Design Opportunity

Problem

78% of teens aged **12-17** own a mobile phone (https://bit.ly/2RSE8Zn) and on average, spend over **7 hours** on their **phones everyday (**https://abcn.ws/2wJIZVk**)** - this can be a **major distraction** while **studying** (https://bbc.in/3amMIG7**). Trends** show that kids **and** teens' **screen time** is **increasing** (Figure 1**).**

In this **digital age**, it becomes **increasingly difficult** to **limit** screen time and **ensure** students are **productive** when they want to be. **"**A Pew study finds that that **54 percent** of US teens ages **13 to 17 worry** they spend **too much time** on their **phones**" and **more than half** of them **try** to **cut back** on **usage** (Figure 2). However, **self-imposing restrictions** can be a **challenging** task **not only** for teens, **but** for people of **all ages**.

Moreover, it is believed that "the advent of the **smartphone** is the **most plausible** explanation for the **sudden decrease** in teens' **psychological well-being**" (https://bit.ly/3am1tsP**).**

According to the above **research**, **teenagers** would **benefit** from **restricting** the **amount of time** they spend on their **phones throughout** the **day.** They could experience **increased** levels of **focus** and **productivity** while **studying** and enhanced **psychological wellbeing**.

197 words

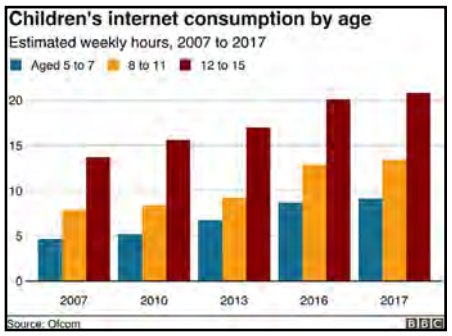
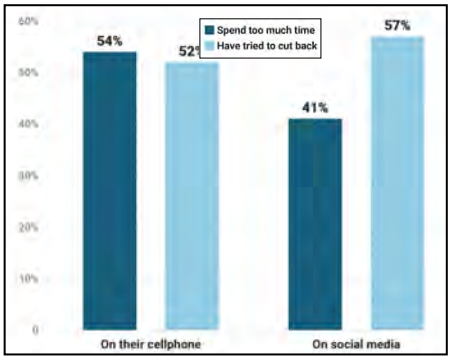


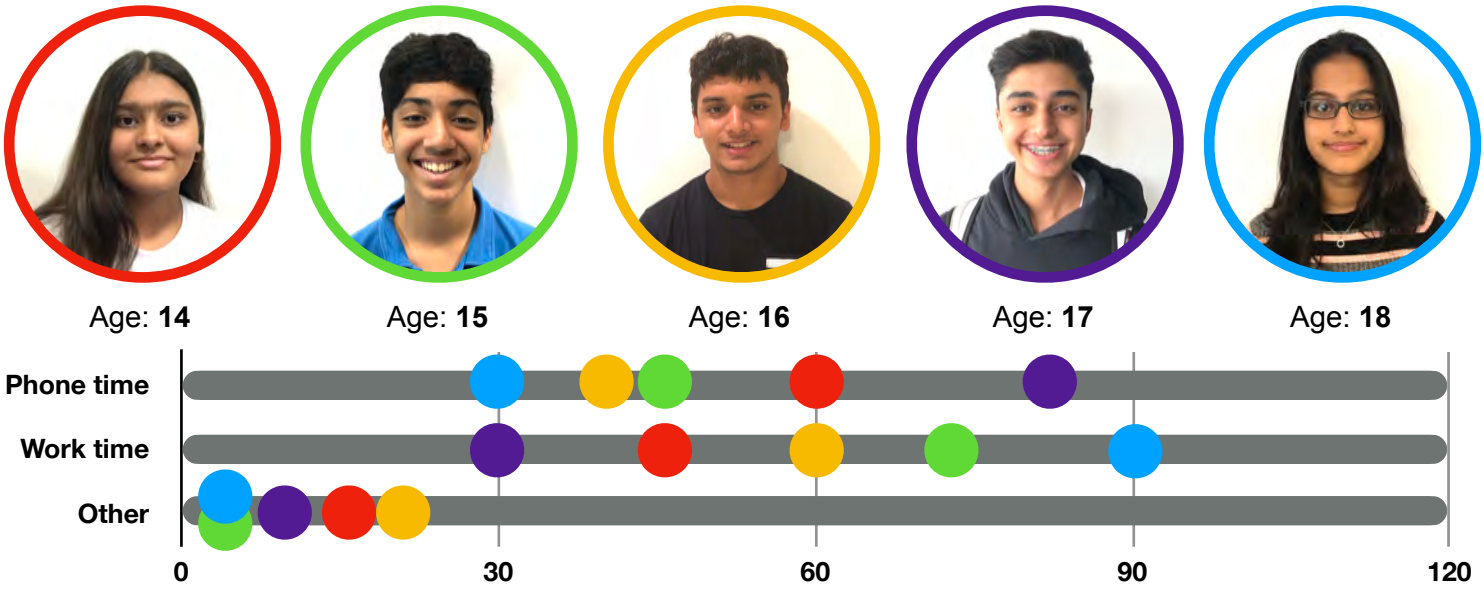
Figure 1



Majority of teens admit to excessive phone use (Fig. 2)

Primary Data

High school students at the school **I attend** are expected to do a **minimum** of **120 minutes** of **homework** on a **daily basis;** the **graph** below shows **where** these **5 teenagers allocate** their time on **during** those **2 hours.**



Conclusion: Even when these teenagers are **meant** to be studying, they spend **a lot of** time on their **phones**.

"His [My son's] **productivity** is much **lower nowadays** because he spends **too much time** on his **phone**, which gives me **stress.**"

"After Arusha [my daughter] moved into **High School**, she spends **more time than usual** on her **phone** while '**studying'.**"

"I am **tired** of **having** to **tell** my **17** year old son, Ranveer, to **study** instead of using his **phone** for **Snapchat** and **Instagram**."

Constraints and Competition

Phone Dimensions

Figure 3

Client Interview Summary (Success Criteria)	
User Needs	**User Wants**
Device that **locks** phone inside	**Aesthetically** appealing
Automated	Made **predominantly** out of **wood**
Should be able to **set** and adjust **lock time**	**Smooth** finish and **not too dark** materials
Should **not** be able to **take out** phone once it is **inside**	**Lightweight**
Develops **self-control**	**Intuitive design**
Displays how much **time** is **left**	Should be able to **see phones inside**
Should **fit** on **study table**	**Compact**

Design Brief

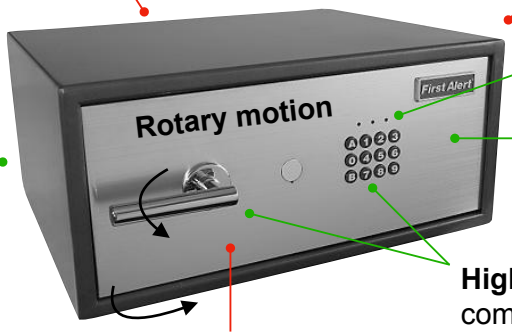
My intended **goal** is to **design** and **manufacture** a **1:1 full scale, one off high fidelity prototype** of an **electronic lock box** to **prevent teenagers** aged **14-18** from getting **distracted** by their **phones** due to **social media**. My **target market** and **user group** are **teenagers,** and my **target audience** is **parents** who want to **solve** the issue of their children spending too much time (over **7 hours)** on **phones**. The product will be used **daily** when teenagers get **back home** from school. To develop a **unique selling point**, this product **must be** able to **lock** the user's **phone** for a **certain** amount of **time** and have an **intuitive** and **easy to use interface**. Moreover, the **time remaining** until the phones are **released** should be **displayed,** and the user should be able to **see** the phone(s) inside the box.

141 words

Existing Products

Product 1 Figure 4

https://bit.ly/3bDPB6H



Dimensions:
210 x 464 x 413 mm

Very High price: **$157USD**

Sharp edges and **dull colours** makes it **less aesthetically pleasing**

Provides **auditory** and **visual feedback** to user

Because of its **large volume** it can fit **multiple** phones

Intuitive design = **increased** ease of use and **low** memory burden

However, it is **very bulky** and has a **large mass**

High affordance components **enhances user experience**

No interface to **display** or **choose** lock **time**

Product 2 Figure 5

https://bit.ly/3eQw5pH

Cannot fit phones **easily**, they must be put **diagonally**

Dimensions:
140 x 140 x 51 mm

Automated - **displays time** to provide **feedback** to the user

Easy to use and **low operating stress** makes it **desirable**

Multifunctional component, but still **intuitive** and has a **high affordance**

Lock domain: 1 min to 9 days - **range of options**

Primarily **designed** to **store food** - may **not** meet user **needs**

Medium-High price: **$59USD - less likely for parents to invest**

Transparent - user can see **which/how** many phones are inside

Minimalistic, **contemporary** design makes the product **aesthetically pleasing**

Product 3 Figure 6

https://bit.ly/2S7cJ65

Difficult to **move around**

Password lock - **not timer**

Can be **controlled by phone**

Aesthetically pleasing due **to minimalistic design**

Tamper alert for **parents** so teens **do not** try and **open** it

Dimensions: 152 x 325 x 86 mm

Too **complex**: **difficult** to use

Very high price: **$136USD**

Design Specification

In Order of Priority

Specification	Requirement	Justification	Market Research Cite
Function	1.1 Must be able to **lock phone** inside 1.2 Must **display** how much **time** is **left** 1.3 Must have the **ability** to **set** and **change time** 1.4 Must **not damage** phone 1.5 Must be **easy** to **replace batteries** if battery operated	1.1 Because **solves** the users **problem** of getting **distracted** by **electronics** 1.2 Lets the user to know **when** their **devices** will **come out** 1.3 **Allows** the user to **set the time** 1.4 Need to **protect** the user's **devices** 1.5 **Prolongs product life**	Client interview summary (page 2) Primary Data collection (page 1)
Aesthetics	2.1 Must follow a **contemporary style** 2.2 Must have an **intuitive** and **easy to use user interface** 2.3 Must be made out of **wood** and **phones should be visible** 2.4 Must ensure that **buttons match** the **style** of the product	2.1 **Ensures** the product is **functional** and **stylish as well** 2.2 **Low memory burden** on user 2.3 Wooden products fit the **style of most houses** and also **lets** the user see **devices inside** 2.4 **Colors** of **buttons** should be **suggestive** of their **function** to make **device intuitive**	Client interview summary (page 2)
Size	3.2 Must be suitable to fit multiple **phones** 3.3 Must be a **suitable size** to fit on a **study table**	3.2 Should fit **all phones—**an **iPhoneX** is **standard** enough to **base** the **final** product around (158 x 77.8 x 8.1mm) 3.3 This is the **environment** the product is likely to be used in	Phone dimensions (page 2)
Material Selection	4.1 Must be made **predominantly** out of **wood** 4.2 Must have a **clear acrylic panel** 4.3 Must be **durable** 4.4 Must be **robust**	4.1 Suits a **common household style** so does **not** seem **out of place** at home 4.2 Because it **allows** the phones to be **visible** to user 4.3 **Prolongs device life** and **maximises customer satisfaction** 4.4 Will **not break** if **dropped**	Client interview summary (page 2)

Target Audience	5.1 **Teenagers** aged **14-18** who want to take **initiative** to **reduce** their **time spent** on **electronics** when **studying** 5.2 **Parents** who want to **help** their **teens reduce screen time**	5.1 **Teens** are often **distracted** when **studying** due to **social media** and I **need** to **solve** this **problem** 5.2 **Parents also** make up a significant part of the market as they **worry** for their **teens** and are **likely** to be the ones who **pay** for this **product**	https://abcn.ws/2wJIZVk https://bbc.in/3amMIG7
Target Market	6.1 **Teenagers** 6.2 **Parents** with **children** who are **teens** - **secondary target market**	6.1 Very **pertinent problem teenagers** face but **do not** know how to **solve** 6.2 **Parents** often get **anxious** when seeing their **teenagers distracted**	https://bit.ly/3am1tsP
Quantity	7.1 Must be a **high fidelity fully functional 1:1 full scale one off prototype**	7.1 Need to be able to **test it** with **users**	Design brief (page 2)
Competition/ Unique selling point	8.1 Must be **designed specifically** to **secure phones** 8.2 Must be priced **at** or **below $20USD** 8.3 Must be **aesthetically pleasing** 8.4 Must **not** be **bulky or heavy** 8.5 Must have a **transparent cover** 8.6 Must **display time remaining** 8.7 Must be **compact**	8.1 **Solves** a problem that **none** of the **competition specifically caters towards** 8.2 **Competition-based pricing** - price is **lower** than **competitors** and is **reasonable** for **parents** to **pay** for for their **teens** 8.3 Most of the **competition's products** are **not aesthetically pleasing** 8.4 **Competing products** are **heavy** 8.5 **Competition lacks** this **feature** 8.6 **Indicates** how much **time** is **remaining** and **most competing** products **do not** have this **display** or **function** 8.7 **Competing** products are **not compact** and take up **a lot** of **space**	Existing product analysis (page 3)
Production Constraints	9.1 **Design** for **manufacture** 9.2 **Lean production**	9.1 **Reduces manufacturing costs** and makes **mass production easier** 9.2 **Reduces waste**: more **sustainable**	

632 words

Conceptual Designs

1 **Sliding clear acrylic** door is opened to put phones inside and once the lock time is **set** using the **3** red momentary push to make (**PTM**) switches, the phone will be locked in by a **magnetic lock**.

Diagonal butt joint - increased surface area **contact,** reduced **sheer force**

Oak is **aesthetically pleasing** due to **grain**

160

Handle **shape**: **intuitive** and **affords** pulling, rubber **grip** provides **comfort**

Clear acrylic too see **which/how many** phones are inside

Handle length is **75mm** - about **average** teen hand **breadth**

Low **visibility**: No **engravings** or **symbols** could reduce **intuitive logic**

170

Can lock up to **6** phones: **ideal** for **family use**

Intuitive user interface and **mapping** results in **low memory burden**

Universal on/off symbols for higher **learnability**

90

Could be **perceived** as **complicated** because it has **many settings**

Set button: **Adjusts** circuit **lock** settings

Lock time adjust buttons: **Increase** and **decrease** time

2 White acrylic top is **pulled** out and phones are **stored inside**, user **closes** the lid and the **magnetic poles** on either side **lock** the phone in for a set amount of **time adjusted** using the **interface**.

Acrylic used because it can **bend easily** and is **lightweight**

But still **affords pulling**

Contemporary design appeals to **teen demographic** due to **fashion trends**

Acrylic piece bent by **90º**

Toggle switch - **low environmental footprint** during **production**

Gap is **too small** to open **comfortably**: **high physical burden**

Non-permanent joints so cover can be removed by user

150

ON/OFF **engravings** should be added to **reduce memory burden**

Magnetic locks activate when circuit time is set

Separated user interface could decrease **ease of use**

150

Not robust due to **multiple joints** and **bends**

Top View

Finger joint: increased **surface area** + **reduced stress**; **reinforced** with **Epoxy Resin**

Circuit box

Could add **ribs** within to **distribute load** on the bend

150

Product life might be **short** as edge pieces **break** off

Screws are fitted at the back to allow for **circuit maintenance**

3 **Sliding translucent acrylic** door is opened to put phone(s) inside and once the lock time is **set** using the **PTM** switches, the **solenoid** is powered and the box is **locked**.

Teak wood used because it is **robust** and **aesthetically pleasing**

x4

CNC Milling Machine provides an **accurate cut**

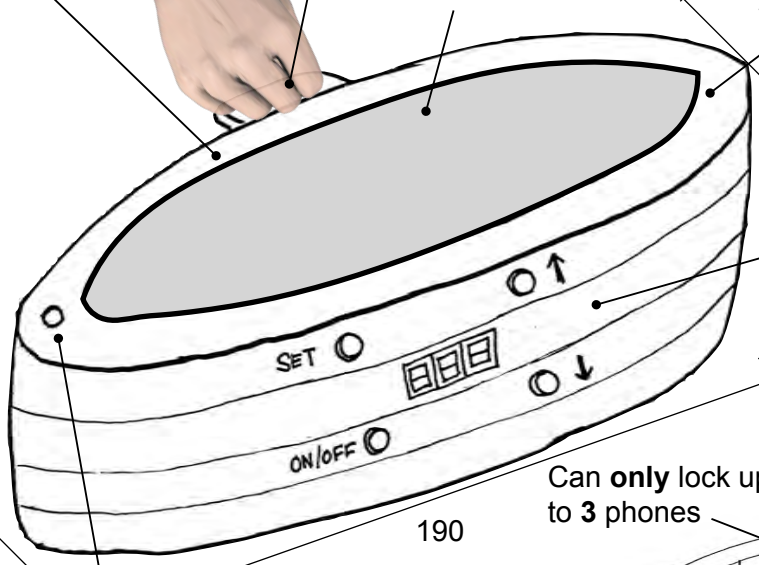
Pieces **glued** using **wood adhesive** and then **clamping** until dry

Handle **doesn't afford pushing** (sliding) very well & is **awkwardly** placed

Translucent acrylic cover to keep track of phones inside

Rebate joint - ensures acrylic is **secure** and can **slide**

Finished using **teak oil**

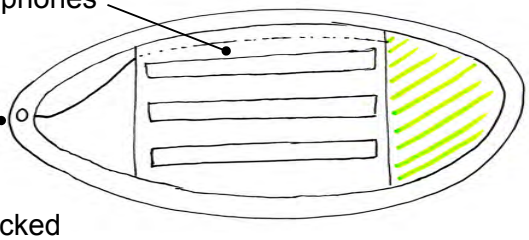


User interface mapping is **unorthodox** but **easy to understand**

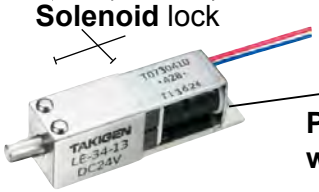
Symbols make **mapping intuitive** and **logical**

Can **only** lock up to **3** phones

Top View



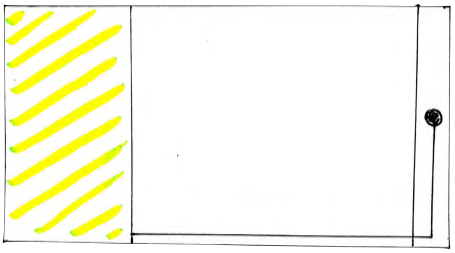
Solenoid lock



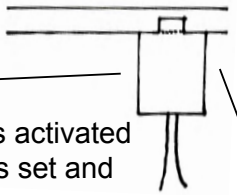
Pushes upwards into **wooden notch** when locked

4 User turns on device by **flipping** the **rocker switch** and **LED** light goes off; **teak latch** opens and allows user to **store phones** inside; and once the time is set, **solenoid** locks device.

Top View

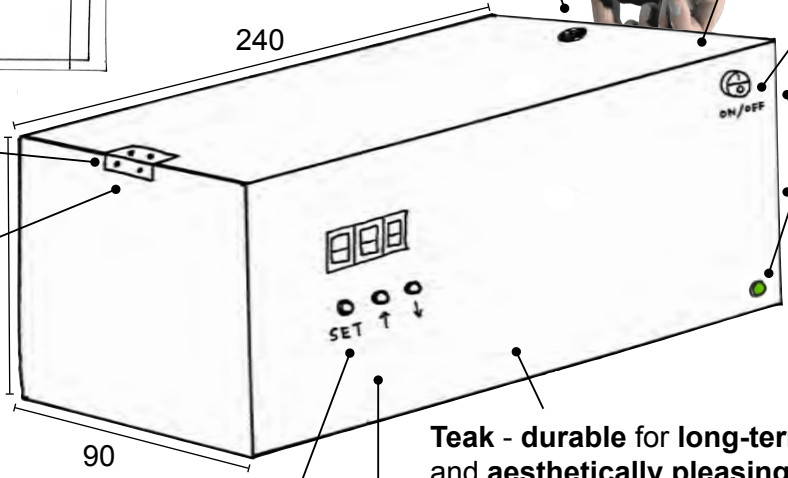


Solenoid is activated once time is set and **pushes up**



Minimalistic design is **aesthetically pleasing**

Engravings along with **symbols** make the device **easy** to **use**

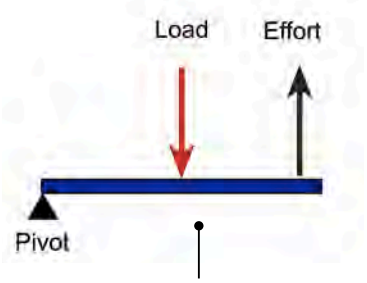


LED provides **visual feedback** when rocker switch is flipped

Butt joints for **increased rigidity**

Hinge allows for **opening** of **latch**

2nd class lever



Provides a **mechanical advantage**, makes design more **inclusive**

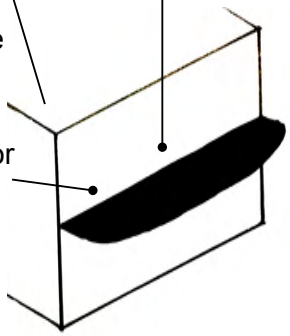
Teak - **durable** for **long-term** use and **aesthetically pleasing**

Function and **setting** to **choose** may be **unclear without instructions**

Not very portable but **lightweight relative** to **size**

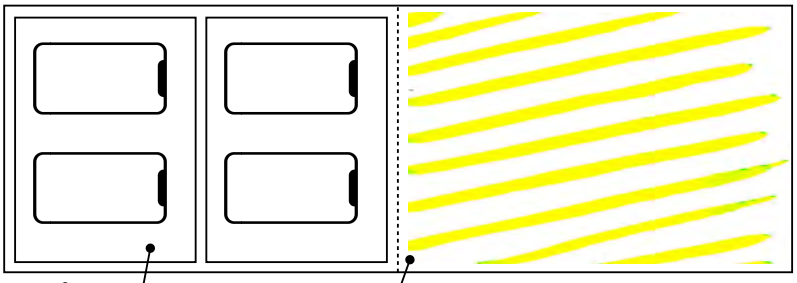
Acrylic flap to **afford** pulling **upwards**

Ergonomic grip below for **four fingers** to hold onto



5 **Shape and form** is inspired by a **wallet** - the user opens the device **laterally** and there are **two phone compartments**. Secure phones by clicking **'SET'** and the **LED** will light up.

Front View



Phone compartments - difficult to open: **worsens user experiences**

LED provides **visual feedback** to indicate phone is **locked**

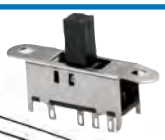
Circuit: difficult to mount on **thin** piece of teak

Clear acrylic door to see phones inside for **easy identification**

Acrylic - **robust** in case device is closed with strong **force**

No handle which **increases strain** on user when **opening**

6mm Oak - suitable for **long-term use**; **attractive** when **finished**



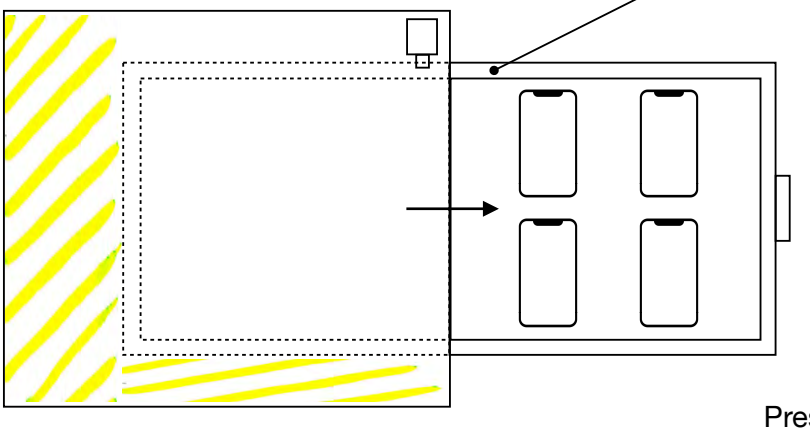
Slide switch: motion differentiates from PTM switches

Up-down **arrows** used so **language** is **not** a **barrier**

Momentary PTM switches with **symbols** and **text** for greater **intuition**

6 **Drawer-like** shape to insert phones into compartment. **Solenoid** is placed inside box and is activated when **"SET"** is pressed.

Top View



Ball bearing runner - most **efficient** way to **open drawer**

Easy to repair and allows for **smooth push** and **pull**

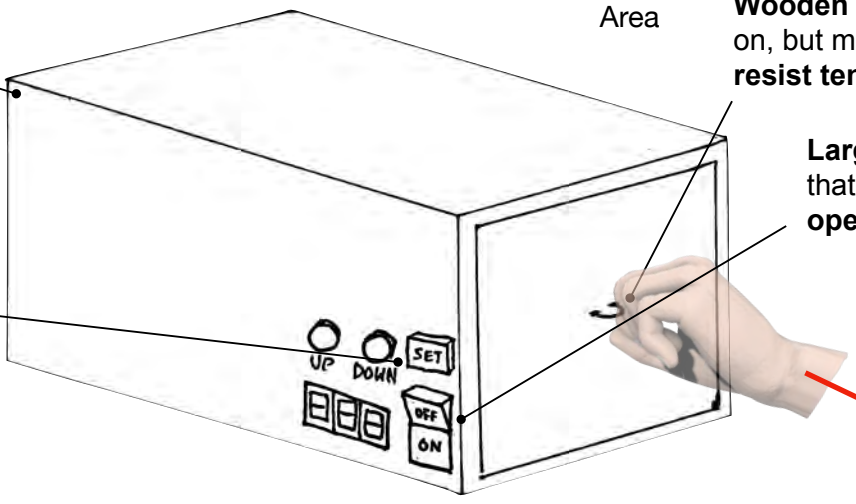
Because less surface area contact with box, **increased pressure**

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Wooden handle **glued** on, but might **not resist tension** well

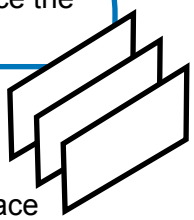
Could incorporate **rubber guard** for **protection** from **sharp corners**

Aesthetically pleasing PTM switch, but **might seem like an LED**



Large button - shows that it's **important** for **operating** the device

7 **Clear acrylic** cover **rotates laterally** and user put phones inside and **sets the time**; once the time is over the **buzzer goes off** to indicate the **solenoid** is **pulled back**.



Buzzer provides **auditory feedback** when **device opens** to release phones

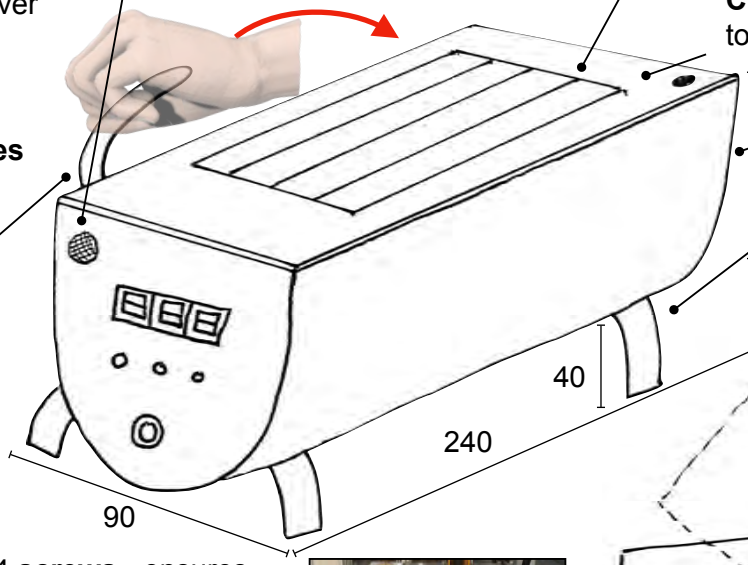
White acrylic barriers separating phones

Ridges on grip to **support fingers** when pulling lever

Clear acrylic surface to look into phones

Rubber grip is comfortable and **enhances user experiences**

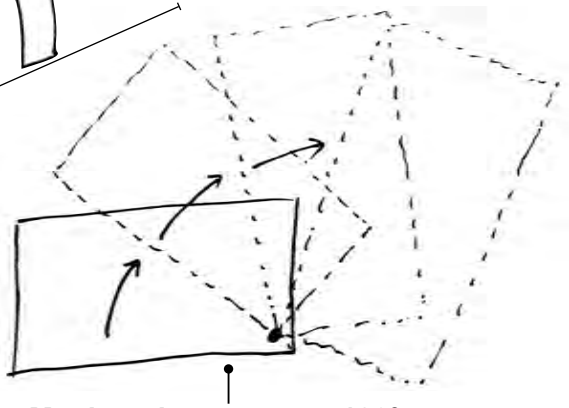
Unique shape could make teens and families **receptive to purchase**



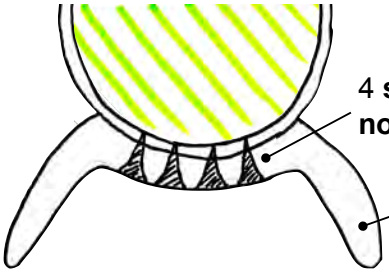
Torque: handle provides **mechanical advantage**

Provides **stability** to **prevent falling**, **reduces safety risk**

Top View

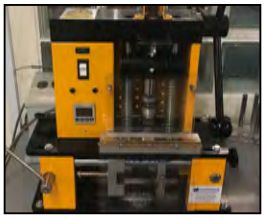


Front Cross-section



4 **screws** - ensures **no twisting**

Injection moulded ABS

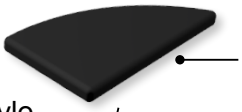


Moving pivots, rotates **180º**

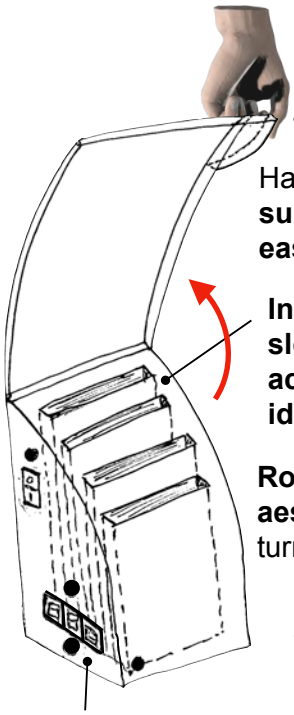
8 **Acrylic latch** opens **upwards** to allow user to place up to **four** phones inside. Upon **closing** the latch and pressing the **upmost PTM** switch, the **solenoid** is **activated** and the device is **locked**.

Heat bend acrylic to get a **curved** shape

3mm matte black acrylic cover for a **contemporary** style



Filleted corners for **aesthetic appearance**, **enhances comfort** when lifting



Handle needs **more surface area** for max. **ease of use**

2nd class lever provides **high mechanical advantage**

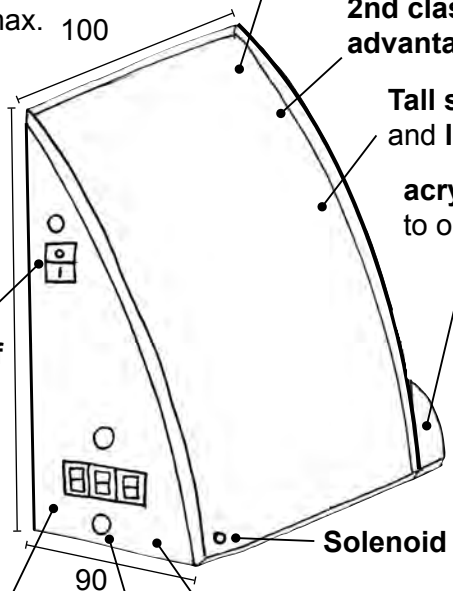
100

Tall structure makes the product **unstable** and **likely** to **fall**

Individual phone slots for **easy access** and **identification**

acrylic grip to open latch

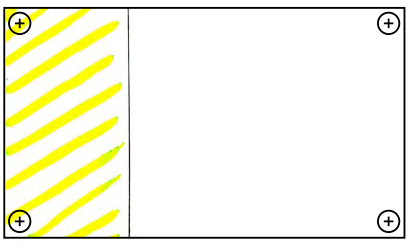
Product is also **not robust** because of **weak butt joints**



Rocker switch is **aesthetic** and turns device **on/off**

Might **not** be **ergonomic/comfortable** since **lifting motion** is **unconventional**

Bottom View



3 digit 7 segment display module; seconds-minutes-hours

Logical mapping of user **interface** enhances **user experience**

Solenoid lock

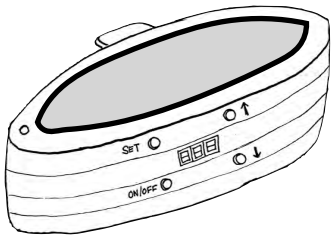
Body made out of **3mm teak** because it's **aesthetically pleasing**

Momentary PTM switch to allow time adjustment - **affords pushing**

Screws to allow for **circuit maintenance** and **battery replacement**

Review of Conceptual Designs

3 I have made **several developments** to design 3 in order to improve the **intuition**, **logic**, and **feasibility** of this design.

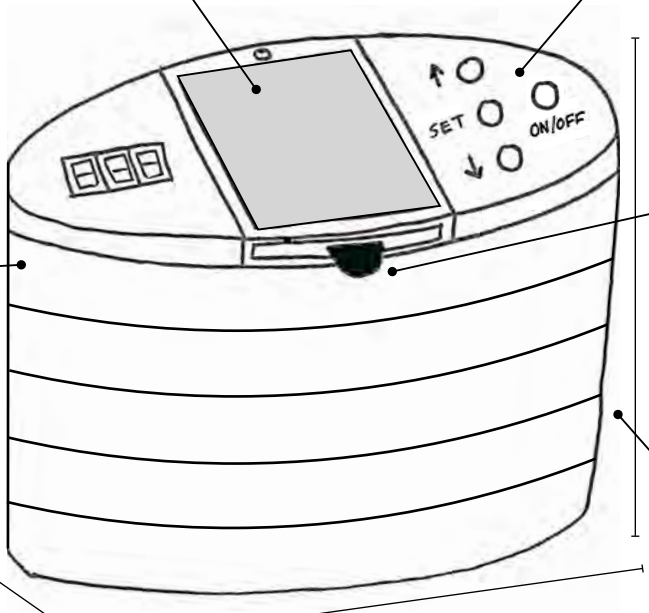


Development: Acrylic cover is **smaller** and **rectangular** - **easier to construct**

Development: **User interface layout** is **less unorthodox** - **easier to use**

Teak has **natural oil content—not suitable** in **humid** conditions

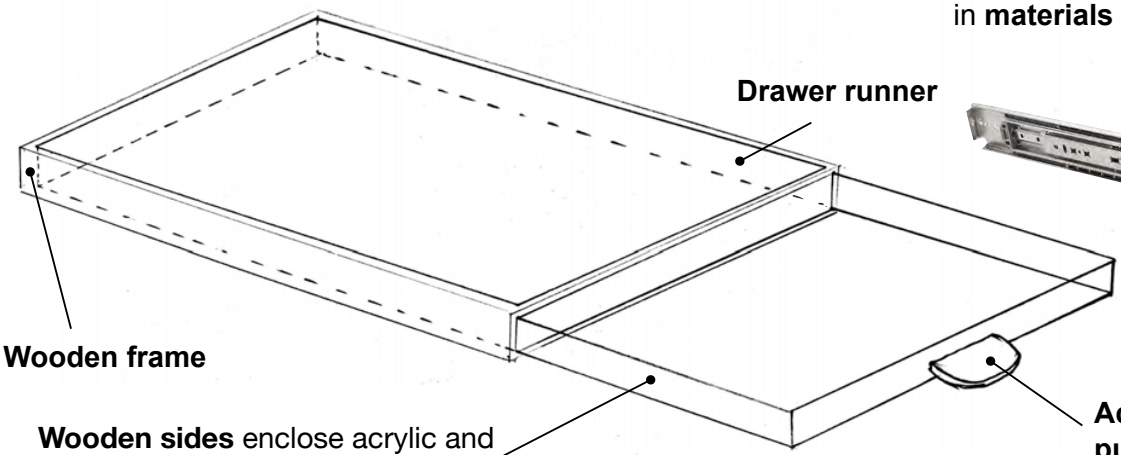
Development: **Ash wood instead** of **teak**



Development: **Pulling motion of acrylic cover is more intuitive**

Development: **Phones slot in vertically so increased height of product**

5 CNC panels needed, **increase** in **materials - less sustainable**



Drawer runner

Wooden frame

Wooden sides enclose acrylic and is attached to **drawer runners**

Acrylic handle affords pulling and **reduces effort required** by user

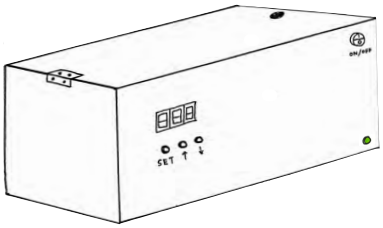
User Interface Switch Choices

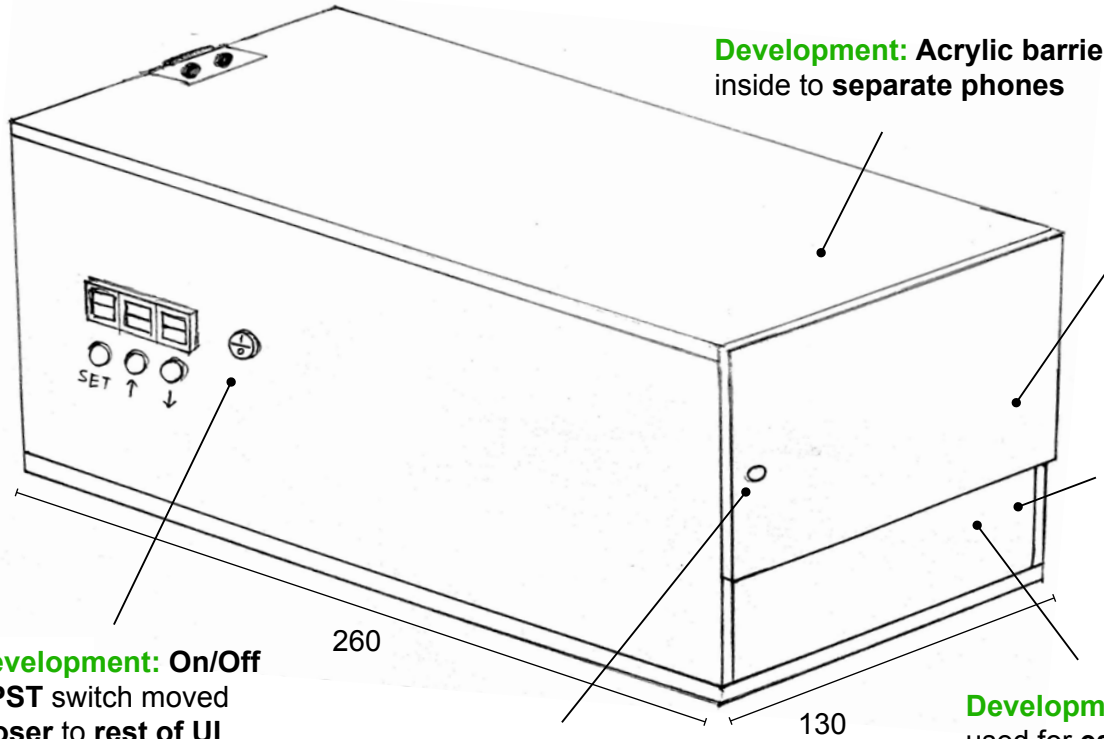
ON/OFF

SET

UP/DOWN

4 Design 4 developments betters **user experience**, enhances **logicality** of **UI mapping**, and **improves functionality**.





Development: **Acrylic barriers** inside to **separate phones**

Development: **Handle** incorporated for **ease of opening** device

Development: **LED removed** as it adds **little value** to **user feedback**

Development: **On/Off SPST** switch moved **closer** to **rest of UI**

Development: **Solenoid** pushes **through handle** to **lock** device

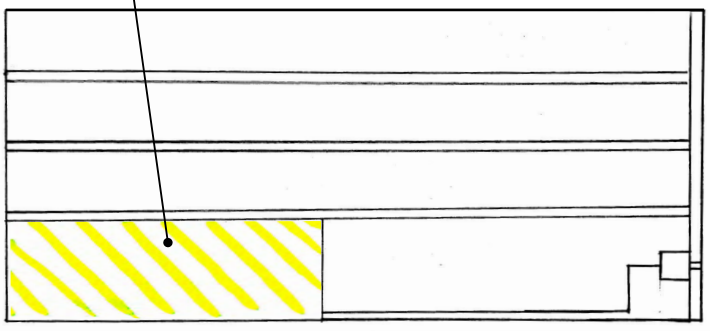
Development: **Butt joints** used for **ease of construction** and **greater robustness**

Circuit is **covered** by **wooden panel**— can be **accessed for maintenance**

Acrylic barriers - **capacity** of **3 phones**

Might be **too little** for one **family**

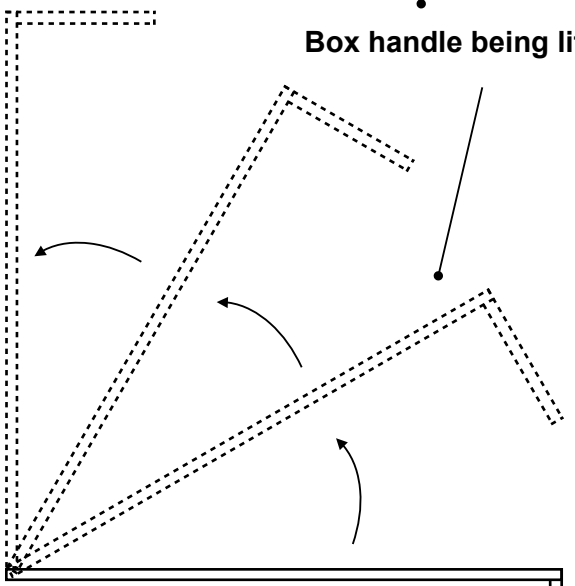
Top View of Product



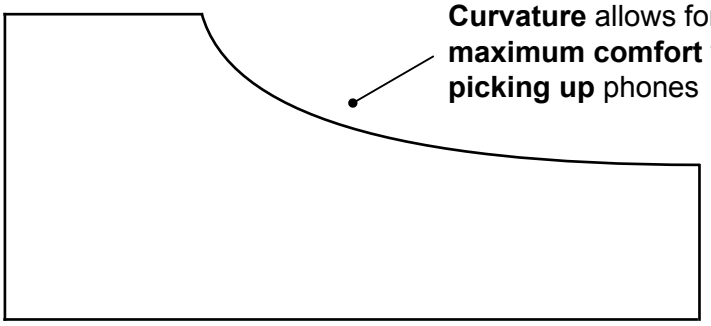
Solenoid pushes **through handle** to **lock** device

2nd class lever as **load** is in the **center**

Box handle being lifted



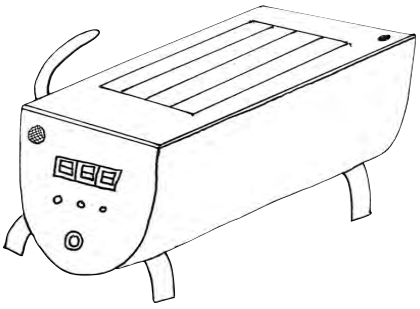
Side View of Acrylic Barriers



Curvature allows for **maximum comfort** when **picking up** phones

High mechanical advantage as **input force < output force**

7 Design 7 has been developed to **enhance** user **operational comfort** such as **rotation axis stability adjustments**.



Development: Buzzer removed because the **user feedback** received is **not valuable**

Development: Hinges for upwards motion instead of lateral—device is compact

Development: Two hinges to **reduce torque** on handle

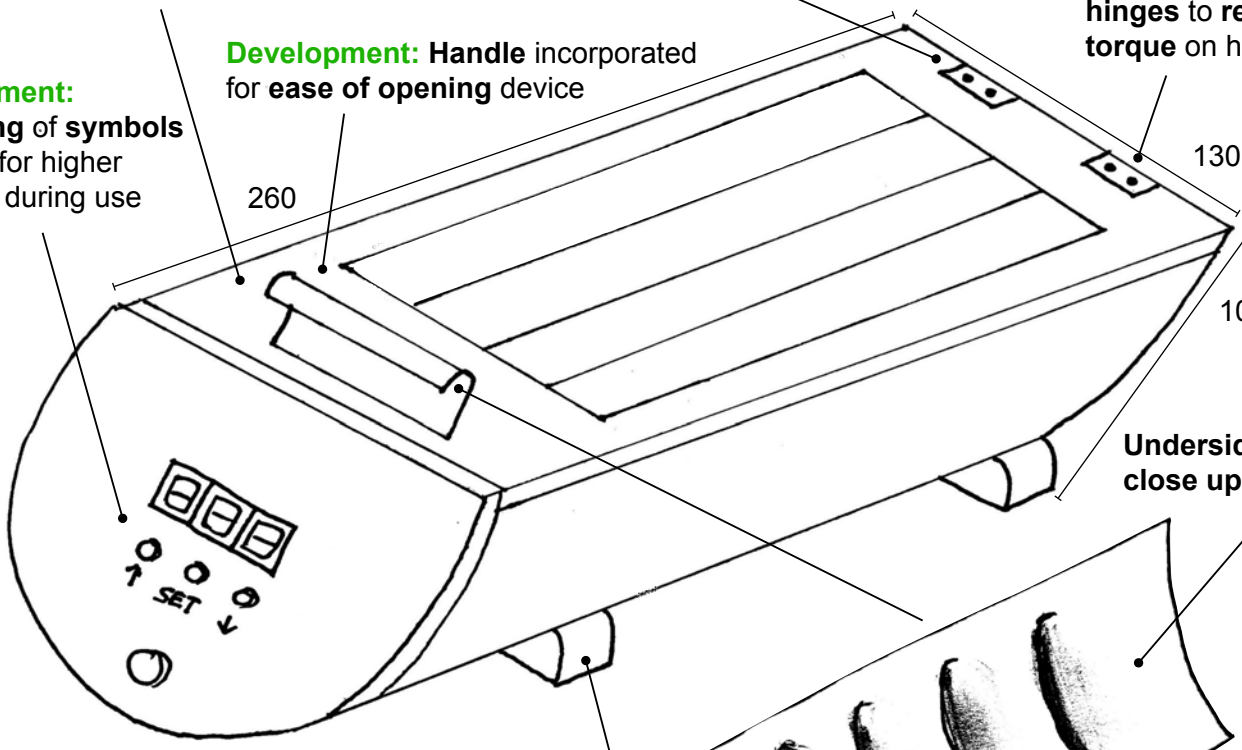
Development: Handle incorporated for **ease of opening** device

Development: Engraving of **symbols** and **text** for higher **intuition** during use

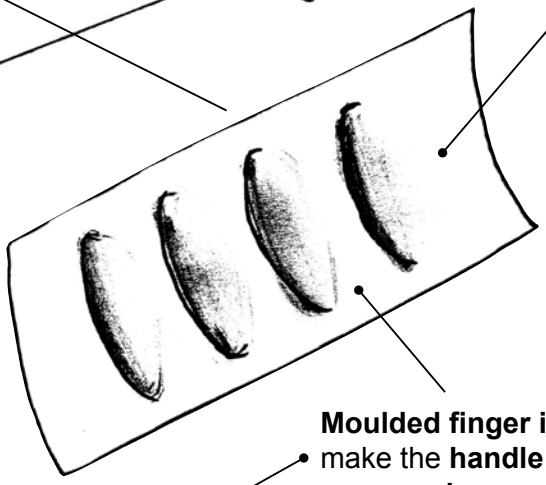
260

130

100



Underside of h**andle close up view**

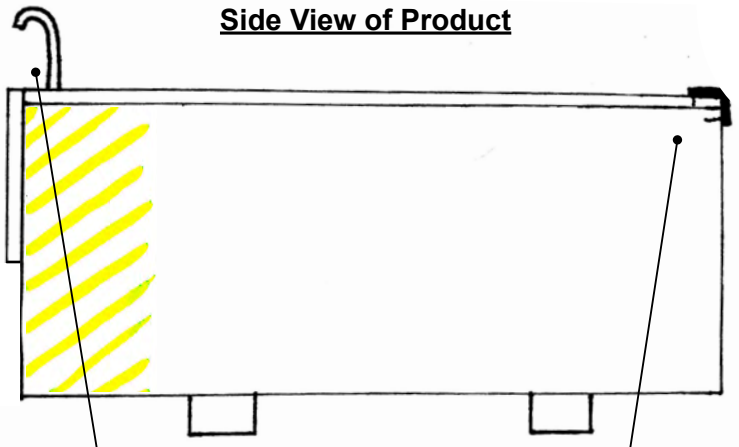


Moulded finger imprints to make the **handle more ergonomic**

Need to use **vacuum forming** in order to **mould plastic**

Will need to **collect dynamic anthropometric data** to design

Side View of Product



White ABS filament

Handle might be **difficult to grip** for users

Repetitive movement could **cause stress** to the user

3D printed as it is a small component

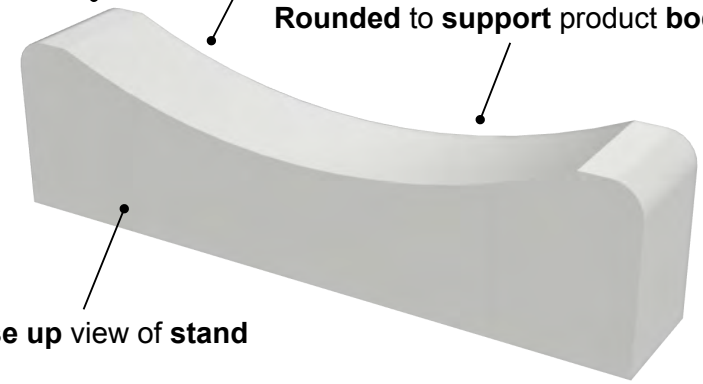
Rounded to **support** product **body**

Difficult to use for **users** with **low strength/physical capacity**

Could add rubber cushioning underneath for comfort

e.g those with **Parkinson's Disease or Arthritis**

Design is **not inclusive**



Close up view of **stand**

Client Feedback Against Design Specification

Type	Specification	Design 3	Design 4	Design 7
Function	Must be able to **lock phone** inside			
Function	Must **display** how much **time** is **left**			
Function	Must have the **ability** to **set** and **change time**			
Function	Must **not damage** phone			
Function	Must be **easy** to **replace batteries** if battery operated			
Aesthetics	Must follow a **contemporary style**			
Aesthetics	Must have an **intuitive** and **easy to use user interface**			
Aesthetics	Must be made out of **wood** and **phones should be visible**			
Aesthetics	Must ensure that **buttons match** the **style** of the product			
Size	Must be suitable to fit multiple **phones**			
Size	Must be a **suitable size** to fit on a **study table**			
Material	Must be made **predominantly** out of **wood**			
Material	Must have a **clear acrylic panel**			
Material	Must be **durable**			
Material	Must be **robust**			
Unique Selling Point	Must be **designed specifically** to **secure phones**			
Unique Selling Point	Must be **aesthetically pleasing**			
Unique Selling Point	Must **not** be **bulky or heavy**			
Unique Selling Point	Must be **compact**			

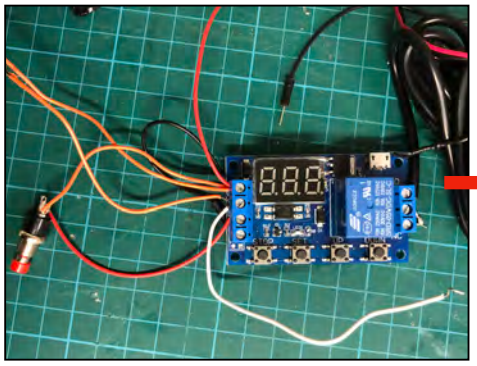
Selected Idea

I have **selected design 4** for **further development** as it **meets** the **specification** criteria **better** than designs 3 and 7. There is **potential** to **further develop** design 4 to ensure it meets the **functional**, **practical**, and **aesthetic needs** of the given **task** to solve the **design problem**.

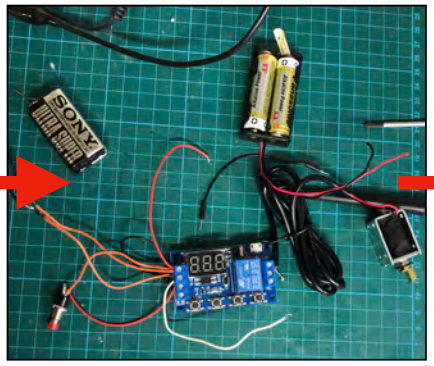
47 words

Development of Conceptual Design

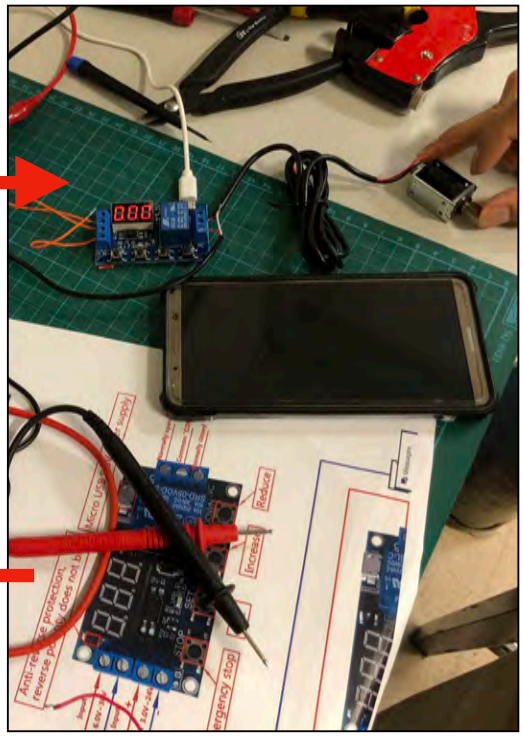
Circuit Development



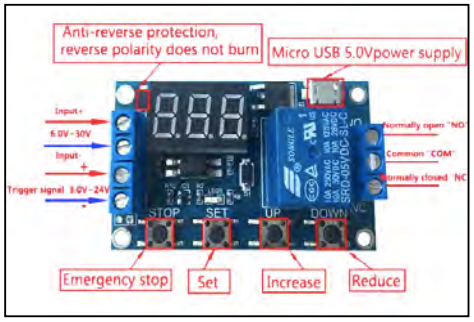
Soldering and wiring



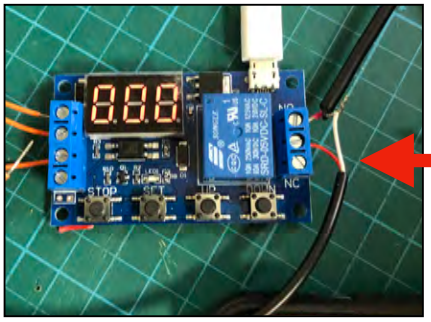
Wiring two power sources



Using manual to finish circuitry



DC Digital Time Delay Circuit



Complete circuit

One Power Source

Even when box is **not operating**, solenoid **draws power**

9V power supply

Heats up and **shortens** component **life**

5V USB Cable

On/Off **Momentary PTM** switch

Using a **smaller supply** might fix the heating issue

Parallel circuit to supply **9V** to **solenoid** and **trigger**

Four **1.5V AA** batteries -**parallel** connection to **trigger** and **solenoid**

Still **not enough power** to **solenoid**

Positive terminal supply **split**

Negative terminal supply **split**

6V supply to circuit

Two Power Sources

Two **1.5V AA** batteries

5V USB Booster

Not enough **voltage** to **input**

Requires **min. 6V** and **max. 30V**

6V to **solenoid**

Using a **6V power supply** might **solve** the **problem**

Circuit is **powered**

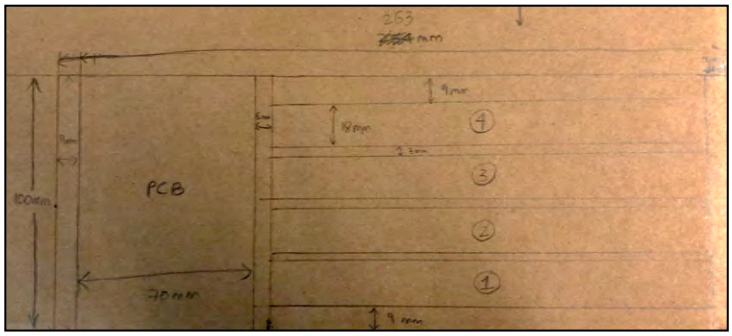
9V wall plug, successfully powers **solenoid**

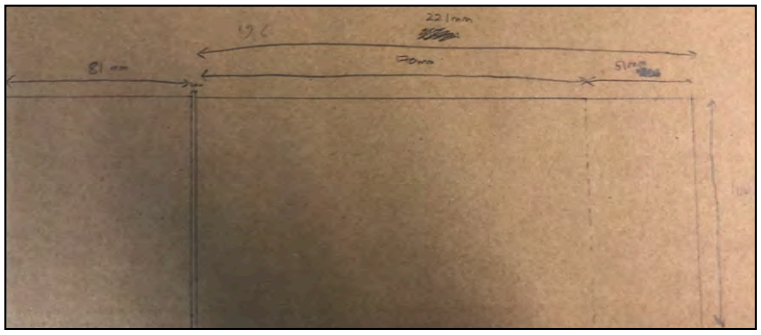
6V to **input**

Product will **need** to plug into **wall socket**

Box Shape and Structure Development

Planning: Marking Out Dimensions On Cardboard





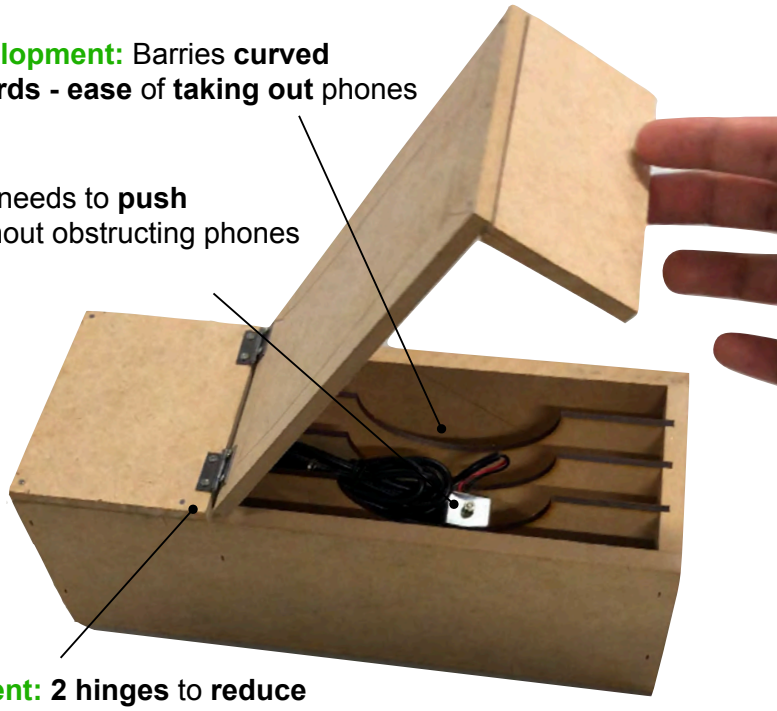
Prototype 1: Laser Cut 3 & 6mm MDF

Solution: **Add another** 'phone' **slot occupied** by **solenoid**

Development: Barries **curved inwards - ease** of **taking out** phones

Development: **User Interface** on **top panel** instead

Problem: **Solenoid** needs to **push through handle** without obstructing phones



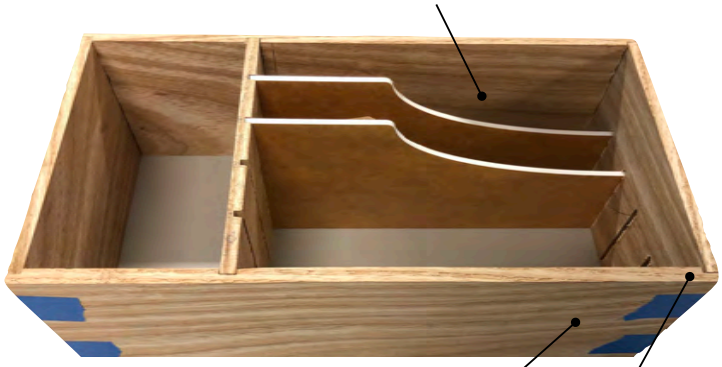
Development: **Circuit housed separately** in a compartment that **does not open with handle—more logical**

Development: **2 hinges** to **reduce amount of torque** experienced by **screw**

Final Housing: Laser Cut 6mm Ash Wood & 3mm Acrylic

Development: **Extra slot added for solenoid to pass through to handle**

Development: **Curve shape adjusted to make it easier to pick up phones**



Problem: **Missing hole** for wire to **plug into wall socket** and **power** circuit

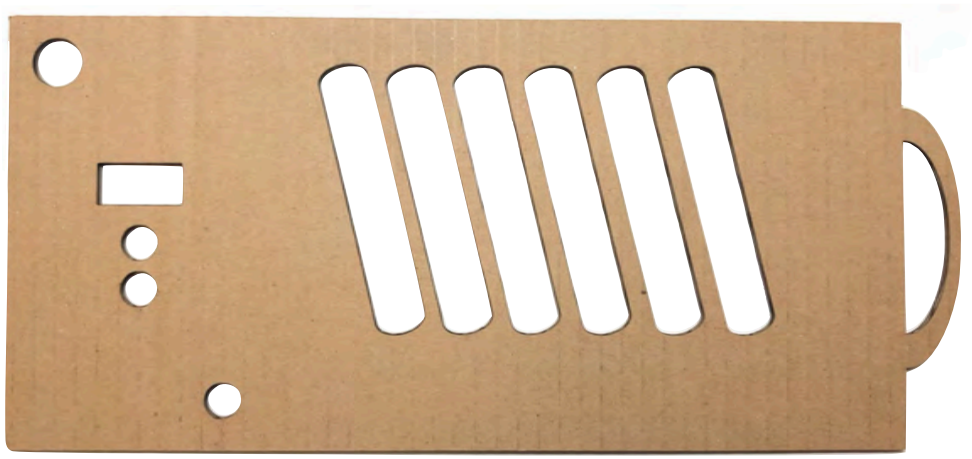
Solution: **Drill hole** of **3mm radius**

Problem: **Missing hole** for **solenoid** to **lock** device

Development: **Rebate joint—increased surface area contact** for higher **pressure tolerance**

User Interface Development

1 Design 1 - has a slanted clear acrylic panel to see phones



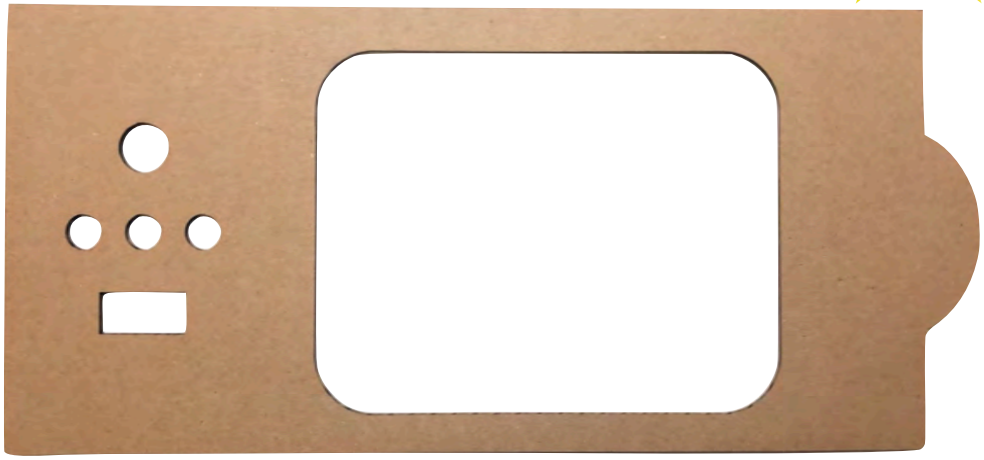
PROS

- **Contemporary**, **unique** design
- **Logical mapping** of components
- **UI mapping** not **aesthetically pleasing**

CONS

- **Difficult** to **see** phones **clearly** as the acrylic **goes across** the **phone**

2 Design 2 - completely clear acrylic panel to see phones



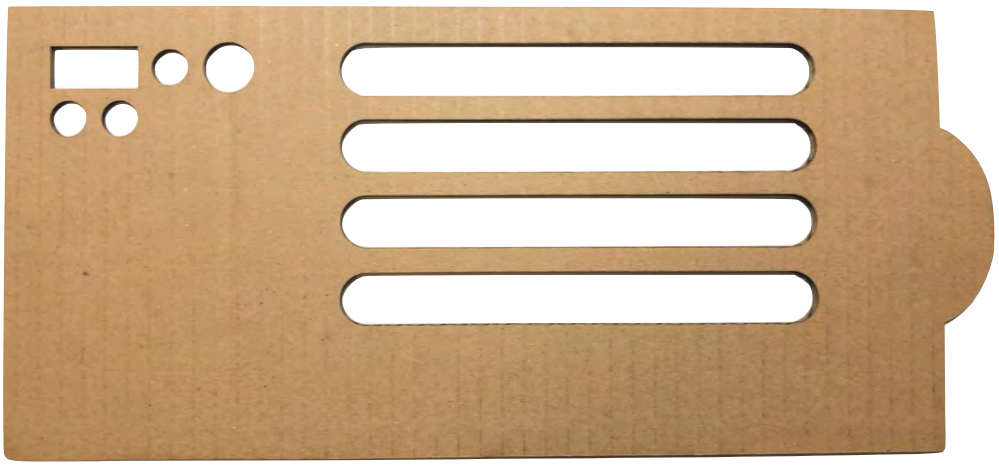
PROS

- **Minimalistic** look is **appealing**
- **Simple** and **compact layout** makes it **easy to use** and **understand**

CONS

- All **3 buttons** together might be **non-intuitive** as they have **different functions**

3 Design 3 - clear acrylic panels to match phone orientation



PROS

- **Easy to see** phones inside due to **orientation** of acrylic panels
- **Precise arrangement (i.e all 90 or 180** degree angles**)** is **attractive**

CONS

- **Too much empty space** on UI panel due to **arrangement** of **components**

Handle Development

1

- **Handle** is **minimalistic** and **aesthetically pleasing**
- May be **too small—reduces operational comfort** and **worsen user experience**
- **Small surface area**—susceptible to **breaking** and **reduces durability**

2

- **Not very aesthetically pleasing**
- **Easy to make** using **coping saw** and **file**
- **Difficult** to use for those in **5th and 95th percentile**
- Might **not afford pulling** upwards **intuitively**.

3

- **High stress** on the **joints** joining handle to the **body**
- As a result, product is **not durable** or **robust**
- Handle is **aesthetically pleasing**
- **Not comfortable** during **operation** due to the **rigid corners**

4

- **Minimalistic style** is **aesthetically pleasing**
- **O**pening the product may **not** be **intuitive**
- **Finger indents** are not **immediately visible** from **all directions**
- **Ergonomic design maximise user experience**
- Suitable for **95th percentile users**

5

- Design is **easy to make** and also **aesthetically pleasing**
- Handle **affords pulling upwards** and is **intuitive** for **all** users
- Design **maximises inclusivity-–high surface area, easy to lift**
- Can **endure repetitive movement**

6

- **Handle** design is very **unique** and **aesthetically pleasing**
- **Difficult to make accurately**
- **Tough** to use for users with **physiological disabilities**
- Handle **does not afford pulling upwards** well—**unintuitive**.

Justification of Selected Final Idea for Detailed Development

Justification of Final Idea for Detailed Development

I chose to develop **design 4** as it **meets** the **specification criteria** the **best** amongst the rest of my designs. The final product meets **all** the specification criteria and **adequately solves** the **design problem**. The **logical mapping** of **user interface** makes the product more **intuitive**, **enhancing user engagement**. Moreover, all the components' **affordance** is **precise**; for example, the **handle** affords **pulling**, the **PTM switches** afford **pushing**, and the **rocker switch** affords **flipping**. Moreover, since the buttons are all **close together**, the user will experience **minimal physical fatigue** as all buttons are **easily accessible**. The **clear acrylic cover** allows the user to **see** how many phones are inside for **practical purposes** and the **countdown timer** provides **visual feedback**. The device is made **compactly** considering that it can **store up to four phones safely without causing damage** during **regular operation**. The **user interface** layout enhances **learnability** to maximise **efficiency** during use. The device is made **predominantly out of wood** to fit with the **common household aesthetic** that has **wooden** products and thus becomes **more desirable** for **purchase**. **Handle** is designed to **maximise operational comfort** and the **large surface** area **reduces physiological stress** on the user.

Further Developments Based on Client Feedback and Testing:

- Include **engravings** of **universal symbol** beneath buttons to make device more **simple to use** for **all types of users**, ensuring there are **no alternate perceptions**
- Device can be made even more **compact** by **rotating phone orientation** by **90 degrees** and **reducing** the **width** of the product
- **Edges** could be **rounded** to make the device more **aesthetically pleasing**
- **Handle panel** could be **redesigned** to **reduce physical stress** on user cause by **repetitive movement**
- **Circuit** could be **changed** so that device is **battery-operated** to make the device **more portable**

289 words

Housing	
Material Selection	**Ash Wood (6mm)** 
Physical Characteristics	• **Hardwood** - easy maintenance since offers resistance to dents • **Durable** - long-lasting material, high strength-weight ratio, won't degrade under normal use • **Smooth texture** - enhances user experience when handling product • **Lightweight** - 6mm thick only so that it is lightweight • **Durable** - High strength to weight ratio
Mechanical Characteristics	• **Movement about hinge** - wood is rigid: user easily open device • **Strong** - won't deform easily under an applied load if any • **High compressive strength** - if placed under high load, won't fracture due to compressive strength
Aesthetic Characteristics	• **Light color** - client want: "not too dark" (pg. 2) • **Grain** - aesthetically pleasing as it has a natural look • **Finish** - teak oil finish is quite aesthetically pleasing
Environmental/Moral Issues	• **Deforestation** - Trees were cut down for wood: habitat loss • **Endangerment** - Ash wood species are listed on the IUCN red list of endangered wood species: population projected to reduce by over 80% (https://bit.ly/3omjn5C)

Barriers to Separate Phones and Top Panel	
	White and Clear Acrylic (3mm)
Material Selection	
Physical Characteristics	• **Lightweight** - easy to manoeuvre and slot into product • **Durable** - long-lasting: no need for replacement, reduces user effort • **Smooth** - smoothness prevents scratching/damaging any of the phones • **Self finishing** - no need to apply a finish
Mechanical Characteristics	• **Fracture resistant** - will not fracture while inserting into wooden slots: material thickness does not allow the neutral axis to bend • **Ease of use** - curved shape allows user to pick the phone up easily: enhances user experience • **Brittle** - Cracks easily but will not shatter if dropped
Aesthetic Characteristics	• **White** - white acrylic works well with the light colour of the ash wood • **Clear Acrylic** - is transparent so phones can be seen inside
Environmental/Moral Issues	• **Recycling and biodegradation** - difficult to recycle—not biodegradable • **Reusability** - thermoplastic which can be reheated and reformed • **Toxicity** - extraction of raw materials that are non-renewable is unsustainable

193 words

Justification of Manufacturing Processes

All Wooden Panels

Material Selection	Ash Wood (6mm)

Marking out / Preparation	• Panel type and Dimensions (mm)
	  • **Larger Top** Panel: **185 x 130**
	  • **Smaller Top** Panel: **80 x 130**
	  • **Handle** Panel: **92 x 130**
	  • **Bottom** Panel: **275 x 130**
	  • **2** Smaller **Side** Panels: **123 x 90**
	  • **Middle P**anel: **125 x 90**
	  • **2** Longer **Side** Panels: **275 x 90**
	• Check if wood is **square** for **consistency**
	• Make a **datum edge** for **base measurements**

Process / Technique	• Cut **all** panels using a **drop saw** as it is accurate
Joining	N/A
Finishing	N/A
Environmental/Moral Issues	• **Reduce waste** - use **same piece** to **cut many pieces** • **Stock size** is **2400x 195 x 6mm—**need to cut materials: results in **waste**

Larger Side Panels and Middle Panel

Material Selection	Ash Wood (6mm)
Marking out / Preparation	• **Pencil**, **steel rule** and **try square** to measure+mark wood • Use a **marking gauge** to draw perpendicular indent lines
Process / Technique	• **Routing** - use **table router** as it is **accurate** and **precise**
Joining	• **Rebate joint - attractive, increase surface area** for **strength** • **Through housing joint—**allows **middle panel** to **fit** and **provides slot** for **acrylic** • **PVA glue** for joining middle panel and smaller side panels
Finishing	• **Teak oil—aesthetic** and **easy to apply** finish
Environmental/Moral Issues	• PVA glue—**toxic** to **aquatic environments** if **disposed** into the sea • PVA is **biodegradable** (source for both - https://bit.ly/2Yoxehc)

Smaller Side Panels

Material Selection	Ash Wood (6mm)
Marking out / Preparation	• **Laser cut jig** to guide **hand router** • **Mark out** hole for plug using **pencil**
Process / Technique	• **Stopped housing joint** using **hand router** • Drill hole using **hand drill** and cut using **scroll saw**
Joining	• **PVA** glue creates a **long-lasting**, **strong** joint
Finishing	• **Teak oil** for **aesthetic appeal** and **ease of application**
Environmental/Moral Issues	• PVA glue is **toxic** to **aquatic environments** • Teak oil's "**low VOC formula** has **minimal environmental** impact and is **user-friendly**" (https://bit.ly/3oqLjW4)

Acrylic Barriers	
Material Selection	**White Acrylic (3mm)**
Marking out / Preparation	• **Fusion360 CAD export** to **Adobe Illustrator** (**compatible** with **laser cutter)**
Process / Technique	• **Laser cutter—accurate compared** to **hand-cutting** the acrylic
Joining	• **Tight fit** acrylic into through housing joint - **temporary joint** as it allows for **adjustability**
Finishing	N/A
Environmental/Moral Issues	• Use of **thermal energy** to cut material can release **dangerous fumes** • Laser cutting results in **large quantities** of **waste material** • Laser cutting can also **reduce waste** as it is **precise** • Acrylic: **non-renewable resource** made from **crude** oil which is **damaging** to the environment

Larger Top Panel and Handle Piece	
Material Selection	**Ash Wood (6mm)**
Marking out / Preparation	• Mark out wood piece using**—**increases **accuracy** when cutting
Process / Technique	• Cut **finger joint** using **scroll saw** and **bevel-edge chisel** for **precise** cut • File with **flat edge file** for **smoothness** • **Hand drill—**allows **scroll saw** to cut for **precision**
Joining	• Use **PVA** glue and **mesh** both finger joints—**tenon lines up** with the opposite **shoulder** • **Clamp overnight** to let **dry**
Finishing	• **Teak oil protects** wood surface from **cracking** and **stains**
Environmental/Moral Issues	• Saw uses **electric motor** so is **sustainable** (low **carbon emissions)** • **Teak oil** is **less damaging** for the **environment**

Circuit	
Material Selection	**Solder**
Marking out / Preparation	• Leave **soldering iron to heat** so it actually **melts solder** • **Strip wires** using a **wire stripper** to make connections • **Tin solder wire before** soldering component for easy connections
Process / Technique	• **Heat component then** place **solder wire** to **melt** on connection for **quality control** • **Heat shrink connections** to **prevent shorting**
Joining	• **Solder** - **temporary joint,** allows **conductivity**
Finishing	N/A
Environmental/Moral Issues	• **Lead soldering** can cause **detrimental fumes** and **bioaccumulates** in **ecosystems** during **disposal** of **electronic products** in **landfills** • Solder contains **flux** which **worsens asthmatic conditions** and can cause **eye/respiratory irritation**

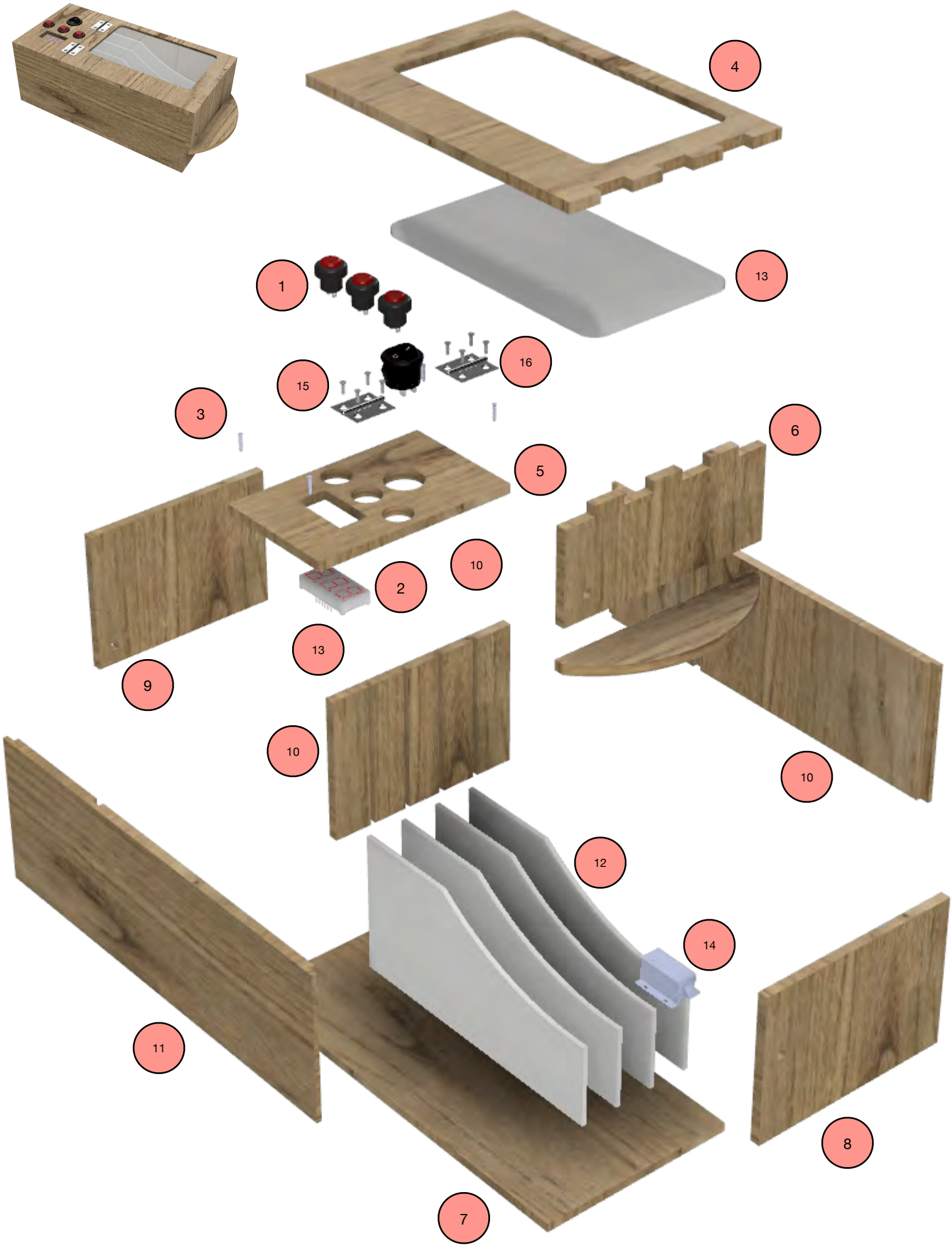
Bottom Panel	
Material Selection	**Ash Wood (6mm)**
Marking out / Preparation	• **Align housing surface** to that of the **bottom panel** for **precision**
Process / Technique	• **PVA glue— strong bond** makes device **long-lasting** and **robust** • **Clamp** wood in **vice**
Joining	• **Butt joint** - **high stability** as it is the **base** of the product
Finishing	• **Teak oil** for **consistent finish** across product
Environmental/Moral Issues	• PVA is **biodegradable** and has **low environmental impact** • However, **when burned** it releases **toxic fumes**

Smaller Top Panel	
Material Selection	**Ash Wood (6mm)**
Marking out / Preparation	• Mark out position for **buttons** of **7-segment** to ensure a tight fit • Mark out position of **4 screws** so buttons fit **tightly** and don't **collapse** when pressed
Process / Technique	• Using **drill press** as it is **efficient** and **accurate** • Cut **rectangular** section using **scroll saw** as it is **reliable** • **1.5mm cross head screwdriver** to join the panel on wood
Joining	• **Temporary joint** - use **screwdriver** since piece is **very thin** so not to **split** it
Finishing	• **Teak oil** as used throughout the product
Environmental/Moral Issues	• Drill uses **electric motor** which is **sustainable—d**oes **not produce carbon emissions**

Larger and Smaller Top Panels	
Material Selection	**Ash Wood (6mm)**
Marking out / Preparation	• Mark out position of **hinges so device** opens **straight**
Process / Technique	• Use **hand drill** for **accuracy**
Joining	• **Butt Hinge** - allows for **opening** and **closing** of device
Finishing	N/A
Environmental/Moral Issues	• Hand drill is **electric** so it is **relatively sustainable** • Production of **Lithium batteries** is harmful**—extraction** causes **soil** and **air contamination** • Aluminium **extraction** is **energy intensive**, but material is **recyclable**

196 words

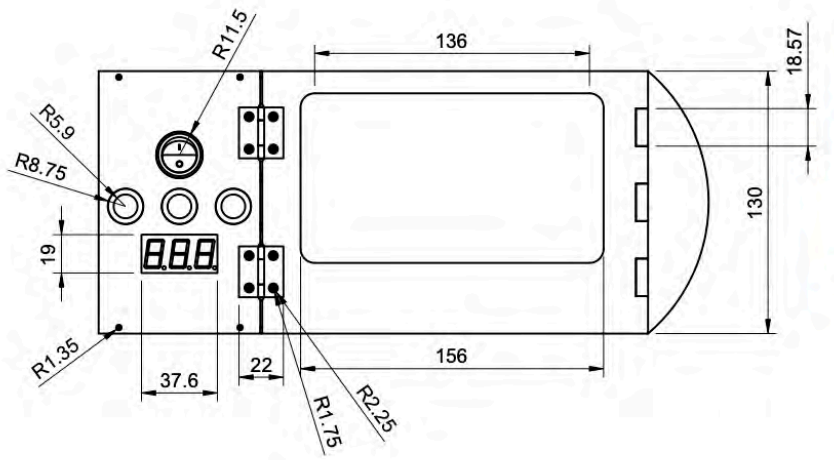
Exploded View

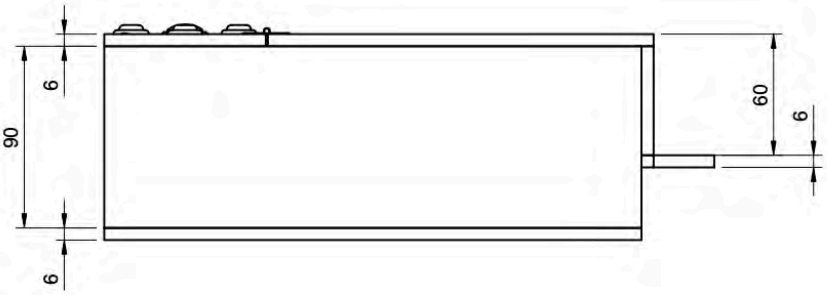


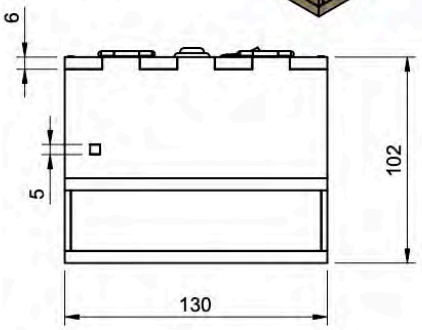
Assembly details with Bill of Materials

No.	Part Name	Material/ Component Description	Section/ Color/ Code	Dimensions (mm)			Quantity	Unit cost (USD)	Total cost (USD)
				L	W	H			
1	Button	Momentary PTM and Rocker	Standard Component (ST)	Diameter: 8.75 (PTM) and 11.5mm (Rocker)			4	0.37	1.48
2	Display	7-segment LED Display Module	ST	19	12	10	1	1.4	1.4
3	Screw	1.5 and 1.75mm Cross Head Screw; Low Carbon Steel	ST	Diameter: 1.5 and 1.75mm			12	0.0069	0.083
4	Larger Top Panel	Ash Wood	Sheet	191	130	6	1	2.09	2.09
5	Smaller Top Panel	Ash Wood	Sheet	80	130	6	1	0.87	0.87
6	Handle Panel	Ash Wood	Sheet	60	130	6	1	0.66	0.66
7	Bottom Panel	Ash Wood	Sheet	266	130	6	1	2.91	2.91
8	Smaller Side Panel 1	Ash Wood	Sheet	124	90	6	1	0.94	0.94
9	Smaller Side Panel 2	Ash Wood	Sheet	124	90	6	1	0.94	0.94
10	Middle Panel	Ash Wood	Sheet	124	90	6	1	0.94	0.94
11	Longer Side Panel	Ash Wood	Sheet	266	90	6	2	2.01	4.02
12	Acrylic Barrier	White Acrylic	Sheet	182	90	3	4	0.45	1.8
13	Clear Acrylic Panel	Clear Acrylic	Sheet	156	90	3	1	0.38	0.38
14	Solenoid	Solenoid	ST	25	20	12	1	1.87	1.87
15	Circuit	Circuit	ST	55	35	35	1	3.75	3.75
16	Butt Hinge	Aluminium	ST	25	20	3	2	0.27	0.54

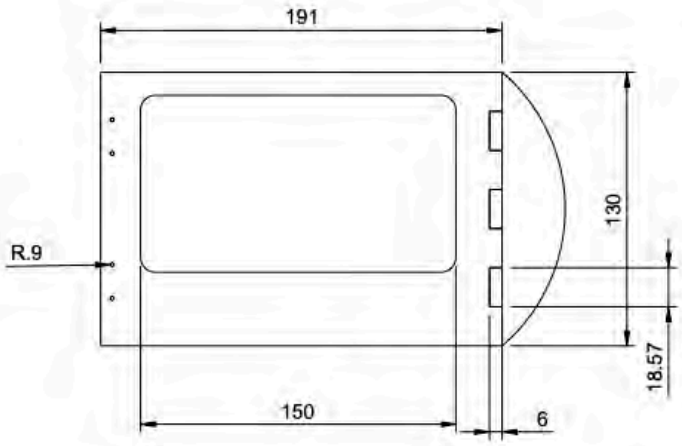
Technical drawings

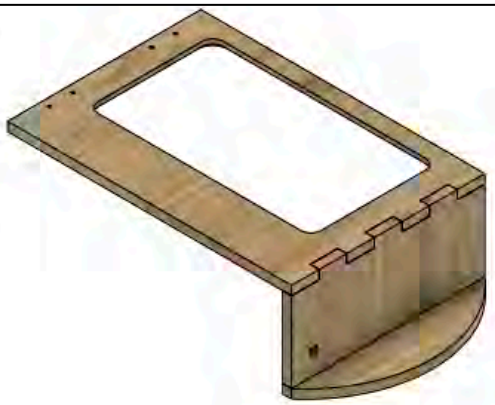


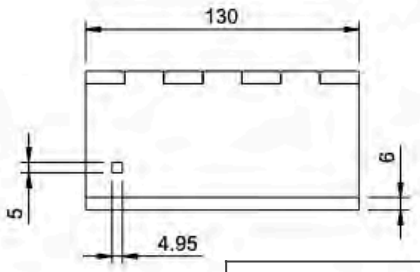


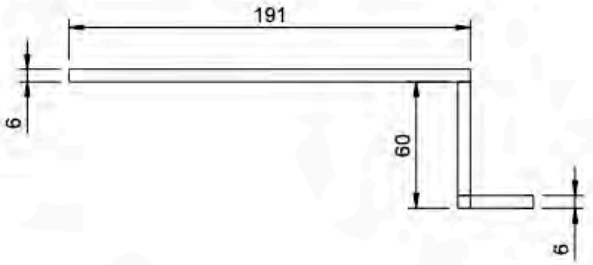


Component Name: Full Product	**Materials:** Ash wood, Clear and White Acrylic	**Scale:** 1:2
Part Number: All	**Quantity:** 1	**Unit:** mm

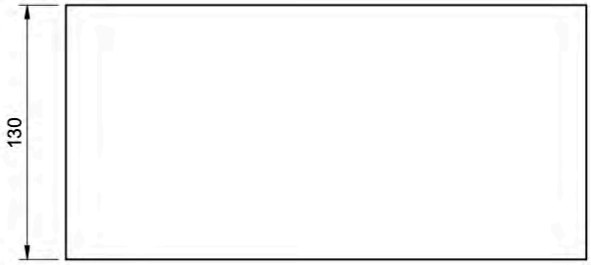


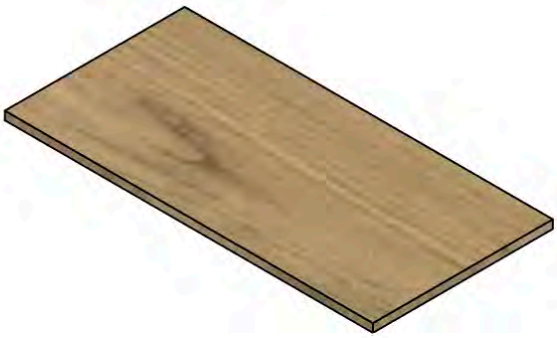


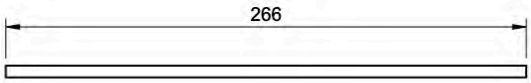


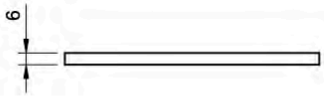


Component Name: Larger Top Panel and Handle panel	**Materials:** Ash wood	**Scale:** 1:2
Part Number: 4, 6	**Quantity:** 1	**Unit:** mm

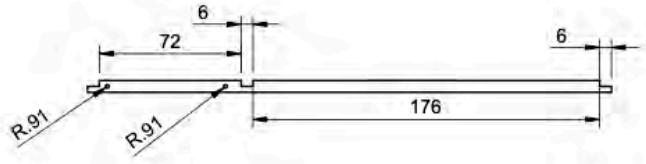


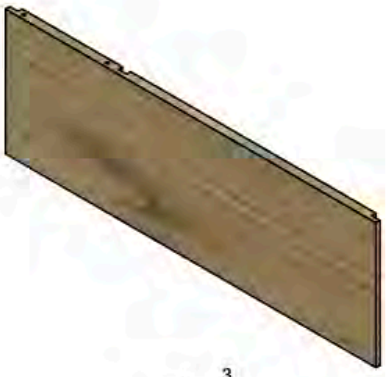


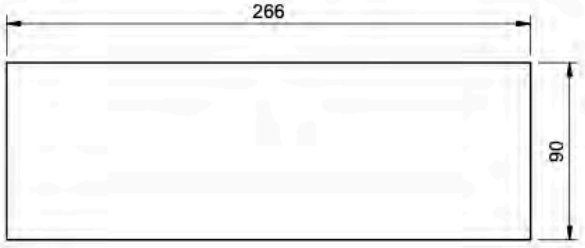




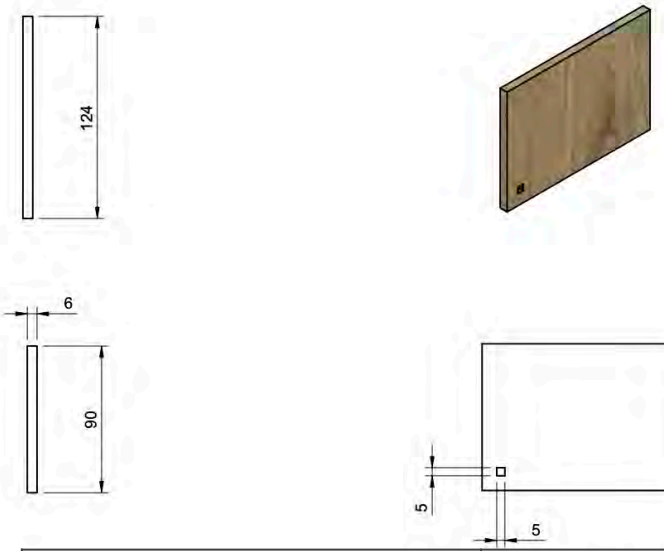
Component Name: Bottom Panel	**Materials:** Ash wood	**Scale:** 1:2
Part Number: 7	**Quantity:** 1	**Unit:** mm



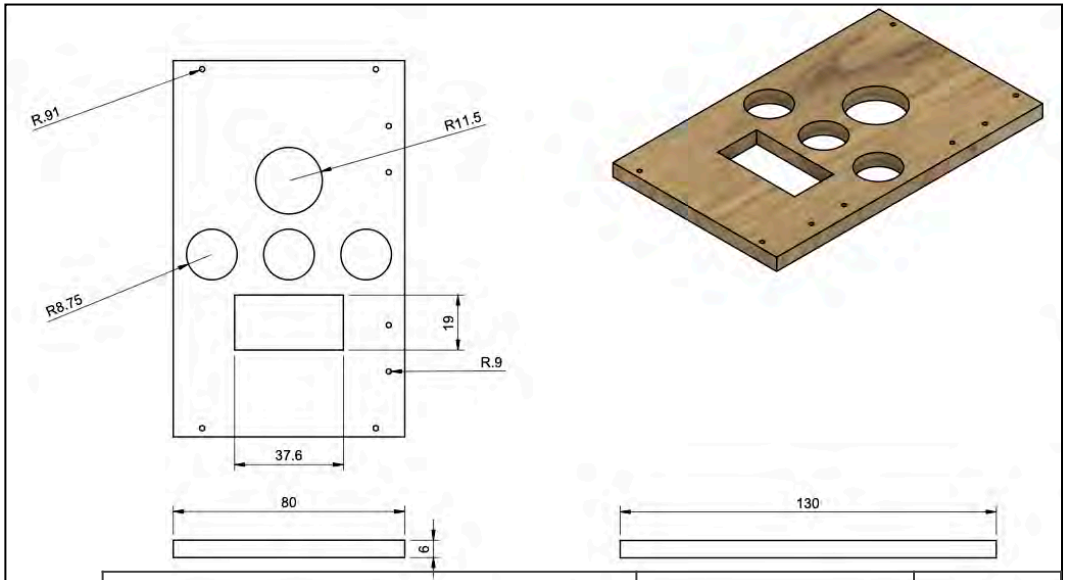




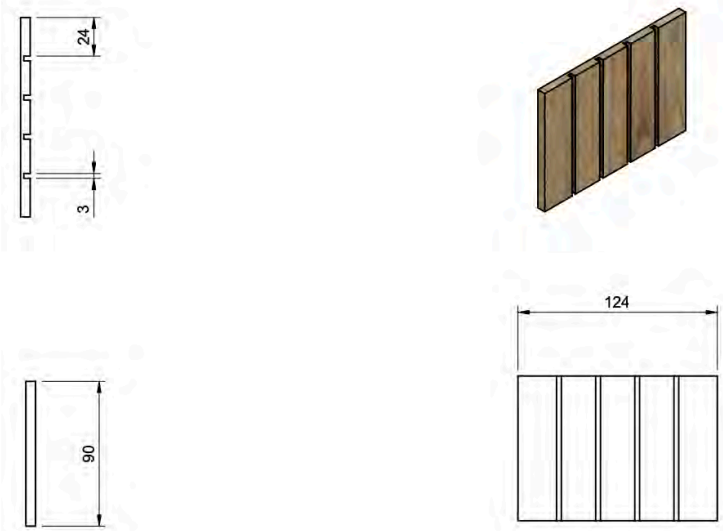
Component Name: Longer Side Panel	**Materials:** Ash wood	**Scale:** 1:2
Part Number: 11	**Quantity:** 2	**Unit:** mm



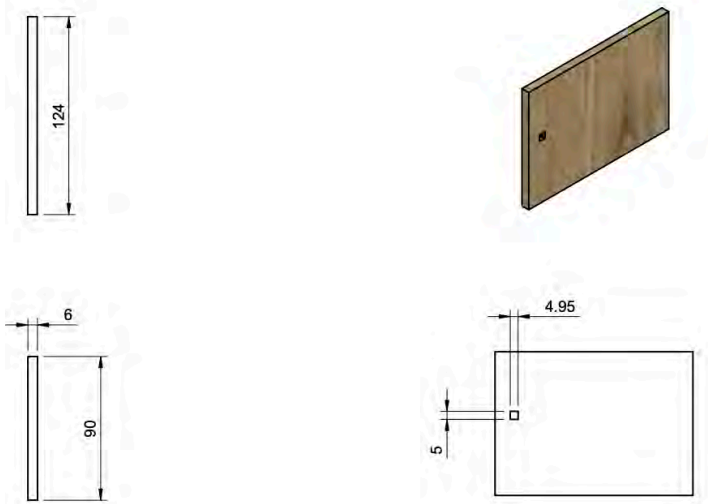
Component Name: Smaller Side Panel 2	**Materials:** Ash Wood	**Scale:** 1:2
Part Number: 9	**Quantity:** 1	**Unit:** mm



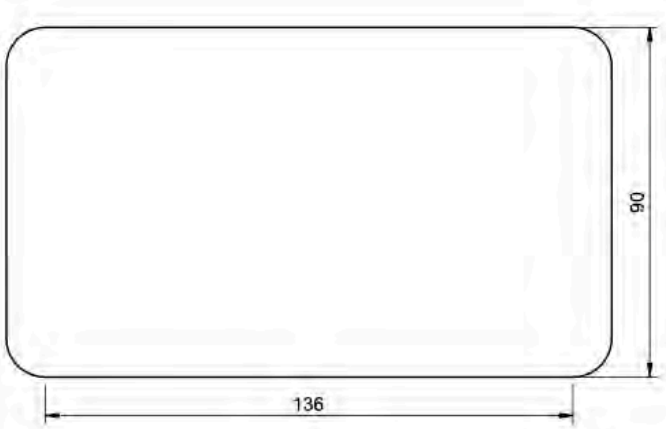
Component Name: Smaller Top Panel	**Materials:** Ash wood	**Scale:** 1:1
Part Number: 5	**Quantity:** 1	**Unit:** mm

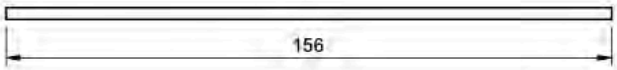


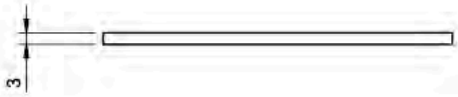
Component Name: Middle Panel	**Materials:** Ash Wood	**Scale:** 1:2
Part Number: 10	**Quantity:** 1	**Unit:** mm



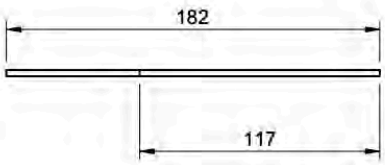
Component Name: Smaller Side Panel 1	**Materials:** Ash Wood	**Scale:** 1:2
Part Number: 8	**Quantity:** 1	**Unit:** mm

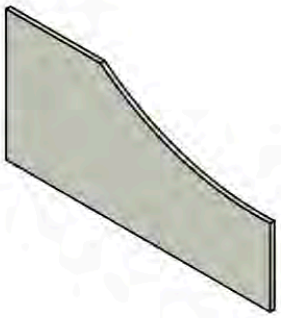


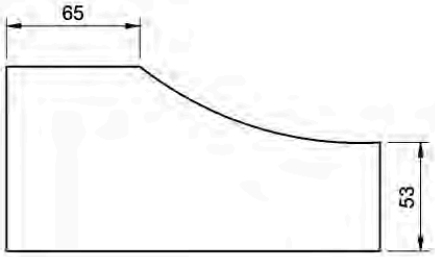


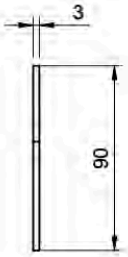


Component Name: Clear Acrylic Panel	**Materials:** Clear Acrylic	**Scale:** 1:1
Part Number: 13	**Quantity:** 1	**Unit:** mm









Component Name: Acrylic Barrier	**Materials:** White Acrylic	**Scale:** 1:2
Part Number: 12	**Quantity:** 4	**Unit:** mm

Plan of Manufacture

Process	Equipment	Scheduling	Quality Control	Risk Assessment
Material Preparation • Check if wood is square using steel rule and try square • Make a datum edge with a try square and pencil • Cut using a drop saw	• Pencil • Steel Rule • Try Square • Drop Saw	30min	• Check if wood is square using steel rule and try square • Make a datum edge with a try square and pencil • Cut using a drop saw and clamp for accuracy	• Drop saw to be operate by teacher or technician only • Ensure guard is in place and saw does not wobble • Wear ear and eye protection
Rebate Joint • Fit 6mm bit inside collet of router • Adjust router bit to height of 3mm using depth gauge • Set fence using steel rule so it cuts a 6mm rebate into edge of panel of wood	• Table router • Steel rule	5min	• Ensure fence is properly secured, clamp to table using tightening screws • Use a test piece to see is 6mm block fits • Cut from right to left only, along grain of wood	• Ensure hands are protected by guard • Lower guard so router bit is covered • Use ear defenders and safety goggles
Through Housing and Cut Holes: Side Panels • Follow same process and specifics as rebate joint, but this time, cut across the grain of the larger side panels • Set fence to 90mm • Mark out wood and cut 5x5mm and 5x4.95mm holes on side panels using hand drill and scroll saw	• Table router • Hand drill • Scroll Saw	15min	• Use a sacrificial piece to prevent any movement of wood • Ensure scroll saw is taut • Ensure air blower is positioned over area being cut	• Pull down guard • Wear ear muffs and safety goggles
Through Housing: Middle Piece • Mark out 5 equally spaced sections in the 125mm panel for the through housing • Follow same process as previous through housing and set fence to 90mm, but this time, use a 3mm bit and set the depth to 3mm then cut	• Pencil • Steel Rule • Try Square • Table router	15min	• Use a sacrificial piece to prevent any movement of wood	• Pull down guard • Wear ear muffs and safety goggles
Stopped Housing: 1 Smaller Side Panel • As above, mark out 5 equally spaced sections for the stopped housing • Plug hand router into power supply and set depth to 3mm • Place wood on jig (laser cut) which forms a guide for the router • Place wooden block at 53mm from the bottom • Turn on router and push through along the panel	• Hand router • Jig	15min	• Clamp jig to workbench using g-clamps	• Eye protection • Collect dust occasionally to prevent any build up

Laser Cut Acrylic Barrier and Clear Acrylic Panel • Draw acrylic piece on Fusion360 • Export .dxf file to Adobe Illustrator (1:1 scale) • Specifics: stroke 0.001, red outline, no fill • Open lid and centre laser on top left corner of acrylic sheet • Focus to material using focus pin and close lid • Send file to laser cutter using GCC panel and export • Press start	• Laser cutter	40min	• Focus laser • Pen 2 • Environment: acrylic 3mm • Speed: 2.2 • Power: 80% • PPI: 600	• Wait until cut and fumes wear off then take out pieces • Don't look at laser • wait until fumes clear. • Turn on extraction in room
Finger Joint: Larger Top Panel & Handle Piece • Mark out 19 x 6mm tenons and shoulders (7 total across each piece) for both pieces of wood such that they would mesh using a marking gauge • Use a pencil and shade in waste area • Cut using scroll saw • Use a flat hand file with safety edge to file down for smoothness • Use a bevel edged chisel with bench hook and mallet	• Pencil • Marking Gauge • Scroll Saw • Flat hand File With Safety Edge • Bevel Edged Chisel • Mallet • Bench Hook	30min	• Position air blower in direction of cutting area to prevent any dust from obstructing • Turn on extraction in room • Make sure to cut fibres from top to bottom using chisel for easier cut	• Keep fingers tucked in and away from blade • Wear safety goggles • Position guard • Cover feet • Keep blade taut
Solder Circuit • Follow instructions give on circuit for soldering connections • Connect to input to 6V battery pack input • Connect a 9V plug into power socket that powers solenoid • Setting: 1.3 • Use micro screw to secure input connections • Heat shrink leads using soldering iron • Extract pre-soldered buttons and attach new 3mm PTM switches	• Soldering Iron • Solder wire • Sponge • Helping Hand • Magnifying glass	2hrs	• Turn on soldering iron and leave to heat for about 3min • Strip wires using a wire stripper • Tin solder wire before soldering component • Place soldering iron on component to heat then place solder wire to melt on connection	• Do not touch soldering iron or hot solder • Wear safety goggles as solder can "spit" • Wear workshop coat and gloves as lead exposure is damaging • Wear protective footwear (covered toes) • Ventilate area • Keep cleaning sponge wet during use • Always keep soldering iron on stand when not in use
Join Clear Acrylic Panel to Larger Top Panel • Mark out wood • Place wood on jig (laser cut in 10mm MDF) which forms a guide for the router and set router bit depth to 3mm • Turn on router and cut panel • Join acrylic using Epoxy resin glue	• Jig • Hand Router • Epoxy Resin Glue	15min + dry overnight	• Position air blower in direction of cutting area to prevent any dust from obstructing • Clean excess glue with wet tissue paper	• Use ear defenders and safety goggles • Ensure router bit is secured properly • Clamp down work

Finger Joint: Larger Top Panel & Handle Piece • Mark out 19 x 6mm tenons and shoulders (7 total across each piece) for both pieces of wood such that they would mesh using a marking gauge • Use a pencil and shade in waste area • Cut using scroll saw • Use a flat hand file with safety edge to file down for smoothness • Use a bevel edged chisel with bench hook and mallet	• Pencil • Marking Gauge • Scroll Saw • Flat hand File With Safety Edge • Bevel Edged Chisel • Mallet • Bench Hook	30min	• Position air blower in direction of cutting area to prevent any dust from obstructing • Make sure to cut fibres from top to bottom using chisel for easier cut	• Keep fingers tucked in and away from blade • Wear safety goggles • Keep blade taut and ensure it is secured properly • Keep fingers curled downwards at all times
User Interface Holes: Smaller Top Panel • Mark out position for buttons and a rectangular section for the 7-segment display to fit on the panel • Cut holes using drill press with 1.5mm drill bit • Cut rectangle using hand drill scroll saw	• Pencil • Center Punch • Ball Pein Hammer • Drill press • Hand drill • Scroll saw	15min	• Do not press down in one stroke, slowly lower the drill then lift and then lower again until hole is drilled •	• Bring down the guard for drill press to keep fingers safe • Keep hair tied back
Finish • Finish all wood with teak oil before joining	• Teak oil • Cloth	15min + dry overnight	• Apply in single strokes • Use cloth to apply on all edges and faces	• Wear workshop coat to prevent staining clothes • Good ventilation
Assembly • PVA glue all side panels together • Slot in middle piece with PVA glue • From the bottom, fit acrylic barriers • Then butt join bottom panel to rest of housing • Separately, PVA glue finger joint pieces • Place circuit inside smaller compartment, mount PTM switches and LED display	• PVA glue • Several G-clamps	15min + dry overnight	• Clamp all pieces together in a location where it will not be disturbed • Clean excess with wet tissue paper	• Wear coat to prevent glue from coming in contact with clothes/skin
Screw and Hinge: • Mark position by making a cross with a pencil and then use a center punch and ball pain hammer to make an indent • Use Xmm screw driver to screw in the 4 corners since the wood is thin and a drill would split it • Place butt hinges on smaller and larger top panels • Mark position using pencil, ball pin hammer, and center punch	• Xmm screw driver • Pencil • Center Punch • Ball Pein Hammer	20min	• Press firmly down so the wood is less likely to split and the screw is under minimum torque	• Be accurate when hitting center punch with ball pein hammer to prevent hand injury
Butt Joint Bottom Panel • Align wood using marking gauge • Apply PVA glue on housing and place in vice	• PVA glue • Wood vice	10min + dry overnight	• Wipe any excess glue using wet tissue • Place product firmly • Do not close vice too tightly	• Wear workshop coat

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