004 Engineering Project and Operations Management‡		3				2,3		
ENV2201 Land Studies		1				1		
ENV4107 Water Resources Engineering		2				2		Pre-requisite: (ENV3104 and ENV3105) or Students must be enrolled in one of the following Programs: GCEN or METC or MEPR or GCNS or GDNS or MENS
ENV4204 Environmental Technology®		1				1		Pre-requisite: ENV2105 or Students must be enrolled in one of the following Programs: PDEV or GCEN or METC or MEPR or GCNS or GDNS or MENS
GIS1402 Geographic		1				1,3		

Major Study: Civil Engineering (Major Study Code: 16923)								
Course	Year of program and semester in which course is normally studied						Residential school	Enrolment requirements
	On-campus (ONC)		External (EXT)		Online (ONL)			
	Year	Sem	Year	Sem	Year	Sem		
Information Systems£								
MEC2401 Dynamics I		1				1		Pre-requisite: ((MAT1502 or MAT1102 or ENM1600) and CIV1501) or Students must be enrolled in one of the following Programs: GCEN or GCNS or METC or MEPR or MENS or GEPR
SVY1104 Survey Computations A		2				2		Pre-requisite: SVY1102 or SVY1500 or Students must be enrolled in one of the following Programs: GCST or GDST or MSPT
URP3201 Sustainable Urban Design and Development		2				2		
URP1001 Introduction to Urban and Regional Planning		1				1		

Footnotes

§ Unavailable online in S3 2023

† The semester 3 offering of this course is offered in odd numbered years only.

‡ The semester 3 offering of this course is offered in even numbered years only.

@ Students who wish to enrol in ENV4204 Environmental Technology as an Approved course, should consult their Program Director.

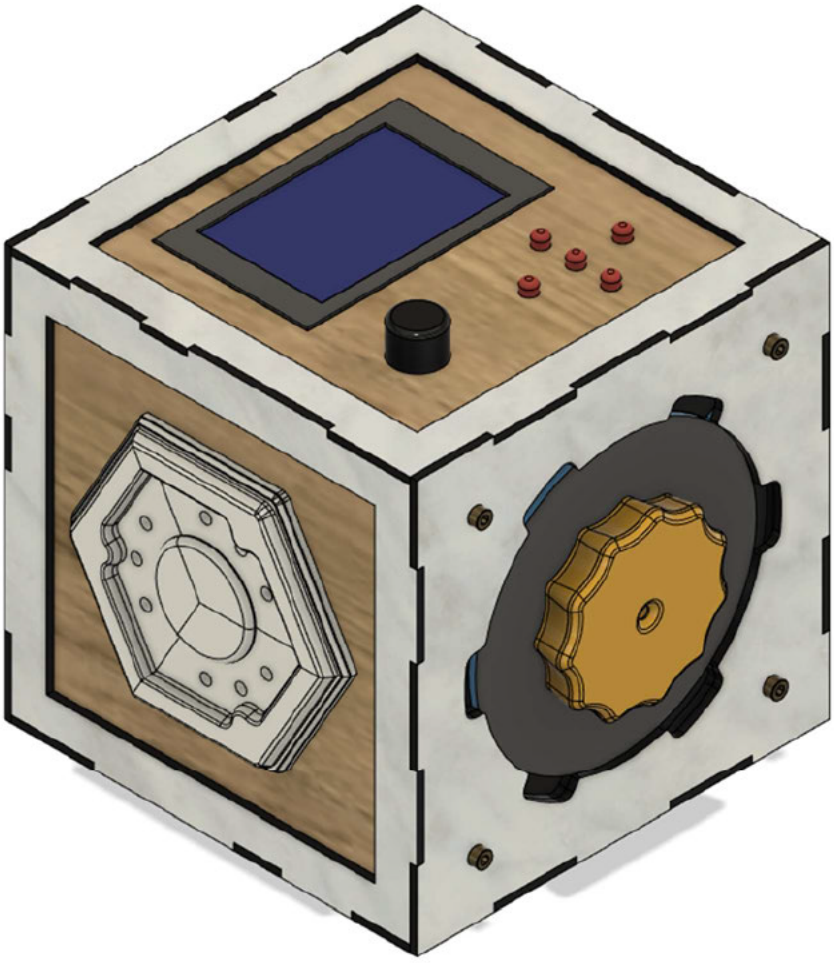
£ In Semester 3, 2023 this course will be delivered as a Transition (9 week) semester, commencing on 13 November 2023 and

Appendix L

Tesseract Device User Manual

User Instructions for the Tesseract

Modular Puzzle-Activity Platform



Angus Hampshire
2023

This document covers instructions for the use, setup, and modification of the Tesseract.

Contents

Introduction to the tesseract.

The tesseract is a modular open-source ingress box. This design is intended to mimic the challenge styles of an escape room while being safe and comfortable to use for all age-groups. The design takes the form of a cube with 5 modular faces, containing puzzle development activities, and one door face that has an electronically locked/unlocked door.

The tesseract is an innovative platform tailored for educators seeking to enhance their teaching approach. It is a modular puzzle-based-activity development and deployment platform that aims to assist educators in create engaging learning activities for students. By leveraging the capabilities of the tesseract, educators can develop customized puzzle-based activities that supplement traditional classroom lessons in an enjoyable and interactive manner, thereby facilitating students' comprehension and retention of subject knowledge.

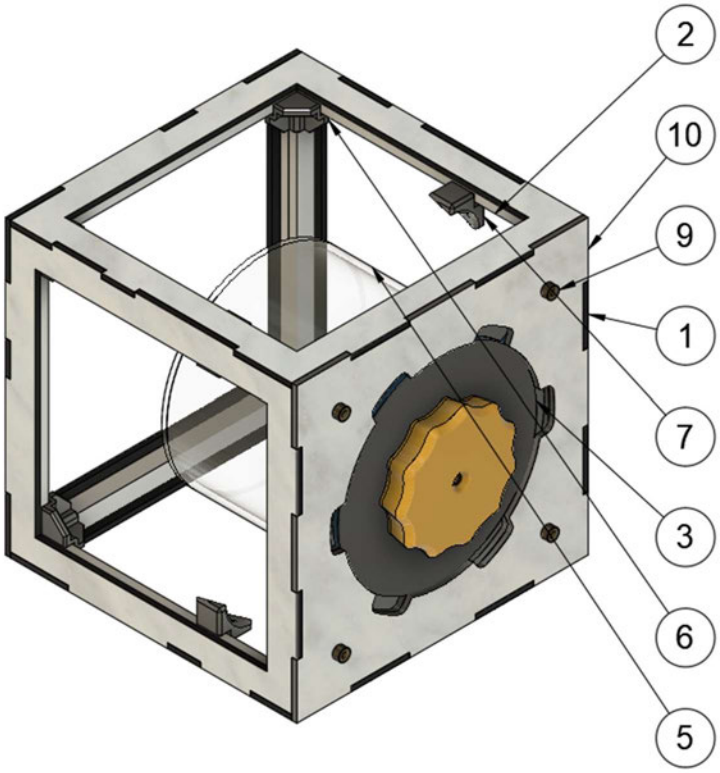
The tesseract's core operation is controlled by a standard Arduino style microcontroller. The availability of comprehensive Arduino system documentation and the widespread adoption of this device empower users to create activities using the tesseract without extensive prior experience in electronics.

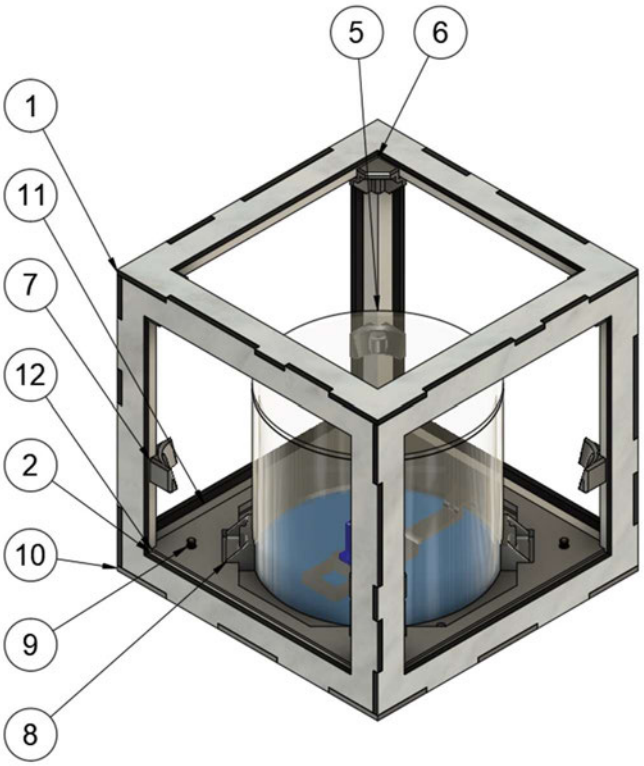
The standard setup of the Tesseract features four separate multi-role activity faces and one ingress face. The tesseract offers a versatile setup capable of generating activities across various educational curriculums. These faces are thoroughly explained in this document, and a well-documented example of activity development using the standard faces is provided.

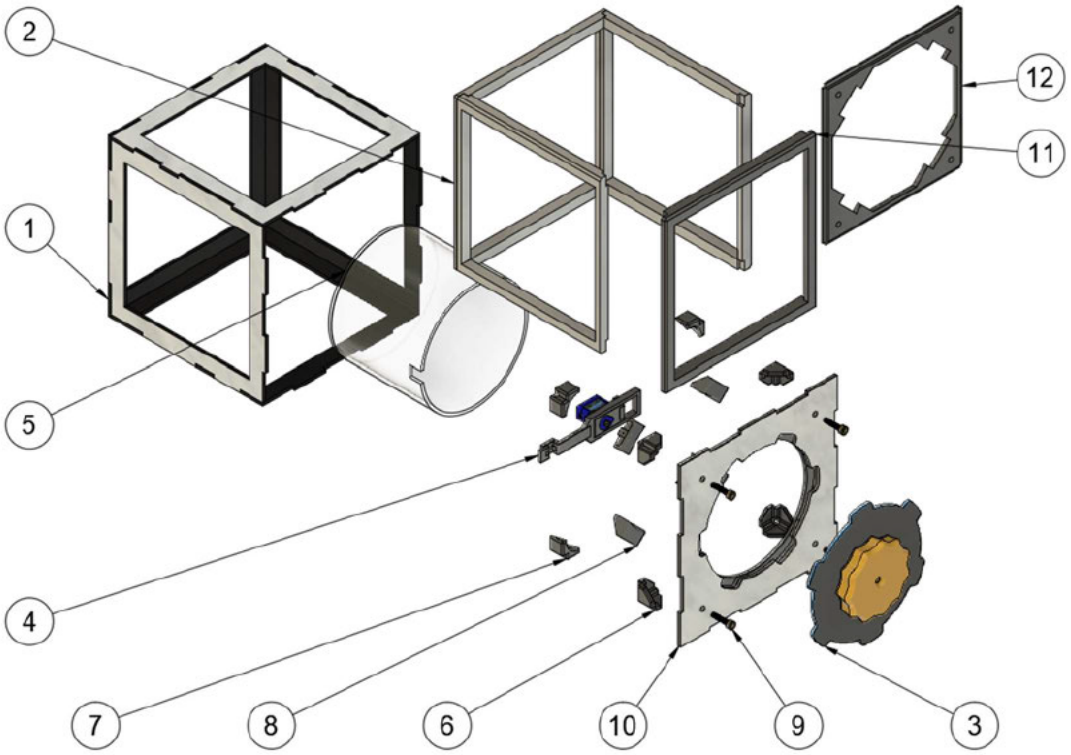
Furthermore, the tesseract is designed as a creative common, allowing end users to easily modify it according to their needs. This design's modularity lies in the removable puzzle faces, which can be effortlessly detached and are connected to the controller using a standard four-pin I2C connection. Consequently, users can replace these faces with custom components developed either by themselves or the broader community. Such modularity opens limitless possibilities for the tesseract, enabling the creation of new and stimulating activity options.

Design and Component:

Design





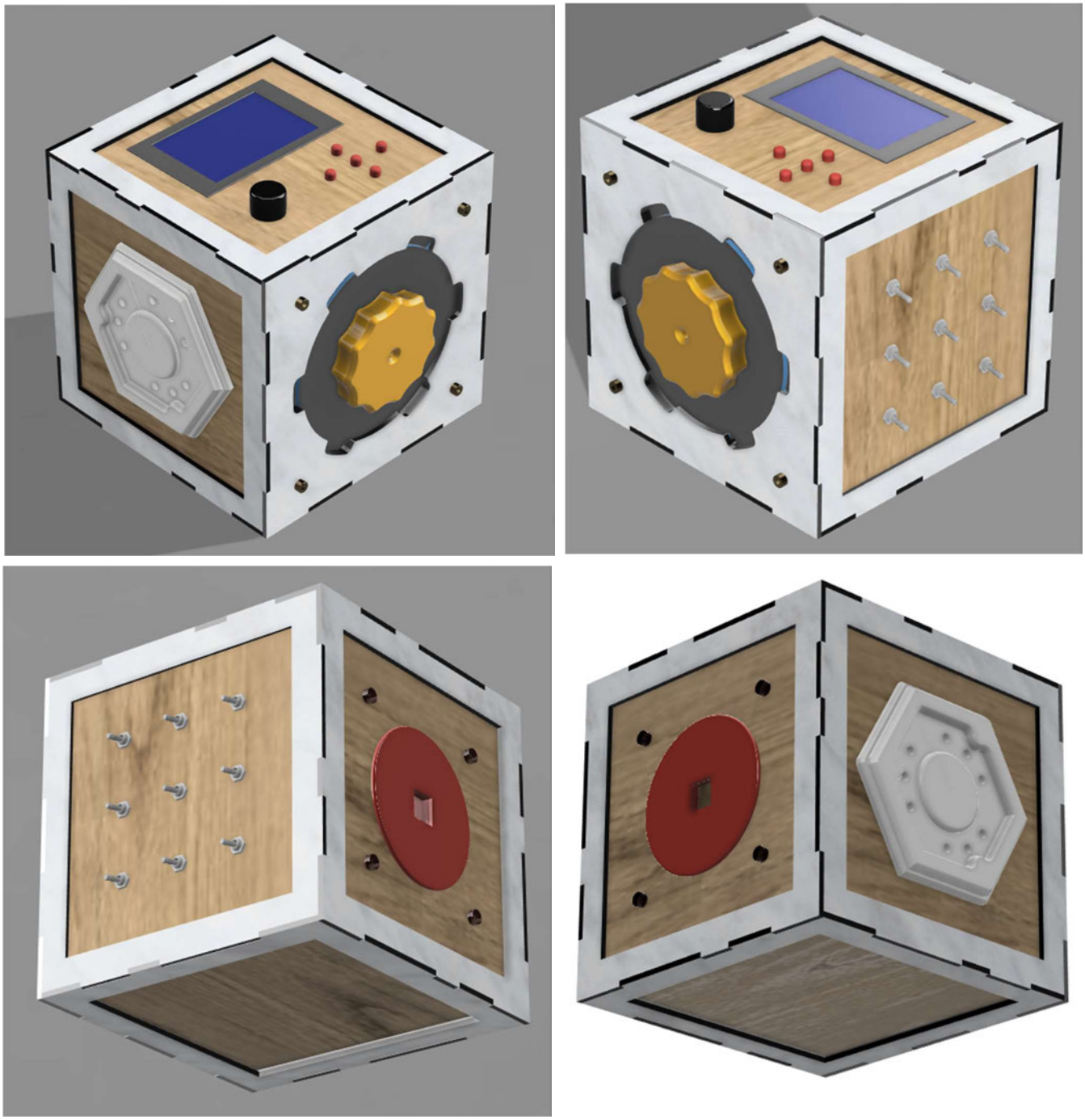


Item	Qty	Part	Description
1	1	Outer Shell Structure	The outer shell is the visible component of the structural frame for this device. the shell holds the faces of the modular puzzle panels.
2	1	Inner Structure	The inner structure frames and supports all of the modular inner faces
3	1	Door	Electronically controlled door
4	1	Hinge mechanism	Hinge for the door
5	4	Inner Chamber	A barrier to avoid having the internal components exposed to the device users
6	4	Corner bracket	A bracket that holds the modular faces inside the inner structure and against the outer structure.
7	4	Pillar Bracket	A bracket that holds the modular faces inside the inner structure and against the outer structure.
8	4	Inner chamber mount	Brackets to mount the inner chamber to the Door face
9	4	M4 Door Face Screw	Screws to mount the door face to the suspension frame.
10	1	Door Face	The front face of the platform.
11	1	Door Inner Frame	A removable internal component that must be removed to access the faces.
12	1	Suspension Frame	The bracket that fixes the Door face to the inner structure via the 4 bolts.

Faces

This section covers the standard faces. There are descriptions of the standard faces and their capabilities/uses.

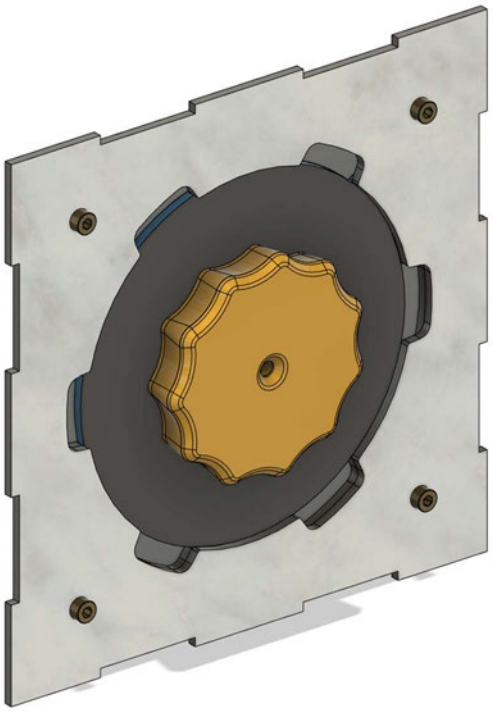
The box with the standard faces installed.



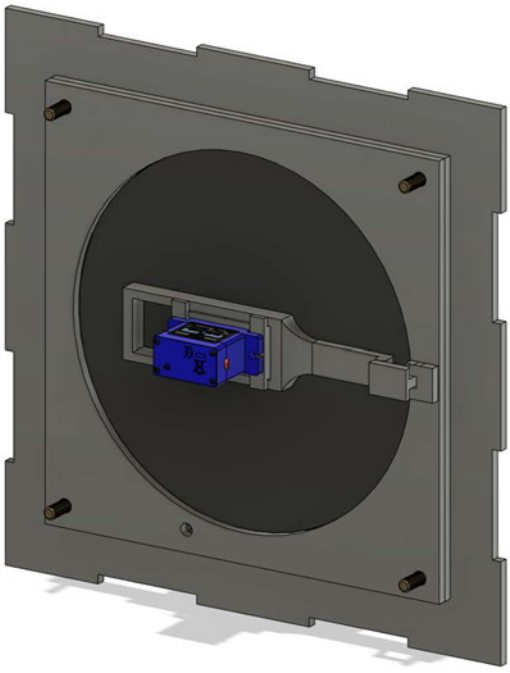
Ingress face

While any part of the design can be modified for the users' requirements, the ingress face is the one face of the box that in not natively designed to be modular. The ingress face has a round volt style door that is controlled electronically by the microcontroller. This door is intended to be the goal of the platform. The user can setup an activity with multiple challenges culminating in the ingress face opening and the activity participants gaining access to something stored inside of the box (a prize or some other token).

Front view:



Rear View:



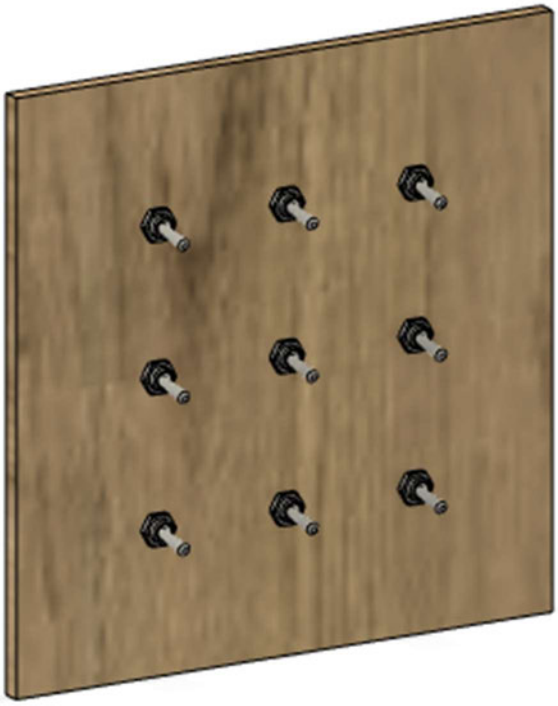
Switches

The switch panel consists of a bank of 9 switches in a 3x3 matrix, and two (2) LED's (red and green). The purpose of this face is to have the participants switch the correct switches on in order to have the red LED turn off and the green LED turn on.

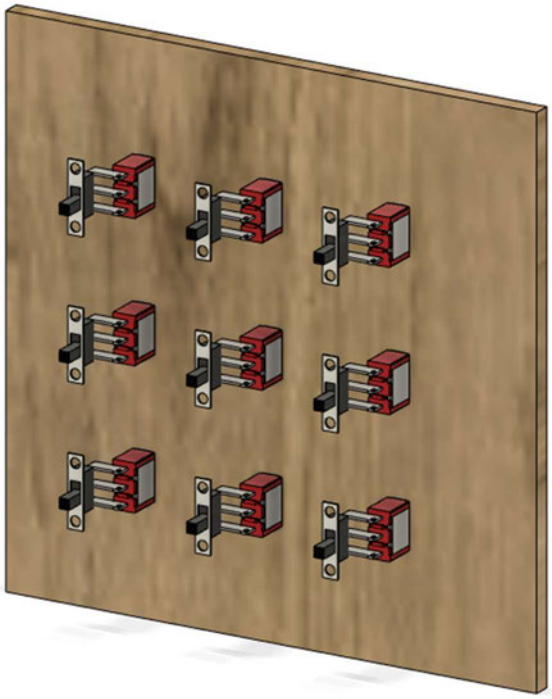
The 'correct' switch combination can be set using the micro switches on the back of the panel and the puzzle can be setup using external information (such as a question given to the participants), the onboard LCD screen, or information written on the face itself.

Whether this is used to have the participants select the correct answers to questions or to create a resistor chain, this face can be used to challenge students to think about a question. The design of the face and 'everything is correct, or nothing is correct' output of the face forces students to critically consider their answers and to contemplate all options to succeed while the physical nature of the puzzle (flipping switches and changing lights) stops participants form becoming bored or annoyed by the activity.

Front view:



Rear View:



GPS

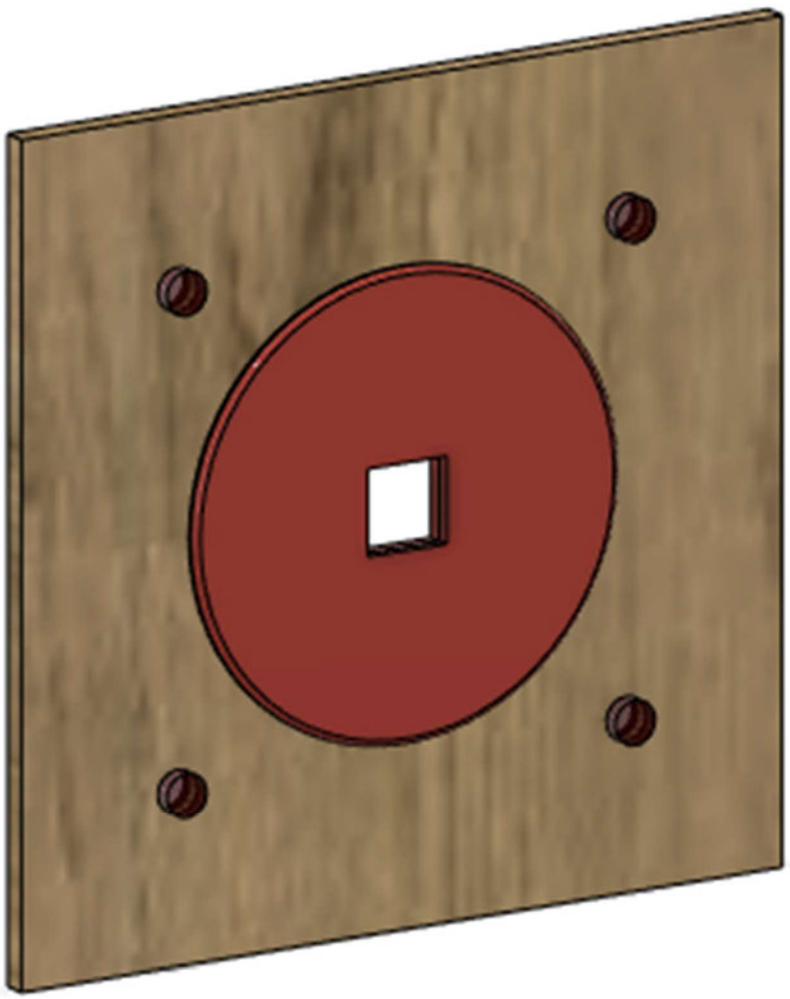
The GPS face consists of a central GPS receiver and 4 surrounding LED's. The purpose of this face is simple, the face tracks the GPS position of the box. This face can be used to trigger an event when the participants arrive at a specific location.

The LED's give an indication of how far the participants are to the target location. The LED's flash faster as the participants close on the target and the face will trigger 'complete' when the GPS reads within ten (10) meters of the target.

The face requires line of sight to the GPS satellites to function correctly, this means that it will only function outside of buildings. It also requires a couple of minutes to accurately acquire the location. If using this face, let the GPS configure for a few minutes prior to starting the activity.

This face can be used to direct participants to clues or the next location in the activity. It can also be used as part of another activity.

Front view:



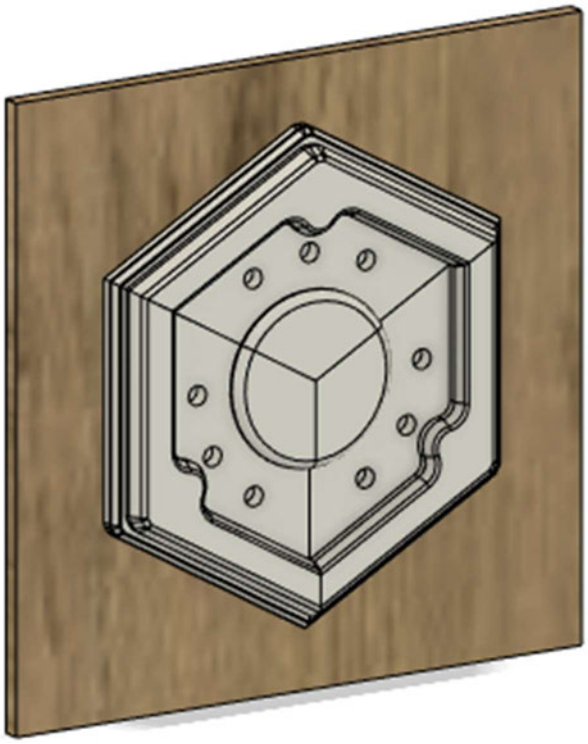
Magnetic Keys

The magnetic key face is a plane panel with magnets in the face. There are 3 magnetic keys that can be attached to this face. The controller can read how many of the three magnetic keys are connected to the face.

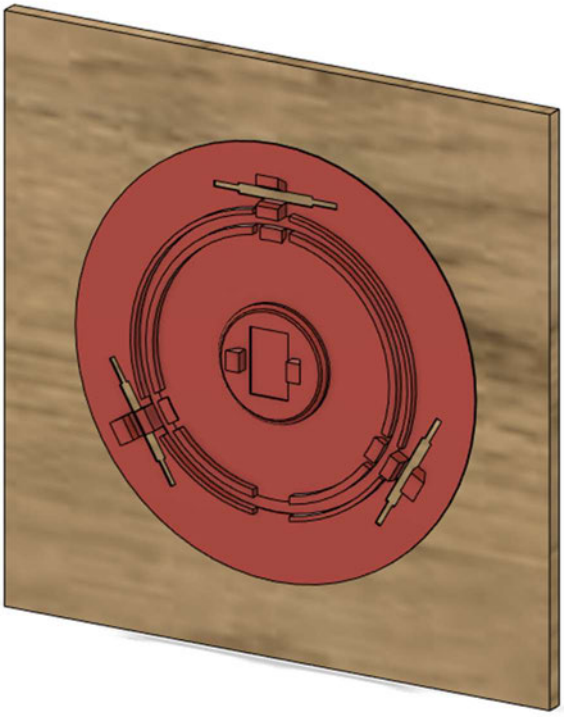
The magnetic keys have wireless LED's embedded in them this means that when the keys are attached to the face they light up. This gives an additional boost to the feeling of completion when a new key is found.

The magnetic keys that connect to this face can be hidden or used as a reward for completing tasks within the grater activity. They are ways for the tesseract to track completion of tasks outside of those that are completed using the box itself.

Front view:



Rear View:



Control Face

The control face is the base input and output face of the platform. The face contains a rotary encoder and 5 buttons as well as a 4x20 character LCD screen. In the standard setup this face is used to deliver messages to the participants as well as to receive text answers to question challenges.

The face can also be easily used for multiple choice questions, or any other input/output communication with the participants.

Front view:

General design information

The box shape and weight

The base dimensions of the Tesseract are 176x176mm. Additionally, the box 10mm protrusion on the front face due to the door knob.

The basic frame weight of the Tesseract is 0.85Kg. This includes the weight of the microcontroller battery, and front (door) face, but it does not include the weight of the modular faces.

The Standard setup of the Tesseract weighs 1.25Kg. This weight includes the basic frame an all 5 of the panels in the standard setup.

Faces

The panels of the faces must be 150x105mm. they also must be between 3-6mm thick.

The Face on the bottom of the box **cannot** have protrusions greater than **3mm.** Having protrusions will cause the tesseract to not be able to be set down on its base.

Power

The tesseract platform is powered using a single 9v battery. It is connected to the microcontroller via the microcontroller Barrel jack.

Using the tesseract

Using the standard setup

Setting up the Arduino IDE

To use the tesseract platform, you will need to download the Arduino IDE (integrated development environment) and set it up with the required libraries and board information. This is a simple process and does not require purchasing any additional software.

To download the Arduino IDE follow this link:

https://www.arduino.cc/en/software

To use the standard setup for the Tesseract there are some libraries that need to be added to the IDE. The libraries that are required are:

- DFRobot_VisualRotaryEncoder.h
- LiquidCrystal_I2C.h
- SparkFun_u-blox_GNSS_Arduino_Library.h
- SerialWombat.h
- Adafruit_PCF8574.h
- Wire.h
- Servo.h

These libraries can be downloaded from the Arduino IDE library manager. If you have limited experience with the IDE, instructions for library installation can be found at:

https://docs.arduino.cc/software/ide-v1/tutorials/installing-libraries

In addition to downloading the libraries, the IDE will need to be setup for the microcontroller. The box uses a SparkFun RedBoard turbo and instructions for setting the board in the IDE can be found at the SparkFun website:

https://learn.sparkfun.com/tutorials/redboard-turbo-hookup-guide?_ga=2.162386292.939361055.1697083524-139801736.1697083524&_gl=1*1dc19l6*_ga*MTM5ODAxNzM2LjE2OTcwODM1MjQ.*_ga_T369JS7J9N*MTY5NzA4MzUyNC4xLjAuMTY5NzA4MzUyNC42MC4wLjA.#uf2-bootloader-and-drivers

Creating activities for the standard faces.

The basic code for the standard faces is listed at the end of the manual. To setup an activity using the code follow the steps listed in the section “example activity development”. This section will take you through the development of an activity using the standard code and faces.

Adding modules/activities

Adding activities

The code at the end of this manual is a good initial code for running a variety of activities using the standard platform setup. However, the deice utility is not limited to this code. Each of the libraries used for the device have significant documentation and the code can be edited to suit any use case that the end user encounters.

Adding modules

The modular design of the tesseract allows for the development of custom faces. A custom face for this platform must be a 150x150mm panel that is no more than 6mm thick (not including components). The face must communicate back to the controller using 5v I2c connection. Additional things to be aware of:

- The total power used by all devices should never exceed 500mA.
- Each face of the device must have an independent i2c address.

Other common modifications

Replacing the microcontroller mounting method. In the standard design the microcontroller is mounted to the bottom face of the Tesseract using double sided tape. A common modification is to replace the double-sided tape with Velcro.

Replacing the 9v battery. In the standard design a 9 Volt battery is used to power the microcontroller, through the barrel jack on the microcontroller. a common modification is to remove the 9 Volt battery and replace it with a small (approximately 4Ah) 5v rechargeable battery pack. A 5v rechargeable battery pack can connect directly to the USB port of the microcontroller.

RFID sensors. A common modification is to add an RFID sensor to the internal face of the bottom panel. This modification gives the tesseract additional scavenge hunt style capabilities. is often preferred over the use of the GPS panel, due to the restriction and price of the GPS panel.

Wireless connectivity. An easy modification would be to use a Wi-Fi or Bluetooth enabled microcontroller. Using a Wi-Fi enabled microcontroller would allow the end user to directly track and interact with the progress of the activity wirelessly. If the activity is being conducted in a greater area, where Wi-Fi or Bluetooth connections are not viable, a LoRa board can be used to connect the device to the things network.

Example activity development

To assist with the use of the tesseract, in this section we will go through the step-by-step process of developing a simple activity using the standard face setup.

The activity will be developed in stages referring to the physical and code setup of the platform.

The Activity

The sample activity developed in this section will be a simple group development activity.

The activity will cover the use of all 4 panels and include some ways in with activities ran using this box can include external information or challenges.

The example situation is:

A small local library is starting an after-school youth club for students aged 12-15. The library would like to create a short (30-45 minute) puzzle activity to introduce the students to the library and each other. The activity will have 3-5 participants who will be supervised throughout the activity. Due to the ages of the students the activity must take place within the library and its attached, fenced, outside area.

Development

This section covers the development of the activity and the individual challenges within it.

<u>The specifics of the implementation are covered in the next section 'Making the activity'.</u>

Identify the intended outcomes.

The first thing to do when developing an activity is to determine the key Intended Learning Outcomes. For our example these will be to:

- Introduce the students and get them working together as a group.
- Encourage a sense of belonging withing the group.
- Challenge the students, allowing them to demonstrate their individual capabilities.
- Introduce the students to the library's facilities, services, resources, and staff.
- Begin to teach the students how to locate and interoperate information in the library.
- Get the students interested and excited about the opportunities available to them in this club.
- Provide students the opportunity to relate with their individual interests within the club.
- Identify specific high need student and what they might require to be successful in the club.

When listing the intended learning outcomes of an activity you don't need to be specific and they don't necessarily all have to match the learning outcomes of the course in which the activity is done. The outcomes can be as vague as 'have the participants demonstrate their general knowledge' or 'make the participants fell confidant about their prospects'. Additionally, some of the outcomes can be for the user running the activity, such as 'identify participants who seems to be lacking sufficient prior knowledge of the subject'.

The activity challenges.

The next step is to generate the challenges for the participants to overcome through the activity. The challenges should be developed with the outcomes in mind.

Initial setup

Before the activity, the person running the activity will discuss the rules of the activity with the group. The group will be told the area where they are allowed to go (inside of the library and in the

fenced outdoor area), the behavioural expectations (be respectful of each other and of the library), and any other rules that may be relevant (don't smash the box, don't go into the storage areas, ect)

The students will then be given the box and a fictional situation.

The students will be told that the head librarian has put her keys and some of her treasures inside of the puzzle box for safe keeping, unfortunately she has forgotten how to get into the box.

They will then be told that the librarian has tasked the group to get into the box and give her the keys and that, as a reward for giving her the keys back, the group can keep the other treasures inside of the box.

(for this activity the 'treasures' could be something like lego minifigures)

The students will then be given the box and the first clue.

Challenge 1, Book Hunt.

Clue: The name of a book in the library.

Solution: The reference number of the book entered in via the I/O face.

The students will be given the title of a book as a clue. They will be told that head librarian has said that the first answer has something to do with this book.

The group will have to use the resources available in the library to locate the book. They will then have to work as a team to figure out that the solution to the puzzle is the Dewey decimal system reference number of the book.

Once they have worked out answer. The group will enter the correct answer into the box using the text selection knob on the i/o face of the platform.

Challenge 2, Book Return Key Hunt.

Clue: A text message on the LCD directing them to the location of a key

Solution: To locate the returns pile and the key that is hidden inside of it.

When the students successfully complete the first task, they will get a success notification then the screen on the box will give them the next clue.

The screen will read:

"The first of three"
"keys should be"
"RETURNED to me"

The group will have to work together to determine that the answer to this riddle is that there is a key hidden in the book returns. They will then have to locate the book returns and search through the returns pile to find the hidden key. When they have found the magnetic key and connected it to the correct face, they will get a 'SUCCESS' message on the screen and be given the next challenge.

Challenge 3, A Thinking Problem

Clue: A text message on the LCD asking them to input an answer to a question.

Solution: To enter 6 weeks into the i/o face using the text selection knob.

After the students find the key and get the Success message, they will get their next challenge. The challenge question will be given as a message on the LCD screen. The Question will be:

“What is the maximum”
“time that you can”
“borrow a book for?”

This is a trick question that will require the students to think harder than they were required to in the first two questions.

The obvious answer, for this library, is two weeks, because the standard book loan length is 2 weeks. However, the library allows a person to re-borrow the same book up to 3 times in a row making the correct answer 6 weeks.

This challenge will require the group to think about the library procedures and to collectively think laterally to determine the correct solution.

When the students enter the correct response, they will get a ‘success’ message and be given the next challenge.

Challenge 4, Find a Book.

Clue: A text message on the LCD instructing the students to find and present a book that they have read.

Solution: the students will have to present a book that they have read to the librarian and answer some general questions about it.

After the students complete the previous challenge, they will get their next instructions using the LCD on the i/o face of the box. The instructions will be:

“Find a book that”
“you have read and”
“show it to the”
“librarian”

The students must then all find an individual book that they have read and present it to the librarian at the front desk. The librarian will then get the students to describe the book, what they liked about it, what they learned from it, and what genres they think that the book would fall in to.

This gets the students to think about books and subjects that they enjoy and it demonstrates how the after school library club could allow them to spend time doing or learning about those things. It also helps to familiarize the students with the library and where to find things within it.

Once the students have all spoken to the librarian the librarian will give the group the next key and a sheet of paper containing the next clue.

Challenge 5, Emergency Assembly.

Clue: The group will get given a clue from the librarian after the previous challenge.

Solution: go to the emergency assembly point.

After completing the previous challenge, the group will be given a sheet of paper as a clue.

The sheet of paper will contain a map of the library including the internal rooms, fire equipment, emergency assembly points, outdoor areas, and fence line.

At the bottom of the sheet there will be a riddle for the group to solve. The riddle will be:

From a fire you flee,
to a place of safety,
and there you'll find me,
the next clue to a key.

The group will have to interoperate this and come to the conclusion that they should go to the emergency fire evacuation point. (in this example this is in the outdoor area of the library)

When the group goes outside the GPS face of the box will activate and the LEDs on the face will start to flash (they flash faster as you approach the target).

This challenge gets the students to consider the layout of the libraries and the different rooms/areas that are a part of it. It also gets the students to consider the location emergency evacuation exits and the emergency assembly point.

When the GPS recognises that they are at the evacuation point, the students will get a 'success' message and they will receive the next challenge.

Challenge 6, Fact or Fiction.

Clue: A text message on the LCD instructing the students to sort titles by non-fiction or fiction.

Solution: To use the switch face to sort 9 titles by non-fiction or fiction.

After arriving at the emergency assembly point, the box will give a 'success' message and then give the group their next task.

The task will be:
"Use the switches to"
"sort the books into"
"non-fiction and"
"fiction."

The students will then have to use the switch face to sort 9 titles into fiction or non-fiction. They will do this by switching the switch next to a title up, for fiction, or down, for non-fiction.

This challenge has the group thinking about different types of books that can be found in the library as well as exploring the library or using the library resources to determine the answers.

When they have successfully completed all 9 titles, they will get a green light on the switch face and they will get the final clue.

Challenge 7, The final key.

Clue: A text message on the LCD instructing the students to collect the final key from the head librarian.

Solution: To go to the office of the head librarian and collect the final key.

After completing the switch face the box will give the students their final instruction using the LCD screen. The instruction will be:

"The last key is in"
"top draw of the"

“head librarians”
“desk!”

The students will then go to the office of the head librarian and request the final key.

The librarian will hand the group the key and the box will unlock.

The head librarian will get the keys and the students will get their prizes.

Making the activity

The full code for this example is at the end of the document.

This section covers the details of setting up the tesseract for the previously described activity. It covers the physical setup as well as the coding of the box.

Due to this activity being developed for the standard setup there is relatively little setup required.

There is some physical preparation required to ensure that the activity runs smoothly and some limited artistic modifications that need to be done to the front of the switch face but there are no significant physical modifications required.

This activity is created using the supplied Arduino code. This activity does not require any modifications of any function within the code. The only part of the code that the user will need to touch is the main ‘void loop()’ section and they will only need to use the pre made functions.

Challenge 1, Physical

This section does not require any physical changes to the box.

The user will have to make sure that the book is on the shelf prior to starting the activity.

Challenge 1, code

```
char q1Text[20] [20]=
{{"Moby Dick"}};

char q1ans[]="LF123";


textQuestion(1, 0, q1ans, q1Text);
```

Challenge 2, Physical

This section does not require any physical changes to the box.

The user will have to hide one of the three magnetic keys within the book returns pile.

Challenge 2, code

```
delay(1000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("--clue--");
  lcd.setCursor(0,1);
  lcd.print("The first of three");
  lcd.setCursor(0,2);
  lcd.print("keys should be");
  lcd.setCursor(0,3);
  lcd.print("RETURNED to me");
    while(keysCollected < 1)
      {keysCollected= keyCheck();}
```

```
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("SUCCESS!!");
  delay(2000);
```

Challenge 3, Physical

This section does not require any physical changes to the box.

The user will have to ensure that information on loan periods and loan extensions is available for the students to find.

Challenge 3, code

```
char q3Text[20] [20]=
      {{"What is the maximum"},
      {"time that you can"},
      {"borrow a book for"}};

      char q3ans[]="2";

textQuestion(1, 0, q3ans, q3Text);
```

Challenge 4, Physical

This section does not require any physical changes to the box.

There must be a librarian at the front desk who understands the activity and their task. The librarian must also have the second key.

Challenge 4, code

```
  delay(1000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Find a book that");
  lcd.setCursor(0,1);
  lcd.print("you have read and");
  lcd.setCursor(0,2);
  lcd.print("show it to the");
  lcd.setCursor(0,3);
  lcd.print("librarian");
    while(keysCollected < 2)
      {keysCollected= keyCheck();}
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("SUCCESS!!");
  delay(2000);
```

Challenge 5, Physical

This section does not require any physical changes to the box.

The user will have to ensure that they have printed out the map and that the front desk librarian has it. The user will also have to ensure that the area is safe and that the group members have any hats or other gear that they may need (weather dependant).

Challenge 5, code

```
char q5Text[20] [20]=
      {{"Follow the clue"}};
```

```
long targetLat = 400909142, targetLong = -1051849833;

gpsToLocation(targetLat, targetLong, q5Text);
```

Challenge 6, Physical

This section requires some alteration to the switch face.

On the external side of the switch face:
the user will have to write the titles and authors of nine (9) books, that are in the library, onto tape or sticky tags. These tags must then be places next to each o the 9 switches. There should also be a tag indicating weather the switch be up or down should signal fiction or non-fiction.

On the internal side of the switch face:
the micro switches on the inside of the switch face must be switched to dictate the correct answers for their corresponding switch on the external face.

Challenge 6, code

```
char q6Text[20] [20]=
      {{"Use the switches to"},
      {"sort the books into"},
      {"non-fiction and"},
      {"fiction"}};


switchpan (q6Text);
```

Challenge 7, Physical

This section does not require any physical changes to the box.

The final key must be in the head librarians desk draw and the head librarian should be in their office at this point in the activity.

Challenge 7, code

```
delay(1000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("The last key is in");
  lcd.setCursor(0,1);
  lcd.print("top draw of the");
  lcd.setCursor(0,2);
  lcd.print("head librarians");
  lcd.setCursor(0,3);
  lcd.print("desk!");
    while(keysCollected < 3)
      {keysCollected= keyCheck();}
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("SUCCESS!!");
  delay(2000);
```

Adding faces

A key feature of the tesseract is their modularity. This modularity gives the tesseract additional utility by giving users the ability to develop their own faces or to use custom faces developed by other users in the community.

There are however some limitations on developing faces. The limitations on developing new faces for the platform are:

- Physical size. The faces must be a 150x150mm panel that is between 3 and 6mm thick. Additionally, there is limited space inside of the box. To be safe, the faces should not have components that extend any further that 20mm from the internal face of the panel.
- Connection to the controller. The faces for the box should all connect via a 5v i2c connection. This commonality allows for a cleaner design and for a more streamlined modular setup, where there is no conflict regarding pin allocations. A suggestion would be to use multiplexers such as the PCF8574t. These multiplexers are cheap, easy to use, and often come pre-mounted for convenience. They also have i2c addresses that can be simply changed if there is a conflict between modules.
- Electronic limitations. In addition to the connection's limitations, there are limitations regarding the electrical consumption of the platform. All of the modules must run using a 5v supply voltage. The total current of all modules must not exceed 500mA (this usually isn't an issue so long as multiple components are not drawing at the same time). In designing the modules consider ways to lower the power consumption of the faces when they are not directly being used.

It should be noted that these limitations can all be overcome with additional modifications to the design. This design can be altered in to allow any number of additional capabilities, there are however always costs.

Warnings

When designing additional components consider safety. Ensure that there is no additional risks to the users or the device.

The platform runs on batteries connecting the device wrong can lead to damage.

The device is not exceptionally heave but it will hurt if you drop it on your foot.

When using the device **pay attention to your surroundings**. Not doing so can lead to injury.

Appendix

Quick reference for fault finding.

1. If during operation the platform begins to have errors. It could be due to the faces attempting to draw too much current from the microcontroller.
    a. This could be due to a battery failure. Try replacing the 9v battery with a new high quality battery.
    b. This can also occur if there are multiple faces operating (and drawing power) at the same time.
        i. In this situation consider either changing the activity to avoid the issue
        ii. Or consider adding an independent 5v voltage regulator that is capable of supplying higher currents.
        Note. If this is done the new volage regulator outputs, - and +, must be connected to the 0v and 5v rails of, the i2c coms line, and the Arduino microcontroller. This must be done for the I2c

Quick reference guide for changing components

Instructions for disassembling the tesseract and removing/changing the battery or faces.

1. Undo the four (4) m4 size retention hex bolts from the door face. (Use a 3mm hex bit)
2. Remove the front frame. (This will remover the door as well as the inner frame.
   The battery can be changed at this point.
3. Remove the retention frame.
4. Disconnect all of the electronics.
5. Unscrew and remove the four (4) pillar face holders. (Using a n1. Philips bit)
6. Remove the left and right faces.
7. Unscrew and remove the 4 back corner face holders. (Using a n1. Philips bit)
8. Remove top bottom and back faces.

Example activity code

The code created for the example library activity.

To create your own code remove the sample code from the void loop() and follow the steps to write your own.

```
/*!*/
#include <DFRobot_VisualRotaryEncoder.h>
#include <LiquidCrystal_I2C.h>
#include <SparkFun_u-blox_GNSS_Arduino_Library.h>
//http://librarymanager/All#SparkFun_u-blox_GNSS
SFE_UBLOX_GNSS myGNSS;
#include <SerialWombat.h>
#include <Servo.h>
#include <Adafruit_PCF8574.h>

LiquidCrystal_I2C lcd(0x27,20,4);  // set the LCD address to 0x27 for a 16
chars and 2 line display

DFRobot_VisualRotaryEncoder_I2C sensor(/*i2cAddr = */0x54, /*i2cBus =
*/&Wire);

SerialWombat sw6C;
SerialWombat sw6E;
SerialWombat sw6F;

Adafruit_PCF8574 pcf;

#define doorPosOpen 60  //door open and closed servo possitions
#define doorPosClose 38
Servo servo_9;

void setup()
{
Wire.begin();
sw6C.begin(Wire,0x6C);
sw6E.begin(Wire,0x6E);
sw6F.begin(Wire,0x6F);

pcf.begin(0x20, &Wire);

  for (uint8_t p=0; p<8; p++) {
    pcf.pinMode(p, INPUT);
  }
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0,0);
  lcd.print("Device on");

servo_9.attach(9); //door servo is connected to pin 9

  sensor.setGainCoefficient(1);// The currently set accuracy value: 10
  delay(2000);

  sensor.setEncoderValue(500);

//Magnetic switches
  sw6C.pinMode(1,INPUT);
  sw6C.pinMode(2,INPUT);
  sw6C.pinMode(3,INPUT);

//gps leds (active low)
  sw6E.pinMode(3,OUTPUT);
  sw6E.digitalWrite(3,HIGH);

//Switch pannle input
  sw6F.pinMode(3,INPUT);
```

```
  //myGNSS.setI2COutput(COM_TYPE_UBX); //Set the I2C port to output UBX
only (turn off NMEA noise)
  //myGNSS.saveConfigSelective(VAL_CFG_SUBSEC_IOPORT); //Save (only) the
communications port settings to flash and BBR

servo_9.write(doorPosOpen);

  lcd.setCursor(0,0);
  lcd.print("Toowoomba Activity");
  lcd.setCursor(0,2);
  lcd.print("to start");
  lcd.setCursor(0,3);
  lcd.print("press select");
  delay(500);
  while (~pcf.digitalRead(2)) {}
  servo_9.write(doorPosClose);
  }


//String q1ans = "17";


//int cursorPosition = 0;

//String answer = "00000";
//int max =1;

void loop()
{
int keysCollected=0;


      char q1Text[20] [20]=
      {{"Moby Dick"}};

      char q1ans[]="LF123";

      char q2Text[20] [20]=
      {{"--clue--"},
      {"The first of three"},
      {"keys should be"},
      {"RETURNED to me"}};

      char q3Text[20] [20]=
      {{"What is the maximum"},
      {"time that you can"},
      {"borrow a book for"}};

      char q3ans[]="2";

      char q5Text[20] [20]=
      {{"Follow the clue"}};

      long targetLat = 400909142, targetLong = -1051849833;

      char q6Text[20] [20]=
      {{"Use the switches to"},
      {"sort the books into"},
      {"non-fiction and"},
      {"fiction"}};
```

```
textQuestion(1, 0, q1ans, q1Text);

delay(1000);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("--clue--");
lcd.setCursor(0,1);
lcd.print("The first of three");
lcd.setCursor(0,2);
lcd.print("keys should be");
lcd.setCursor(0,3);
lcd.print("RETURNED to me");
  while(keysCollected < 1)
    {keysCollected= keyCheck();}
lcd.clear();
lcd.setCursor(0,0);
lcd.print("SUCCESS!!");
delay(2000);

textQuestion(1, 0, q3ans, q3Text);

delay(1000);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Find a book that");
lcd.setCursor(0,1);
lcd.print("you have read and");
lcd.setCursor(0,2);
lcd.print("show it to the");
lcd.setCursor(0,3);
lcd.print("librarian");
  while(keysCollected < 2)
    {keysCollected= keyCheck();}
lcd.clear();
lcd.setCursor(0,0);
lcd.print("SUCCESS!!");
delay(2000);

gpsToLocation(targetLat, targetLong, q5Text);

switchpan (q6Text);

delay(1000);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("The last key is in");
lcd.setCursor(0,1);
lcd.print("top draw of the");
lcd.setCursor(0,2);
lcd.print("head librarians");
lcd.setCursor(0,3);
lcd.print("desk!");
  while(keysCollected < 3)
    {keysCollected= keyCheck();}
lcd.clear();
lcd.setCursor(0,0);
lcd.print("SUCCESS!!");
delay(2000);
```

```
      //switchpan (q2Text);
      //gpsToLocation(targetLat, targetLong, q3Text);

servo_9.write(doorPosOpen);

  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("SUCCESS!!");
  lcd.setCursor(0,1);
  lcd.print("Box unlocked");
  while(1) {}
}



int  keyCheck()
{
 int a = sw6C.digitalRead(1); //digitalRead(1);
 int b = sw6C.digitalRead(2); //digitalRead(2);
 int c = sw6C.digitalRead(3); //digitalRead(3);
 int keysCollected = (a+b+c);
//  lcd.clear();
//  lcd.setCursor(0,0);
//  lcd.print("You have collected");
//  lcd.setCursor(0,1);
//  lcd.print(keysCollected);
//  lcd.setCursor(0,2);
//  lcd.print("of 3 Keys.");
  delay(1000);
  return keysCollected;
}

void gpsToLocation (long targetLat, long targetLong, char qtext[][20])
{
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print(qtext[0]);
  lcd.setCursor(0,1);
  lcd.print(qtext[1]);
  lcd.setCursor(0,2);
  lcd.print(qtext[2]);
  lcd.setCursor(0,3);
  lcd.print(qtext[3]);
  delay(1500);
  int on=1;
  while (on==1)
  {
//long latitude = myGNSS.getLatitude();
//long longitude = myGNSS.getLongitude();
long latitude = 1;
long longitude = 1;

double distanceToTarget = distanceBetween(
    latitude,
    longitude,
    targetLat,
    targetLong);

double courseToTarget = courseTo(
    latitude,
```

```
    longitude,
    targetLat,
    targetLong);

    //distance to target
    //course to target

    delay((distanceToTarget/10)*500);
    sw6E.digitalWrite(3,LOW); //digitalWrite(13,HIGH);
    delay(275);
    sw6E.digitalWrite(3,HIGH); //digitalWrite(13,LOW);
    if (distanceToTarget<7||pcf.digitalRead(2))
    {
      on=0;
      lcd.clear();
      lcd.setCursor(0,0);
      lcd.print("SUCCESS!!");
      delay(2000);
    }
  }
}


void switchpan (char qtext[][20])
{
lcd.clear();
lcd.setCursor(0,0);
lcd.print(qtext[0]);
lcd.setCursor(0,1);
lcd.print(qtext[1]);
lcd.setCursor(0,2);
lcd.print(qtext[2]);
lcd.setCursor(0,3);
lcd.print(qtext[3]);
delay(1500);
while (sw6F.digitalRead(3)==LOW)
{}
lcd.clear();
lcd.setCursor(0,0);
lcd.print("SUCCESS!!");
delay(2000);
}



void textQuestion(int max, int cursorPosition, char corAns[], char
qtext[][20])
{
char answer[12] = "00000";
int on =1;
uint16_t encoderValue= sensor.getEncoderValue();
lcd.clear();
lcd.setCursor(0,0);
lcd.print(qtext[0]);
lcd.setCursor(0,1);
lcd.print(qtext[1]);
lcd.setCursor(0,2);
lcd.print(qtext[2]);
lcd.cursor();
for (int i =0; i<=max; i++)
{lcd.setCursor(i,3);
```

```
lcd.print("_");}
while (on == 1)
{
if((pcf.digitalRead(0))||(pcf.digitalRead(4)))
{
 if (pcf.digitalRead(0))
  {if (cursorPosition == max)
    {cursorPosition=0;}
    else
    {cursorPosition++;}
  }
 if (pcf.digitalRead(4))
  {if (cursorPosition == 0)
    {cursorPosition=max;}
    else
    {cursorPosition--;}
  }
  if((answer[cursorPosition]>64) && (answer[cursorPosition]<91))
  {encoderValue=answer[cursorPosition]+500-65;}
  else if ((answer[cursorPosition]>47) && (answer[cursorPosition]<58))
  {encoderValue=answer[cursorPosition]+525-47;}
  else
  {encoderValue=500;}
  sensor.setEncoderValue(encoderValue);
  delay (200);
}
  encoderValue = sensor.getEncoderValue();
    if (encoderValue < 500)
  {
  sensor.setEncoderValue(535);
  encoderValue=535;
  }
  else if (encoderValue > 535)
    {
  sensor.setEncoderValue(500);
  encoderValue=500;
  }
  char ev2=encoderValue-500+65;
  if (encoderValue > 525)
  {
  ev2=encoderValue-525+47;
  }
  delay(50);

answer[cursorPosition] = ev2; //answer.setCharAt(cursorPosition, ev2);

lcd.setCursor(cursorPosition, 3);
  //lcd.noCursor();
lcd.print(answer[cursorPosition]);
lcd.setCursor(cursorPosition, 3);

if (pcf.digitalRead(2))
  {
    if (memcmp(answer, corAns, max)==0)
    {
      lcd.setCursor(0, 0);
          lcd.clear();
      lcd.print("SUCCESS!!");
      lcd.setCursor(0, 2);
      //lcd.print(memcmp(answer, corAns, 2));
      delay(2000);
```

```
    on = 0;
    }
    else
    {
      lcd.clear();
      lcd.setCursor(0, 0);
          lcd.print("ERROR  ");
      //lcd.print(memcmp(answer, corAns, 2));
      lcd.setCursor(0, 2);
      lcd.print("incorect answer");
      delay(1500);

      lcd.clear();
      lcd.setCursor(0,0);
      lcd.print(qtext[0]);
      lcd.setCursor(0,1);
      lcd.print(qtext[1]);
      lcd.setCursor(0,2);
      lcd.print(qtext[2]);
      lcd.cursor();
      for (int i =0; i<=max; i++)
      {lcd.setCursor(i,3);
      lcd.print("_");}
    }
  }

}
}



double distanceBetween(long lat1_l, long long1_l, long lat2_l, long
long2_l)
{
  // returns distance in meters between two positions, both specified
  // as signed decimal-degrees latitude and longitude. Uses great-circle
  // distance computation for hypothetical sphere of radius 6372795 meters.
  // Because Earth is no exact sphere, rounding errors may be up to 0.5%.
  // Courtesy of Maarten Lamers
  double lat1 = (double)lat1_l / 10000000.0; // Convert lat and long to
degrees
  double long1 = (double)long1_l / 10000000.0;
  double lat2 = (double)lat2_l / 10000000.0;
  double long2 = (double)long2_l / 10000000.0;
  double delta = radians(long1-long2);
  double sdlong = sin(delta);
  double cdlong = cos(delta);
  lat1 = radians(lat1);
  lat2 = radians(lat2);
  double slat1 = sin(lat1);
  double clat1 = cos(lat1);
  double slat2 = sin(lat2);
  double clat2 = cos(lat2);
  delta = (clat1 * slat2) - (slat1 * clat2 * cdlong);
  delta = sq(delta);
  delta += sq(clat2 * sdlong);
  delta = sqrt(delta);
  double denom = (slat1 * slat2) + (clat1 * clat2 * cdlong);
  delta = atan2(delta, denom);
  return delta * 6372795;
}
```

```
double courseTo(long lat1_l, long long1_l, long lat2_l, long long2_l)
{
  // returns course in degrees (North=0, West=270) from position 1 to
position 2,
  // both specified as signed decimal-degrees latitude and longitude.
  // Because Earth is no exact sphere, calculated course may be off by a
tiny fraction.
  // Courtesy of Maarten Lamers
  double lat1 = (double)lat1_l / 10000000.0; // Convert lat and long to
degrees
  double long1 = (double)long1_l / 10000000.0;
  double lat2 = (double)lat2_l / 10000000.0;
  double long2 = (double)long2_l / 10000000.0;
  double dlon = radians(long2-long1);
  lat1 = radians(lat1);
  lat2 = radians(lat2);
  double a1 = sin(dlon) * cos(lat2);
  double a2 = sin(lat1) * cos(lat2) * cos(dlon);
  a2 = cos(lat1) * sin(lat2) - a2;
  a2 = atan2(a1, a2);
  if (a2 < 0.0)
  {
    a2 += TWO_PI;
  }
  return degrees(a2);
}
```

Appendix M

More Tesseract Panels