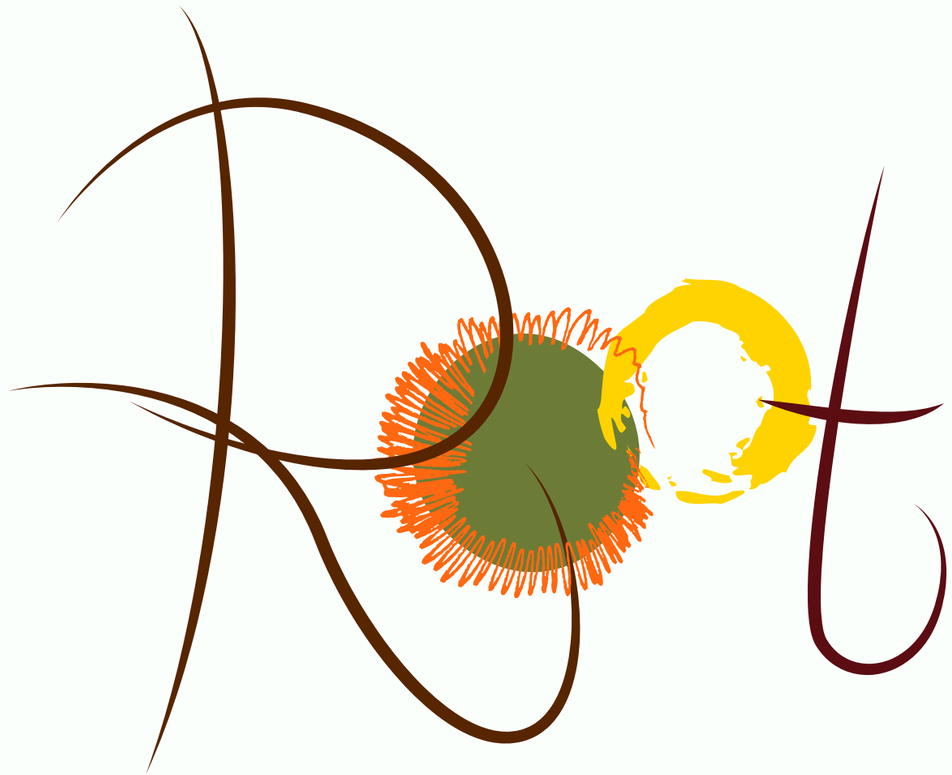


phase 3
20.06.19

approach to prototyping

methods, research and selection

Approach

Phase 3 was approached through converging parallel paths. Prototyping was split into the following areas: form, electrical, heating, mechanical.

What is the most ergonomic portable form?
What form allows samples to be arranged and inserted easily?
How can the button inform the product interaction?
What shapes appeal to both children and the wider market of adults?

Is is possible to create a hand held device that can safely melt and fuse plastic together?
Does it stay cool enough to be handled?
Does it generate enough power?
What is the battery-life?
How can we prevent jamming?

1.1 Heating and electrical laminator teardown.

1.2 Machining elements and building functional test rig.

1.3 Developing electronics systems prototypes and integrating into mechanical model.

2.1 Sketching and form testing to accomodate intuitive interaction

2.2 Device shape developed using foam models and drawing

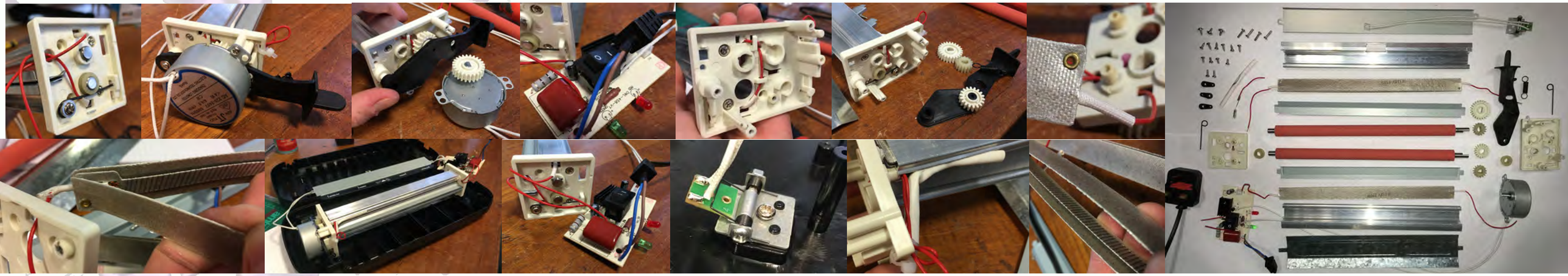
3.1 Compromising on shape of product to accomodate safe function and intuitive use

3.2 Developing further mechanisms and details

4.1 Producing a CAD model of the exterior and testing to optimise function and usability with working internal components.

Laminator teardown

The approach to the build was to test and develop components to work separately; heating, rolling, battery latching mechanism among others. Once working these components were compiled together to produce the final prototype. The iterative process of prototyping occured mostly within the casing design, heating element and power supply.



prototyping

Main considerations to adapt the laminator to suit our product needs were as follows:

Power supply

The bench top design was based on an existing, wall mounted laminator. The objective was to match the power output on the smaller device, while running on 12V DC power, instead of 240V AC from the wall.

Heat

A new heating element was selected for the altered voltage and current values. Not only this but keeping heating constant and contained were considered heavily.

Portability

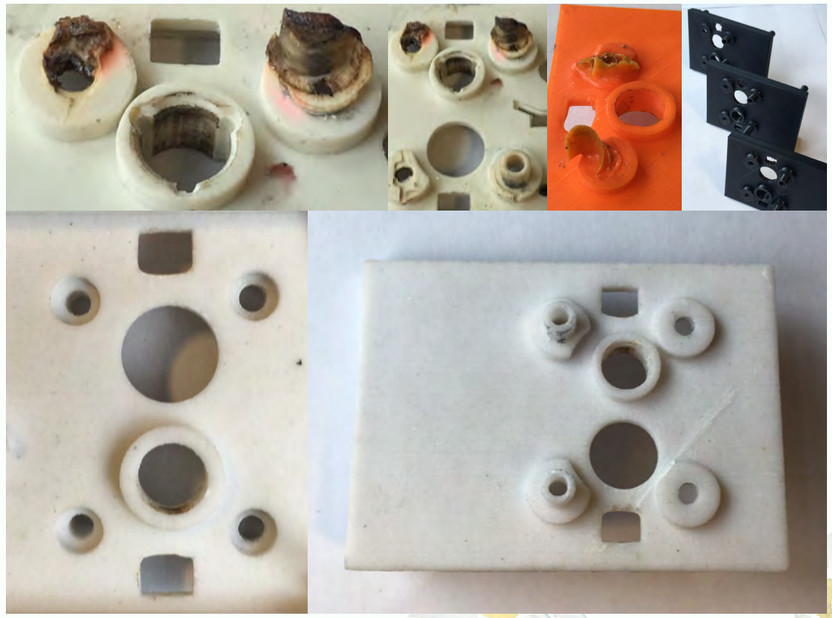
The original laminator was designed to laminate A4 sheets, for the Petit Preserver a 100 × 100mm input sheet was deemed appropriate. The power required was altered to suit this.

Child-friendly

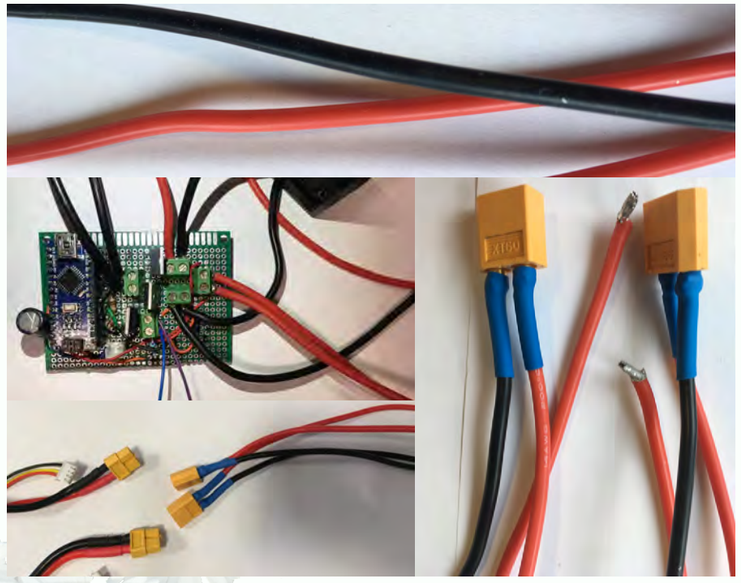
A simple user interaction whilst providing all necessary indications of the Petit Preserver's performance was necessary. The form must be ergonomic and attractive to children whilst retaining wider-market appeal. Preventing any harm from heat produced within the product was paramount.

Issues arisen and their resolution

Primary changes were to replace the heating elements with a 1.2 Ω heating element, instead of the 88Ω heating element present on the 240V version. This lower resistance was selected to match the power at the much lower voltage. Thermal insulation was an issue where the hot aluminium component in contact with plastic bracket caused mild melting. A ceramic 3D print was done to over-come this.
Isolating the heat from the internal rolling mechanism to prevent heating up of the outer casing. The heating element had to be electrically insulated from the aluminium plates in order to prevent shorting.



Major drawbacks were the much higher current requirements (18A) at the lower voltage, putting a strain on the wires. A much thicker copper wire had to be used, in this case a AWG 14 Gauge silicone coated wire. High current limited the battery selection since a fast discharge rate and high capacity was necessary.
A diode was used in designing a switch-mode power supply for the heating elements. We encountered very high current peaks momentarily, which exceeded 90A, this was due to back emf generated by the inductor-like structure of the heating element. A fly-back diode was required to filter peaks.



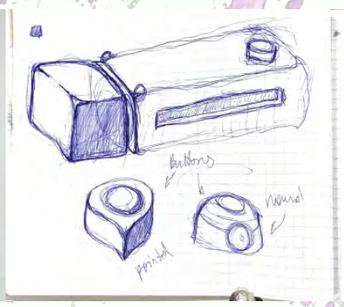
Accomodating the smaller size of the Petit presever was done by turning and machining existing rollers from the torn down laminator. A mechanism was developed to easily and securely latch the battery pack. A spring and hook mechanism was used for this. There was consideration of plastic pouch loading mechanisms as well as user interface.

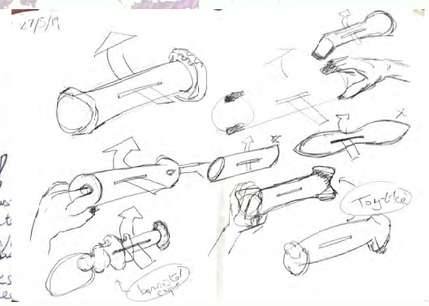
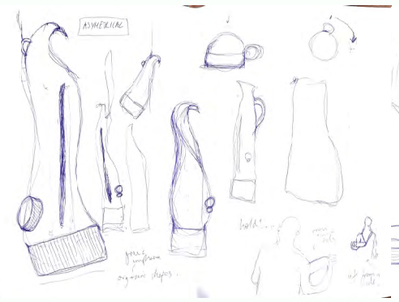
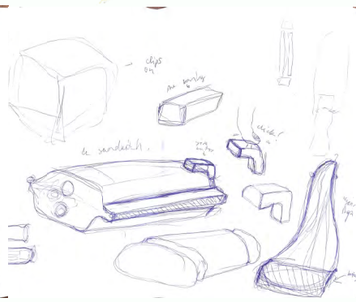


prototyping
exploration of form

Refering to Roman amphorae, Philippe Starck pieces, Anish Kapoor sculptures and more to provide inspiration for casing design.





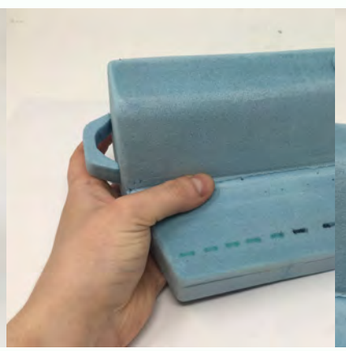






Finding a form that was most intuitive to interact with and allowed a simple 3 step interaction to produce the preserved sample. This was done by referring back to the retro OneStep polaroids since they are an iconic form it was concluded that users would find a form similar to this easy to recognise.





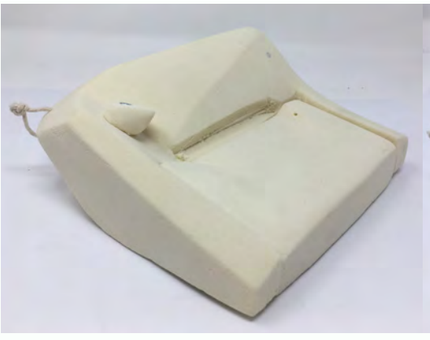










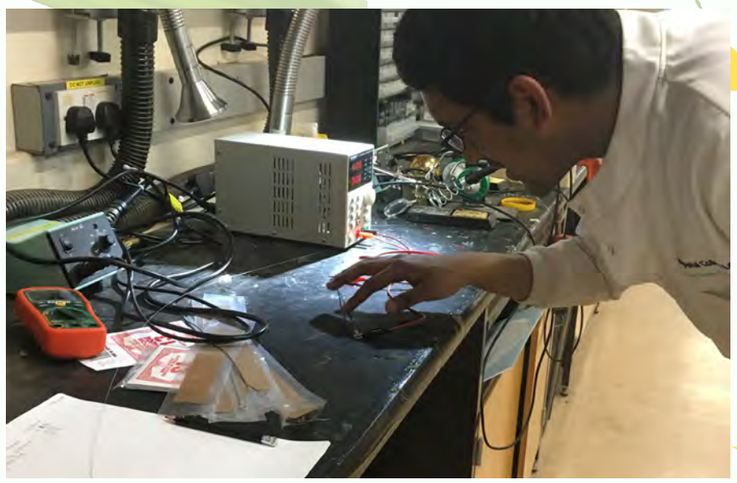




testing
heating elements

Objectives:

- Fast heating time(<30s)
- Outside temperature of device does not exceed 35 °C
- Laminates up to 80 micron films



Resistance across the original heating element (of the laminator) was meansured. The resistivity of the wire was calculated as well as the resistance per ohm. It was rated for 300W. The resistance was far too high because it was designed for 240 volts AC, and generated insufficient power at 12V DC.





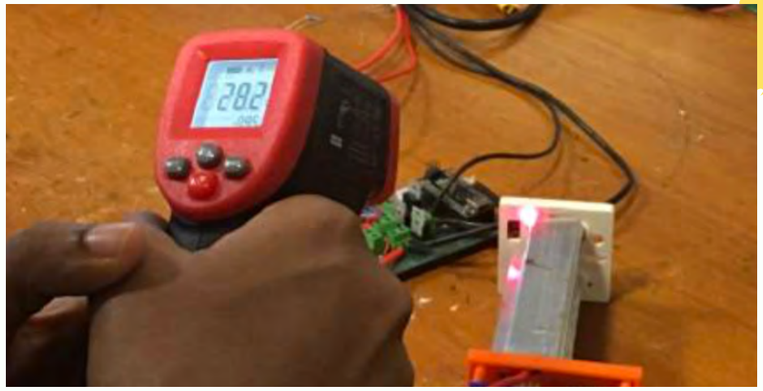
A size 13 guitar wire and two types of impulse sealer heating elements were considered as potential low voltage heating elements. These were suitable for this application since they are structurally stable at high temperatures and have approximately the correct resistance to generate up to 200W at 12V DC.

Table of resistances for wires.

Length (mm)	Wire type	Resistance (Ω)
269	Steel heating element wire	2.8
969	Steel heating element wire	9.1
1000	Guitar wire	9.5

We settled on the impulse sealer heating element as it was already designed for heating applications. These were bought and integrated into the heating system.

Given that the laminated samples would be smaller than in the donor product (approximately A6 compared to origina A4) we determined that the maximum power required by the petit preserver would be 200 Watts.



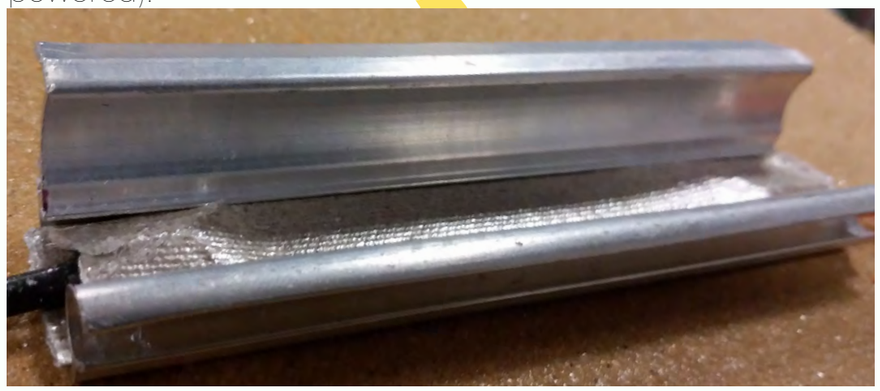
During testing, the temperature of the internal heated roller system was measured using an infrared thermometer. This helped us determine the ideal roller temperature to successfully laminate.

During testing the heating element was coming into contact with the aluminium plates causing short circuits. The heating elements had to electrically isolated by using mica sheets and sufficient clearance from the aluminium.

It had to be ensured that only heat-resistant wires could come into contact with the aluminium plates, otherwise they would easily melt. The heat resistant wires are 14 awg (2.5mm copper core, silicon coated).



Heating element sandwiched between layers of mica, a heat-resistant mineral. The sheets distributed the heat evenly across the rollers. (Heating element glows red when powered).



Mica and heating elements integrating into an assembly between aluminium plates.

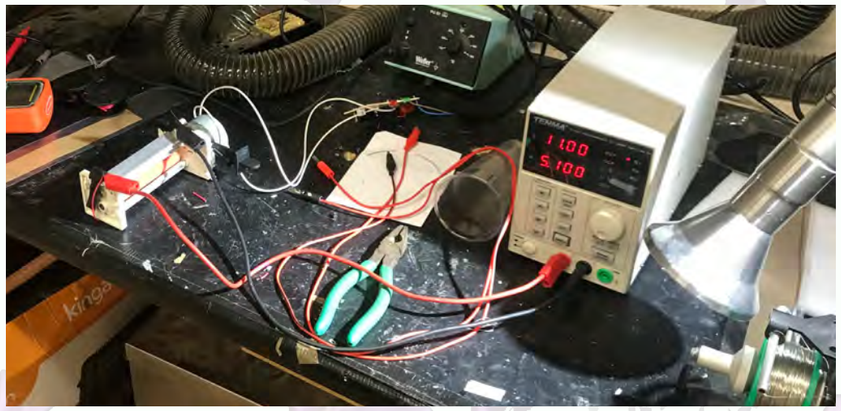
testing

product performance requirements

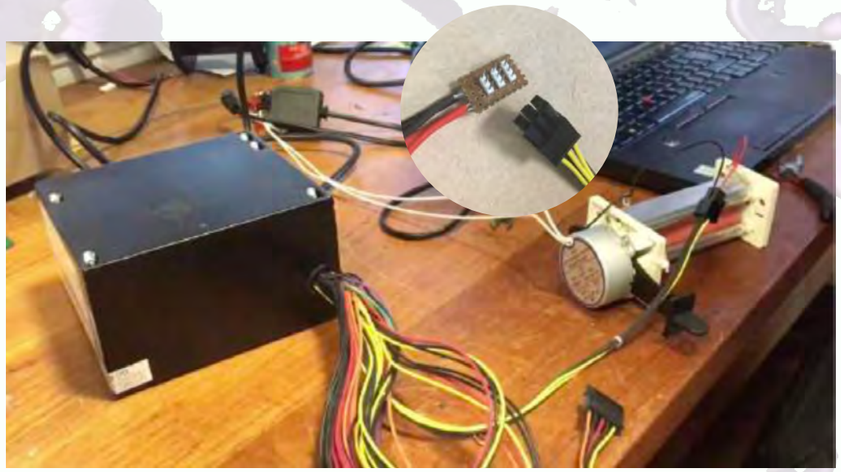
Objectives:

- 15 minutes of run time at full power
- Rechargeable power supply

A bench-top power supply providing up to 3A at 12V was used for initial testing. This was not suffcient power for lamination.



Calculations determined that power of 200W was required and so a computer power supply was adapted for testing. This generated 12 volts. A custom connector was designed to interface the power supply with the bench-top test rig. This was now suffcient for lamination, as verifed with successful lamination on the test rig.



The current load was measured using a high-current ammeter at full power. The power consumption was consistent with calculations of resistance and voltage.

Following power tests a supply was selected. Batteries were selected based on:

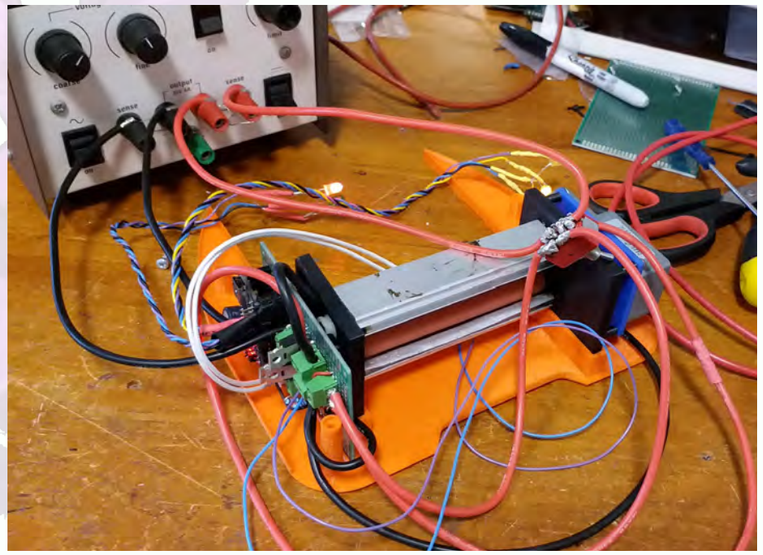
- High discharge rate
- Form factor
- Rechargability



Two 12 volt lithium polymer batteries were selected. The capacity of each was 2200mAh. This gave us a run time of 15 minutes in the worst case scenario (when constantly heating up at full power). Typical runtime was expected to be a total of 1 hour of use in its intended application.

Heating up to required laminating temperature of 110 °C requires full power of 200W This takes 60 seconds to achieve.

Maintaining the laminating temperature requires 50W.



Benchtop model ready for testing. Powered by a benchtop power supply.



power and component load

calculations and testing

The power output of the torn-down laminator was calculated. These values were then adapted to suit our smaller bench-top prototype. Controlling the heat to be variable was done through the use of an Ardunio nano, using PWM control to set the perfect temperature.

We calculated power output of the existing laminator and did calculations to adapt this for the work bench prototype, this resulted in the following:

Power:

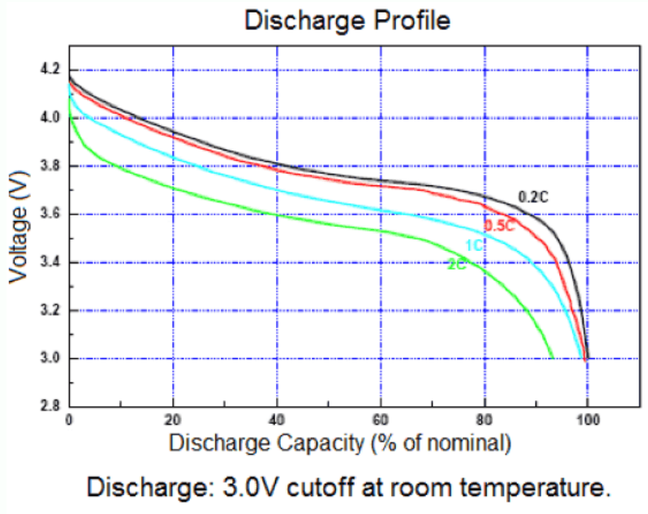
$Power_{max}$	200 W
$Power_{sustain}$	50 W
heating element arrangement:	parallel
$voltage_{heating\ element}$	11.1V nominal (ranges from 10.9V- 12.2V)
$resistance_{heating\ element}$	$\frac{V2}{P} = \frac{(11.1)\ 2}{(200/2)} = 1.23\Omega$
heating control mechanism	PWM at 1kHz. Switching pwm to control of power to heating element. MOSFET to drive heating element.
$current\ load_{max}$	$\frac{P}{V} = \frac{200\ W}{11.1\ V} = 18.01\ A$
	This is the max current from the battery before being distributed to the heating elements and other components.
wire info	AWG 12 gauge silicone coated wire to handle the current.
$run\ time_{worst\ case}$	959s = 15.98min. This run time is calcuated when continuously running at full power. Max power will only required during startup heating.
run time	$\frac{(2)\ (2.4)\ (11.1)\ (60)\ (60)}{200\ W} = 959\ s$



Block diagram of the Petit Preserver

Electronics control

MCU	ATmega328p on Arduino Nano
MOSFET	IRL40S212
PWM info	1kHz square wave duty cycle ranging from 1-100%
Heat sensor	Negative Temperature Coefficient(NTC) thermistor 100kΩ at 25°C the b coefficient is 3960
Battery	2 × Lipo battery 3 cell 2400mAh capacity at 11.1 V



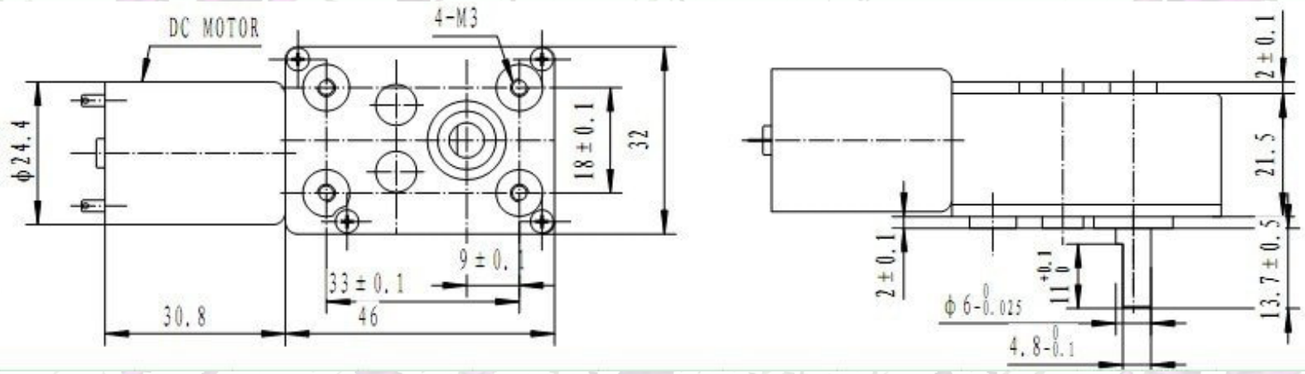
Lipo battery discharge graph

power and component load

motor selection

The RPM of the torn-down laminator's motor was labelled upon it. Re-creating this low RPM, high torque output was done by selecting a worm gear motor running on 12V. A new gearing system was developed to lower the RPM and increase torque further.





		NO- L0AD		AT MAXIMUM EFFICIENCY				STALL	
	VOLTAGE								
MODEL		SPEED	CURRENT	SPEED	CURRENT	TORQUE	OUTPUT	TORQUE	CURRENT
	V	r/min	A	r/min	A	Kg·cm	W	Kg·cm	A
TS-32GZ370-950	12	9	0.035	7	0.14	8.6	0.64	44	0.48

Manufacturer's specification

motor + gearbox package	TS-32GZ370
gearbox drive	wormgear
gear reduction	1 / 1650
motor and gearbox RPM_{max}	16 RPM rotation at 12V
rollers RPM_{max}	12 RPM. Geared to rotate rollers at 2:1 motor speed.
motor control	PWM, giving range of 0-12 RPM
torque	10 kg.cm
current $_{no\ load}$	0.03 A

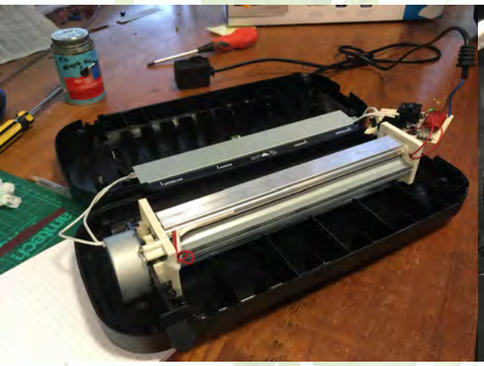


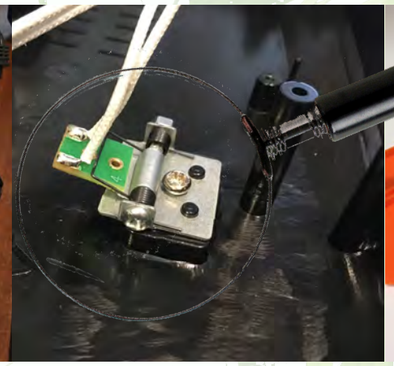
detail design

thermistor cut off

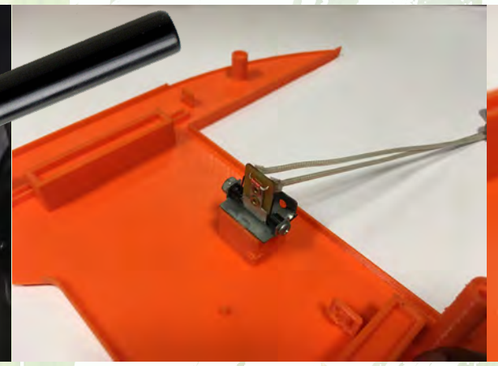
Designing for high current loads

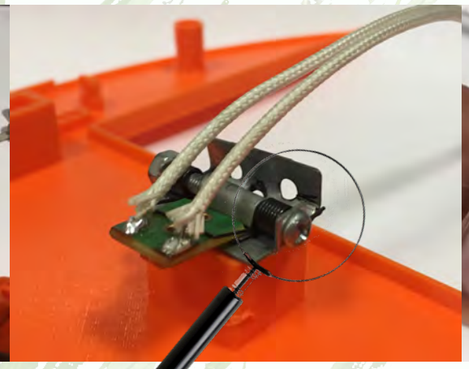
A thermistor was used in the torn-down laminator as part of a feedback loop system. This was recreated in the Petit Preserver to prevent over-heating and under-heating. This was a primary issue since uneven heating would result in the plastic samples laminating poorly.





Thermistor found in the donor product





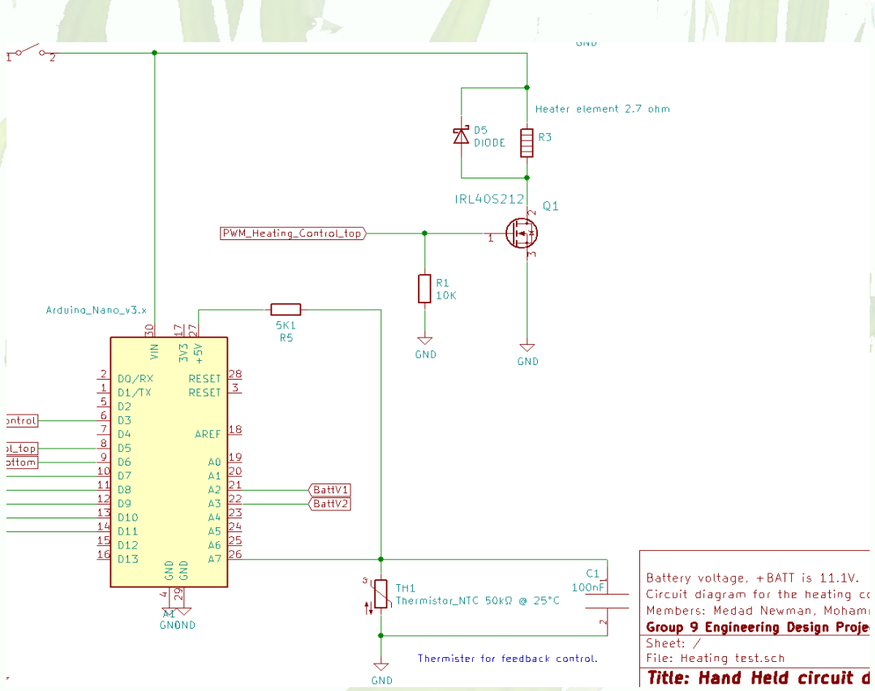
torsion spring





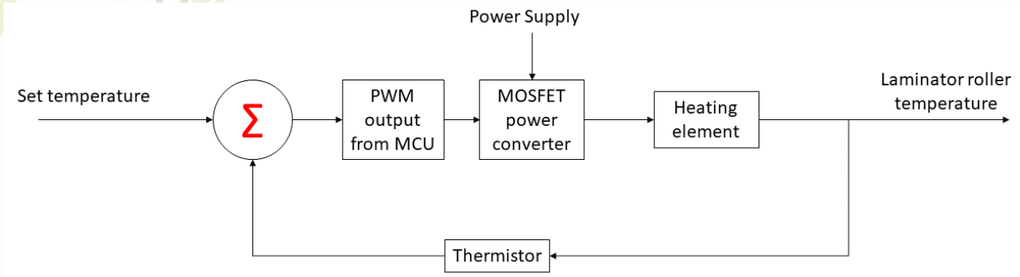
thermistor in contact with the silicone coated roller

Heat resistant tubing used to thermally isolate the hot aluminium section from the plastic supports.



Close up of thermistor and heating element partial circuit. Refer to full diagram in CAD package.

The thermistor was placed next to the internal components and was in direct contact with the silicone coated rollers to directly measure the roller temperature. A torsion spring was used to constantly press the thermistor against the rollers.



Feedback control loop for Petit Preserver.

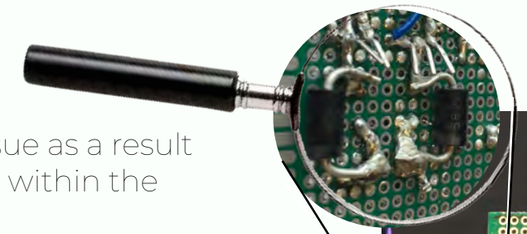
detail design

selecting appropriate electronics

All electronics integrated into the prototype circuit board. Due to the altering of the power supply design measures had to be taken to accomodate the higher current. This was done in the following ways:

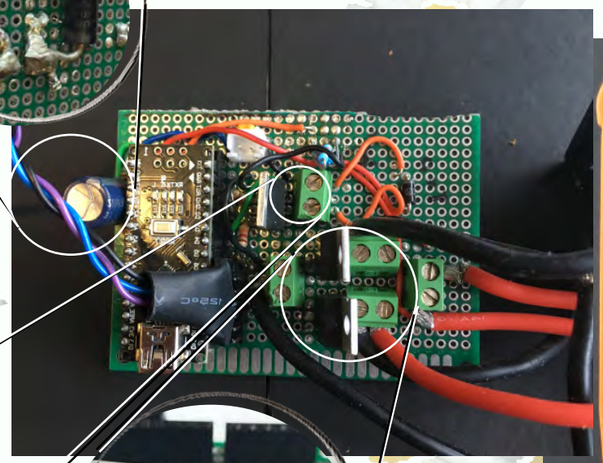
Diode

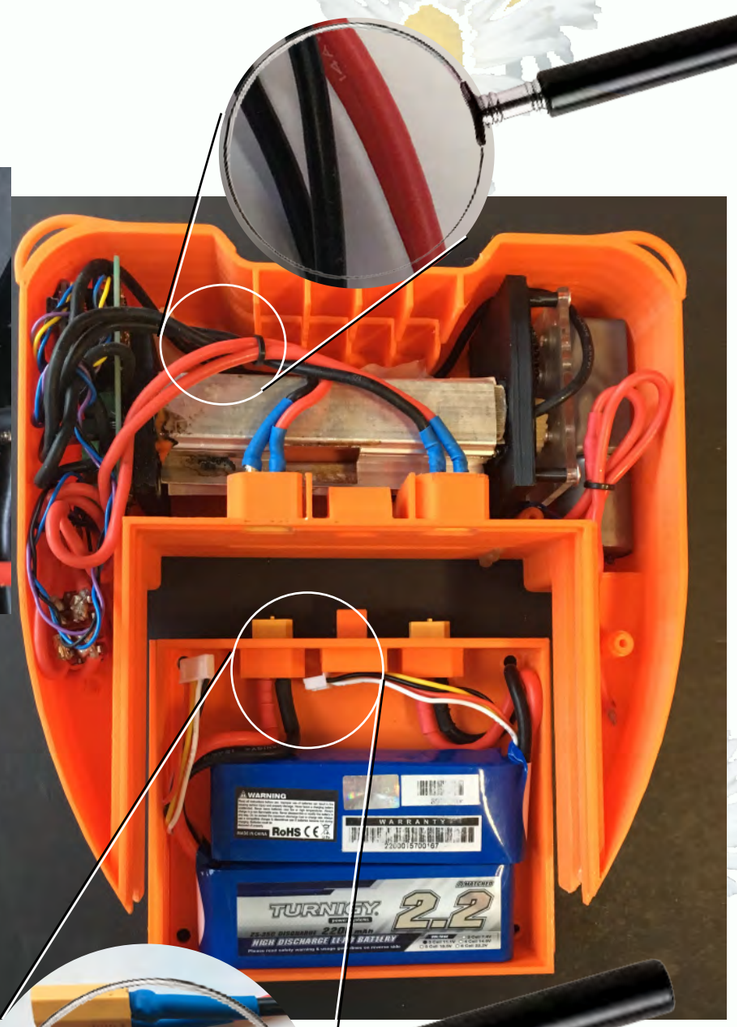
Back emf was an issue as a result of the high currents within the electrical system.





Arfuino nano microcontroller





3mm with 2.5mm copper core

Thicker silicone coated wires were selected to handle higher currents.



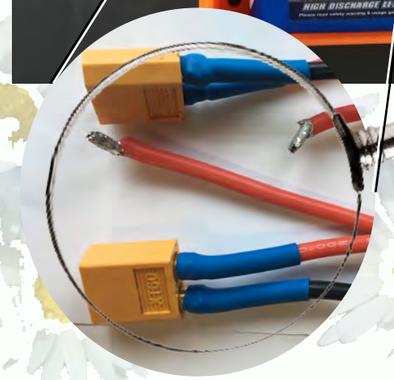
Connectors

LEDs, switch, thermistor and heating elements could be quickly connected in production by either snapping on or screwing into the terminal blocks.



IRL40S212 mosfets

A mosfet was required for controlling the power through the heating elements a PWM signal was used to control the duty cycle supplying power. The mosfet had to be able to handle 9A at 12V.



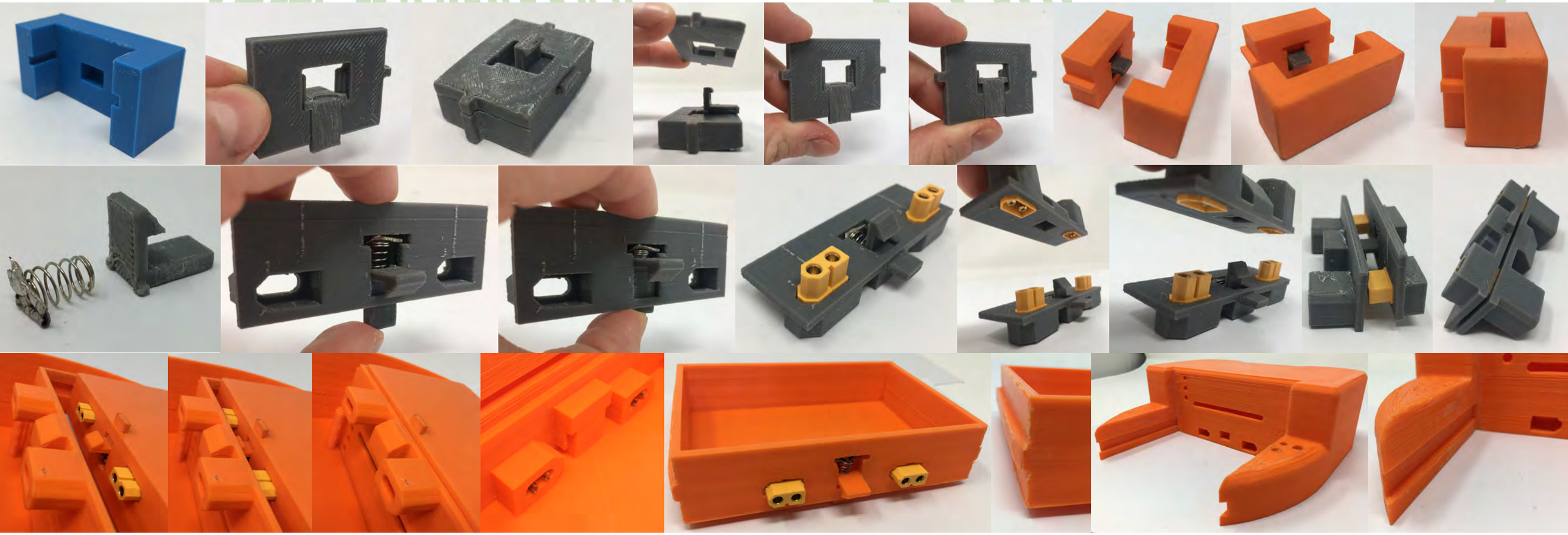
XT60 connectors

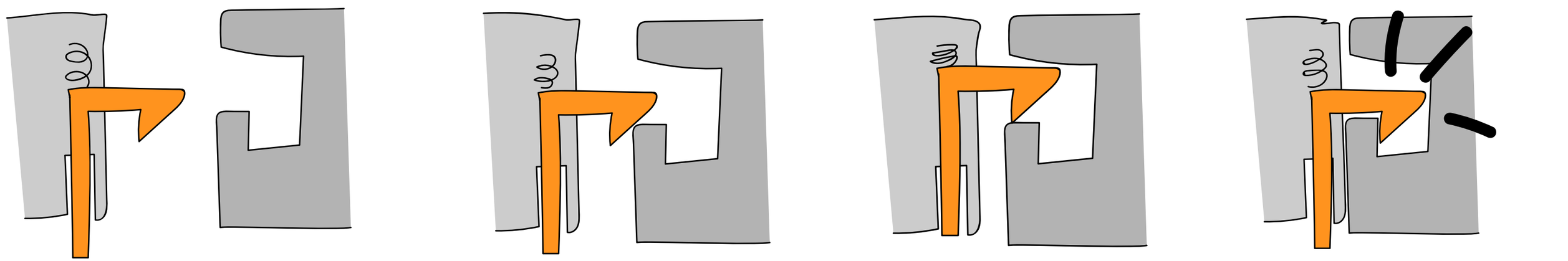
XT60 connectors were selected over other forms of electrical connectors because of their high current rating.

detail design

battery attachment mechanism

The battery pack was designed to be removed, re-charged and reattached. This meant that a secure yet simple mechanism would have to be designed to latch on and off. Concepts for this were sketched and tested with tolerancing of the two parts being the primary issue. Selecting a spring with the appropriate spring constant and the 'click-factor' being other considerations.





detail design

safety features and intuitive interaction

Ongoing HCD led to the following features being integrated into the Petit Preserver:

LED indicators

Simple indicators. First, the battery life bar showing 100%, 60%, 33%. Secondly, the thermistor controlled 'Ready or not' LEDs. Intuitively red for not, green for go!

Embossed symbols

A great piece of feedback from our user, Rosie, was that you cannot prevent children from being naughty! We developed a trio of simple symbols accompanied by the message 'Leave nothing but footprints' to remind kids during collection.



Handles + strap

Our product is portable! To accomodate this we added handles and a strap so it can be slung round whilst walking.

Toggle switch

Button iterations and ideation of something very tactile and mechanical, achieving a clear on and off position. Settled on a classic toggle switch.

Copper guide

Users can place their pouches here prior to preservation. This element guides users to insert through the front slot as well as to inform them of what size inputs are acceptable. Copper was included to broaden appeal to our wider market. A 'living' product: the copper oxidises and scratches uniquely to each user and the product will 'grow and evolve' differently with each owner.

final assembly

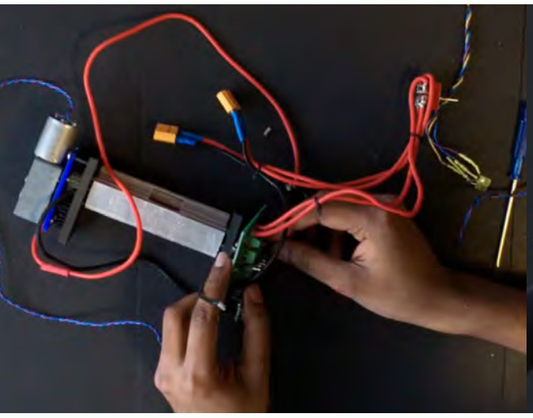
video storyboard

https://www.youtube.com/watch?v=aNyMjh6KlnY&t=19s

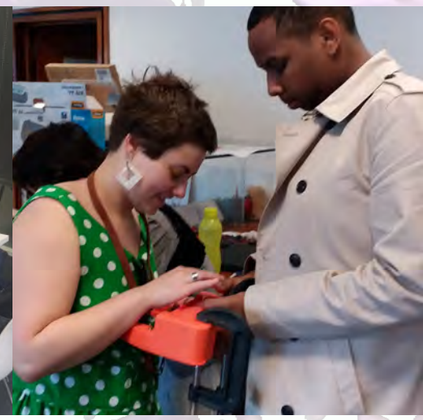


product assembly process

timings and costing estimate





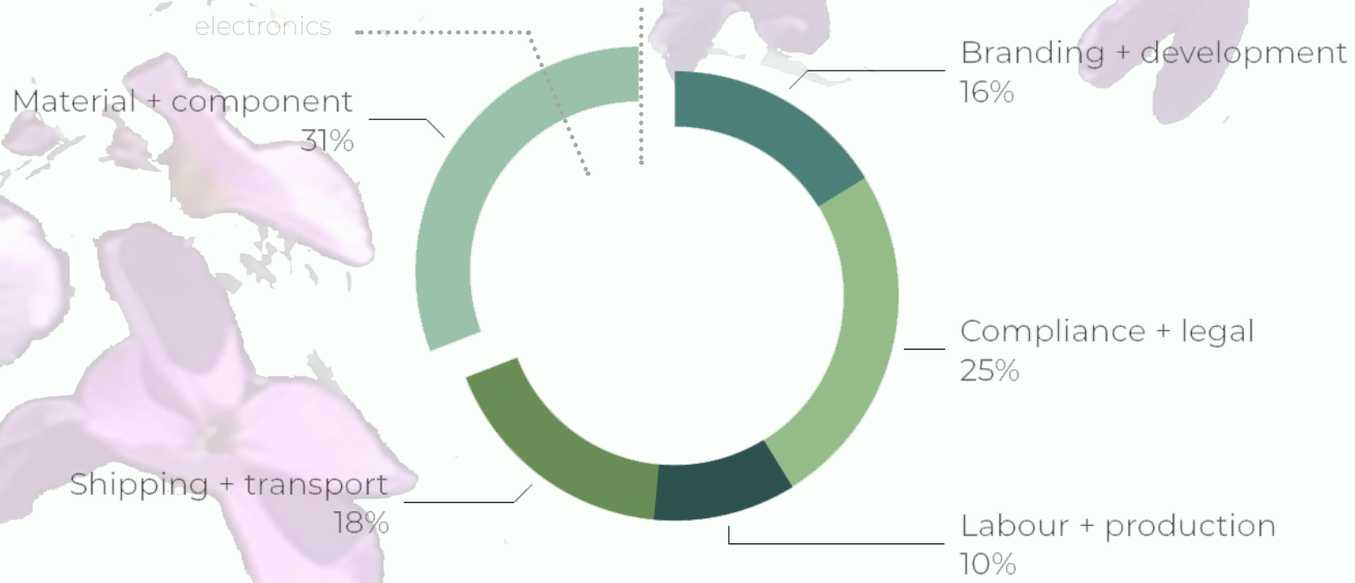


The total assembly time for the Petit Preserver was 20 minutes. This is considered a conservative production time estimate since an assembly-line manufacture would improve this time significantly. The most time intensive aspects of the assembly process were fitting internals and wires within the casing. Design to reduce these could be considered by utilising wire guides and consideration of wires during the CAD.

£90 spent on prototype building. £17 of this was spent on the laminator. This cost would be cut down to £25.

20 min assembly time for our prototype. We assume this would be halved for mass manufacture.

92p is the labour cost per product made. Assuming $7/h wage and premade PCBs.



Additional considerations:

Do we pay ourselves a wage?

Ethical concerns such as do we go for the cheapest manufacture and material cost or consider sourcing ethically?

How can we limit the environmental impact of production? Could the Petit Preserver be carbon neutral?

product compliance

research and requirements

Designing a product that encorporates heated elements to be utilised in an outdoor environment by children meant that complicance considerations were of utmost importance. The main risks associated were high power, high current and high temperatures.

The following documents were referred to for compliance requirements:

GOV.UK

Guidance

Toy manufacturers, importers and distributors: your responsibilities

How to produce and label toys for children to comply with safety and warning regulations.

- Make sure the toy has been designed and manufactured to comply with the essential safety requirements during its foreseeable and normal period of use
- Apply information identifying the toy and manufacturer on the toy or packaging
- Toy must come with instructions
- Carry out a safety assessment of the toy
- The CE Mark, usually together with the name and address of the manufacturer, is required by law to appear on all toys placed on the market in the European Union

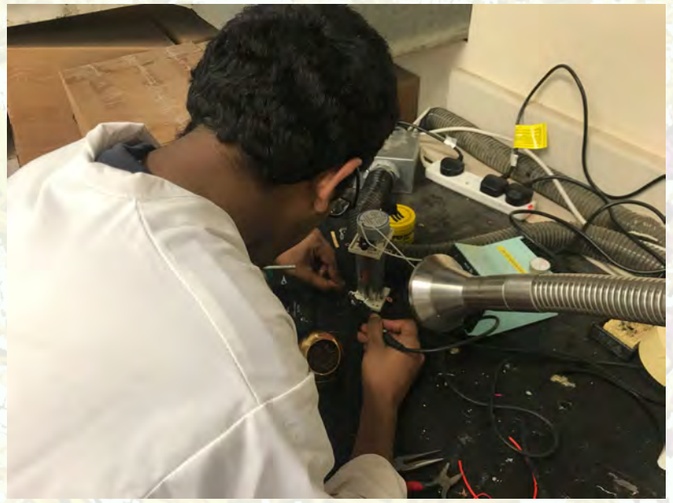
Department for Business, Energy & Industrial Strategy

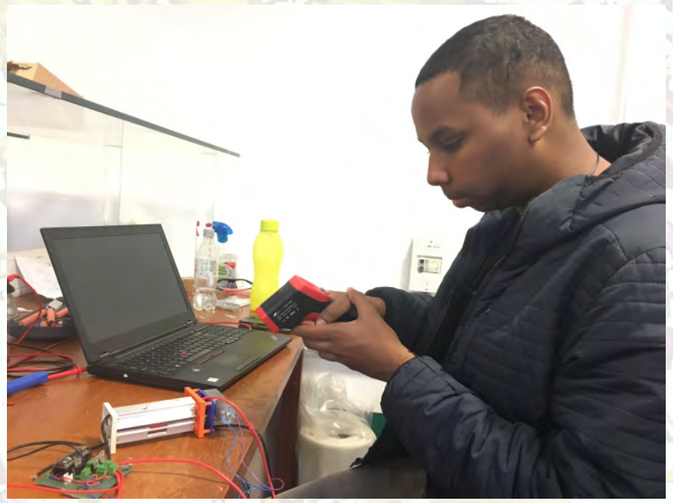
Regulatory Delivery

ELECTRICAL EQUIPMENT (SAFETY) REGULATIONS 2016

Guidance

- Before placing electrical equipment on the market, a manufacturer must ensure that it has been designed and manufactured in accordance with the principal elements of the safety objectives.
- They must, when appropriate with regard to any risk posed to consumers, carry out sample testing of equipment.

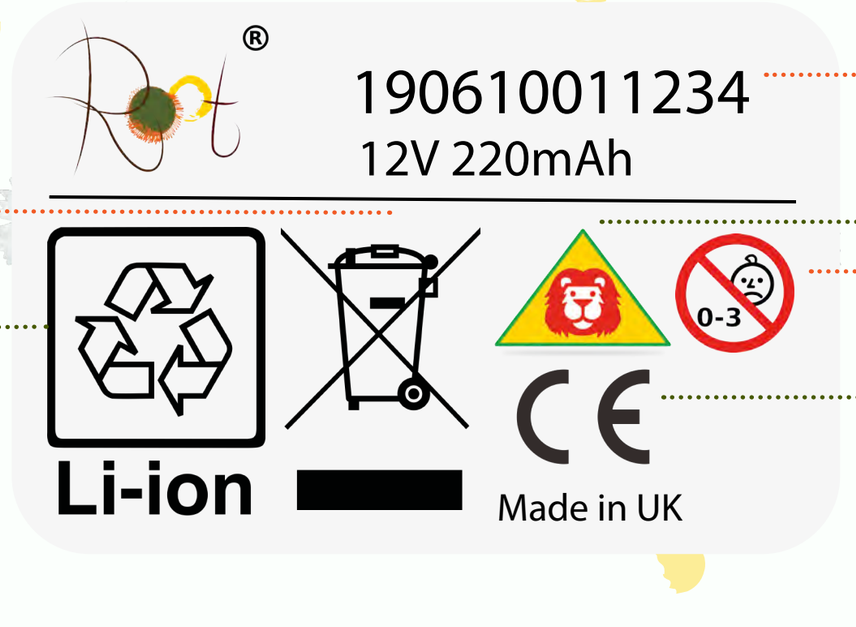




product labelling
user guide designs

The marks shown below indicate the compliance and regulations that the Petit Preserver abides by:

WEEE
Indicates separate collection for waste of electrical and electronic equipment.



Li-ion recycling
Recycle lithium ion batteries contained in product.

Product serial no. and voltage + current rating

British Toy & Hobby Association
A British consumer symbol used to identify toys denoted as safe and of high quality.

0-3
If there are small parts or sharp geometries the product is unsuitable for children less than 3yrs.

CE
Indicates conformity with health,saftey and environmental protection standards for products sold within the EEA. It is required by law to appear on all toys placed on the EU market.



Rosie's feedback on guidance for young kids:

- Reinforce good behaviour
- Younger children benefit from 'one to one' for learning
- Children learn a lot through story-telling
- Children are very tactile and often put things in their mouths
- Children are naughty, they may put insects in...
- Don't overuse text, symbols and images are better





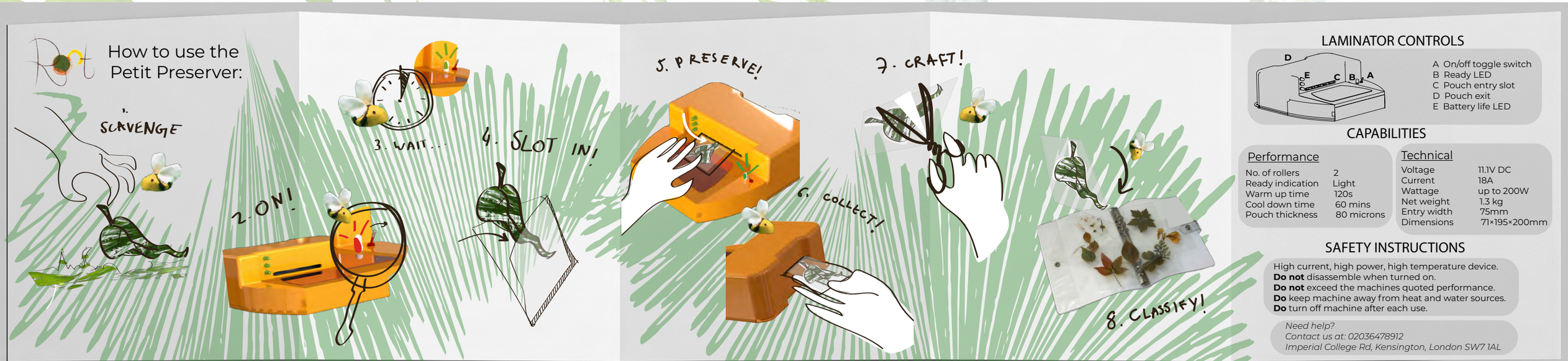


product labelling

user guide designs

The accompanying kit was important in its role of informing users how to collect samples from nature in a non-destructive way as well as giving educational value to the samples once they were preserved. Technical information was included in the user manual.

User instruction manual



Classification booklet





Deciduous, coniferous, flowering, non-flowering, bud, seed-pod, leaf, common, rare, moss, fir, flower...

From user research at the Investigate centre in the Natural History Museum, it was determined that learning about classification is an important part of learning about nature. As well as being educational this additional feature would enable an online community to be developed where samples could be compared and discussed; similar to the collection of football cards, stickers and other such products popular with children.

product packaging

materials, processes + compliance

The packaging must embody the brand identity as well as being appealing on the shelf. The aim was to keep packaging to a minimum and to make it environmentally friendly were possible. Safety and recycling were promoted through symbols on the packaging.



Umbrella

keep the package away from rain or damp conditions.



WEEE

Electronic and electrical waste separately disposed of.



Green dot

Producer has financially contributed to recovery and recycling of packaging in Europe.



Mobius loop

Packaging can be recycled.



Tidyman

'Keep Britain Tidy' do not litter campaign.



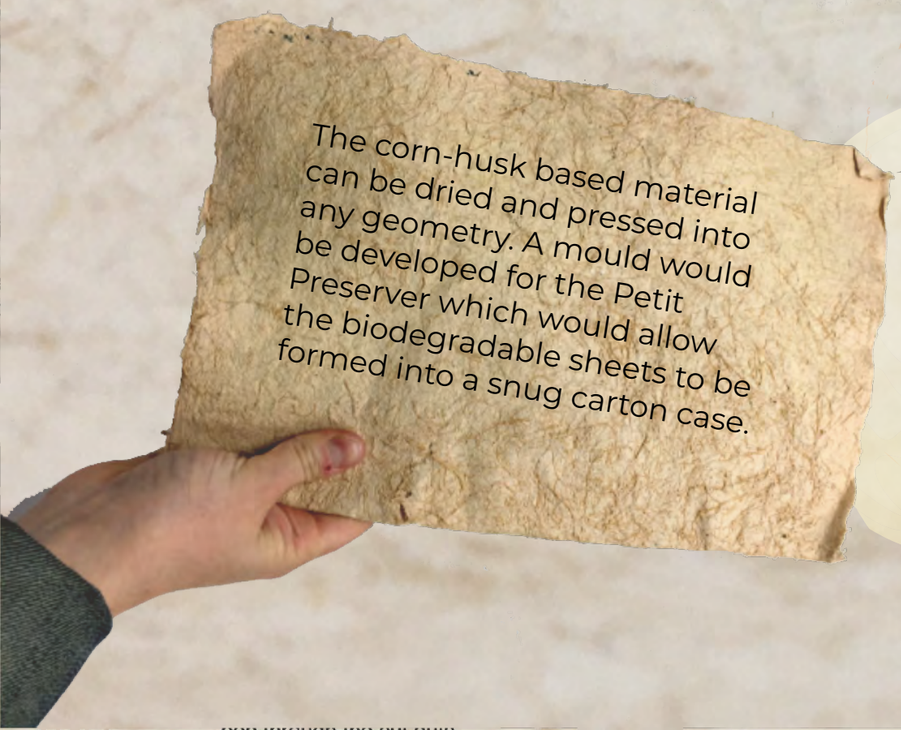
CE

EU standards of health, safety, and environmental protection achieved.



BTHA Lion

British standards of quality and safety assurance symbol.



× Future Green

Sleeve

The sleeve would be manufactured from recycled card and would simply be laser cut. Printing using ink can reduce the recyclablility of card as well adding extra complication and carbon-footprint. We realised that printing is unecessary! The bright orange of our product can pop through the cut outs.

Plastic

Even though we would like to reduce plastic packaging as much as possible it is necessary to waterproof electrical and electronic products in plastic. This is unavoidable in this situation since both outer layers of packaging are water permeable.

product packaging

visual render + branding

Playful yet sophisticated graphic cut-outs encompassed the market of children and nature enthusiasts of all ages. The use of ROOT's brand mascot Mēmo and distinctive visual language embued the packaging with our brand identity.



Calling all budding botanists!
The exploratory educational kit that preserves botanical samples for classification, crafting and collecting.

Includes:
1 petit preserver
1 classification booklet
1 adjustable strap
20 preservation pouches

Mēmo

The mascot embodies the ROOT brand in the sense that it is playful, simple and friendly. It also has connotations of preservation of nature due to the prevalent bee crisis.





final design

visual render + specs

The handheld Petit Preserver by ROOT keeps you curious!

Explore nature, make keepsakes and develop your own classified collection.

Features:

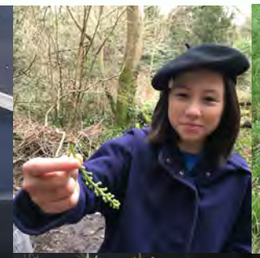
- Fast heating time(<120s)
- Small, hand held form factor to make portable
- Outside temperature of device does not exceed 30 °C
- No access to hot section by fingers
- Laminates up to 80 micron films
- Battery indicator to show charge left
- Detachable battery pack with easylock© mechanism

final design
branding

ROOT will keep children active, curious and environmentally concious. City kids are often detached from nature. Developing environmental awareness and appreciation for our ecosystem is essential and only touched upon in the school curiculum. We want to supplement this learning. We want to see a future where the children of today are environmentally-engaged and go on to actively re-nature cities.



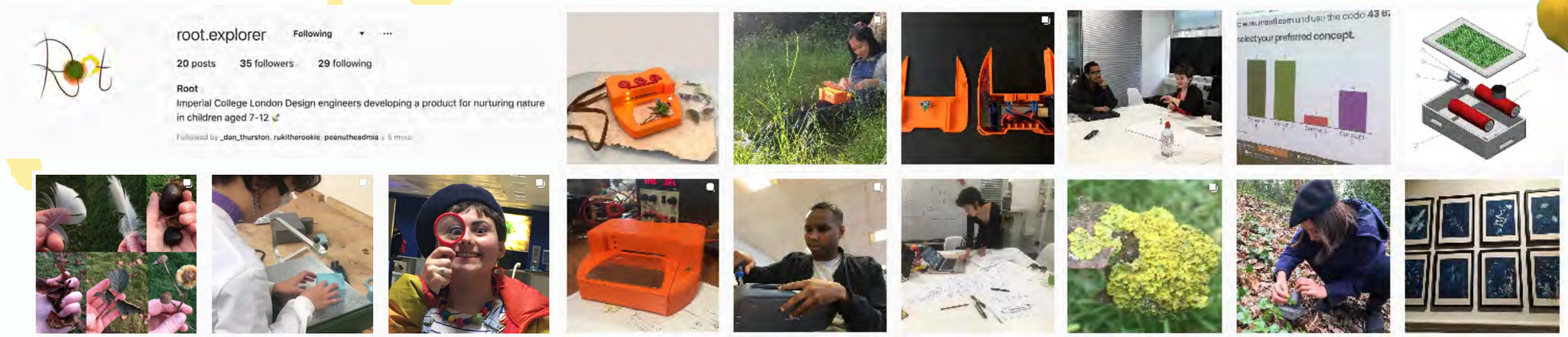




We know that people of all ages love to explore! We want to create a community around our product that means everyone can document and share their discoveries. Knowledge and a relationship with nature is often passed down through generations. We want to expand this and use our online community to benefit everyone. It's never too early or too late to get stuck in!





business case

industry assessment

Product:

Handheld preserver for kids to use in nature.

User:

City Children (7-12), nature enthusiasts - wider market.

Buyer:

Parents, museum gift shops, schools and nature clubs.

Market segment:

family, children, city, nature-enthusiast, active, mid-to-high income.

Industry:

(Environmental) education tool.

Threat of substitution:

Our product offers experiential learning to promote environmental education. This could be substituted by: gardening/ nature clubs, activity books,magazines or an app.

Buyer power:

Large number of customers, cities have high population density. Customers are likely to be high income families.

Supplier power:

No specialist components or materials used.

Ease of entering market/ barriers to entry:

Strongest brand identity to compete with would be National Geographic toys.
No patents or specialist knowledge needed.
No direct substitutes for the Petit Preserver but many market competitors in terms of educational toys.

arket competitors:

No dominant competitors however a large number of competitors in the science + discovery toy market

New entrants:

Our product is not tech driven however the brand and community built around can protect the product.

Is price elasticity of demand elastic or inelastic for our product?

elastic vs inelastic

- toys aren't a necessity
- price is high relative to other toys

inelastic vs elastic

- few substitutes for the product
- high income families targeted
- educational purchase



We concluded that the PED is relatively inelastic. Quantified values are necessary for further analysis.

business case

Porter's five forces

Product	Rivalry	Buyer power	Substitute	Supplier	New entrants	Attractive?
Petit Preserver	medium	low	high	low	high/ medium	medium

Conclusion: The market is not highly attractive. To succeed in this market our brand loyalty must be strong.

Next steps:

Technical:

Further prototyping and getting CE + BTHA certifications.

Brand building:

Commit time to strengthening the brand through developing aesthetic, user feedback, and creating a community.
Long term activities would include expanding the product range, developing our own activities and fairs to promote the use of the Petit Preserver, branch into other areas such as publication of magazines or video channels.

Building a customer base + community:

- Chelsea Physic Garden, Natural History Museum, Science Museum, Kew Gardens, Horniman Museum.
- Green rooms botanical market, 'Nature Detectives' run by Woodland Trust, National Trust activities, 'Evening Tree walk' run by London WIldlife Trust
- London schools (Key stage 2), after school clubs running events such as 'eco-club', 'gardening club', 'botany club'

project plan report

overview + revisions

Key:

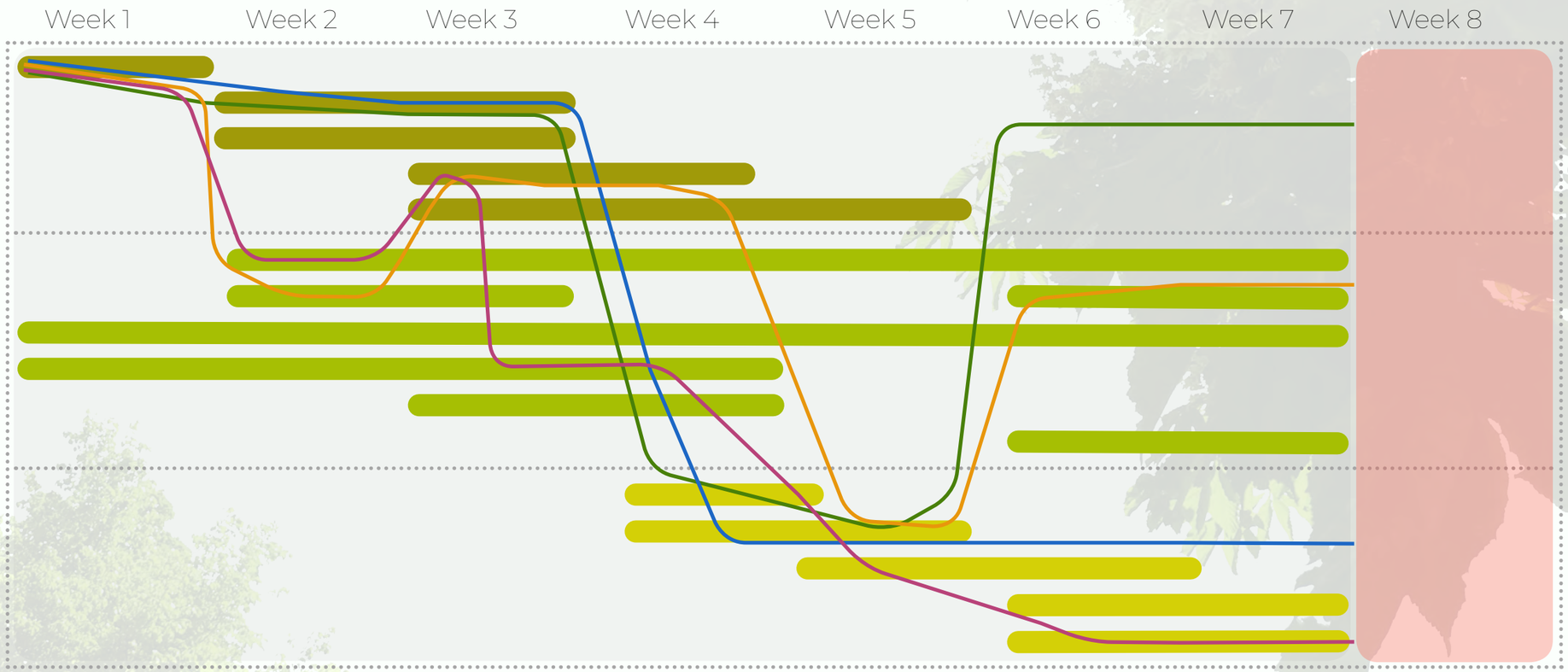
Esther

Mo

Medad

Alisa

Lines on the Gantt chart correspond to where each team member's main focus lay at the time.



Revisions

! Packaging and branding discussions should not have had precedent over form ideation

! 3D printer availability + tolerancing issues

! CAD took much longer than anticipated

! New issues arose w/ heating + power supply

Details

UX in this context considered usability and simplicity of the interaction surrounding the product. We wanted a simple 4 or 5 step sequence from start to end.

Business + marketing included the running of the 'root. explorer' page as well as consideration of how these tools could add value to the product, interaction and brand.

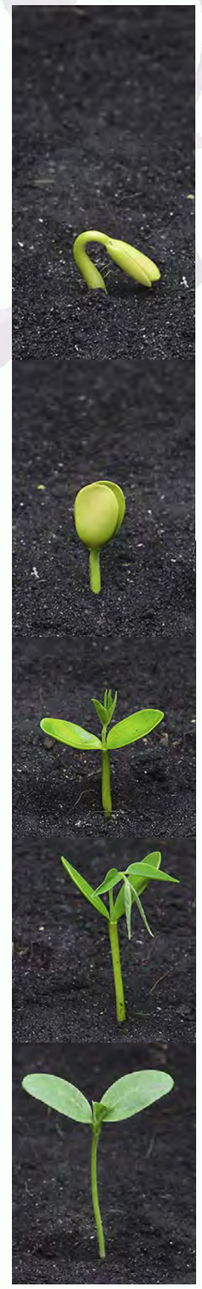
User feedback from the target market and wider market was sought out.

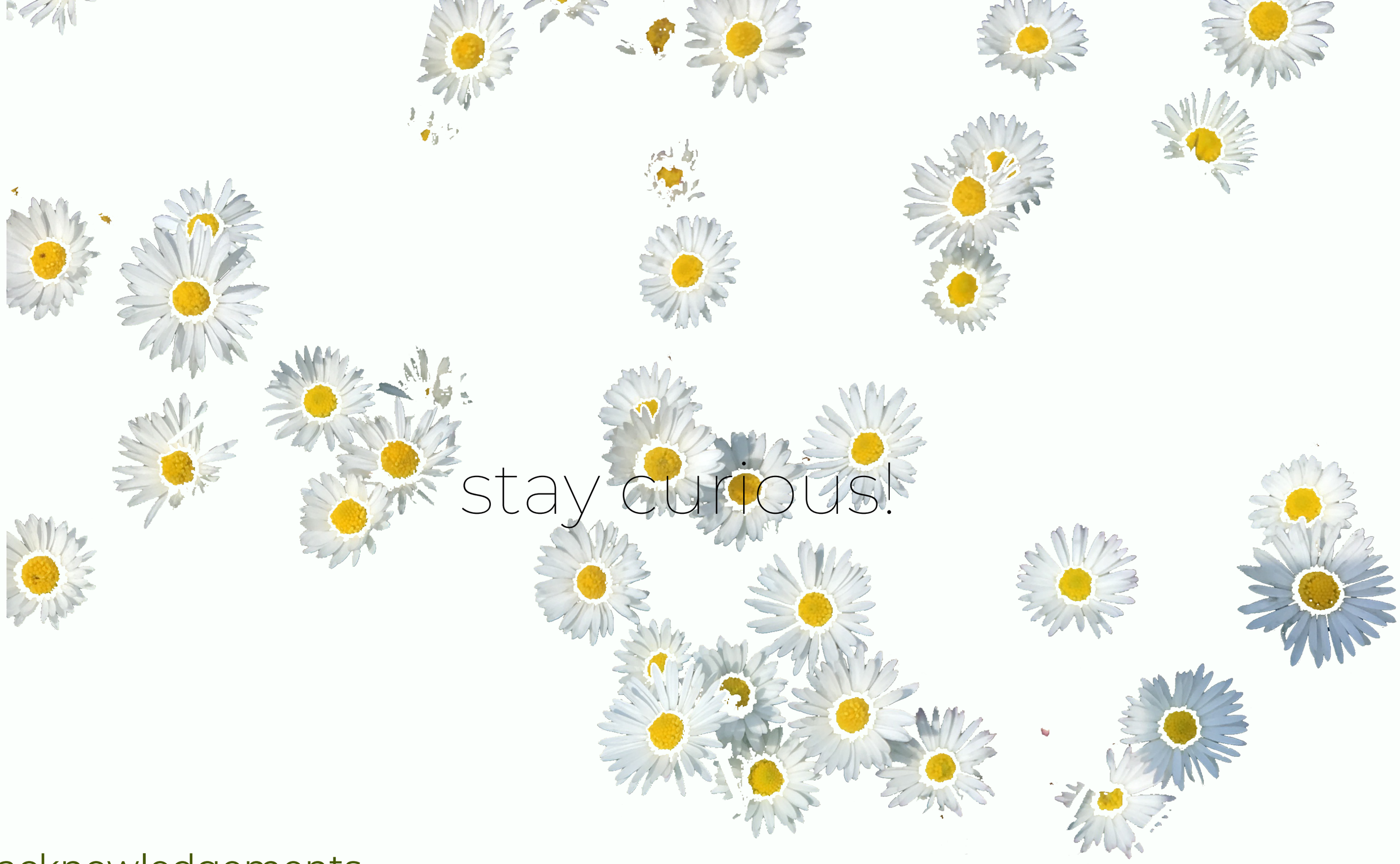
project plan report

milestones + details

A record of each meeting was kept to track progress and set internal deadlines. This is shown below, solo work was carried out but not recorded here. Resources such as Google Drive were heavily utilised to improve workflow.

Date	Activity	Members present	Milestone
01/04/19	Laminating samples, laminator teardown initiated		
03/04/19	Laminator teardown completed, filming footage		
07/05/19	Turning rods, shortening components		
08/05/19	Shortening components continued and assembly initiated		
10/05/19	Initial testing of heating element wires, checking resistances etc		
13/05/19	Further testing of heating element and assembly, testing of power supply		Heating element selected
14/05/19	Divvying out specific tasks to members		
16/05/19	Meeting to divy up slides + create draft of slides submission		
21/05/19	Lateness jar set up, redistribution of workload		1st lamination success
24/05/19	Ordering materials, contacting and setting dates w/ users		
27/05/19	Sketching, 3D prototyping		
30/05/19	Deciding the final form factor, CAD initialised		
03/06/19	CAD continued, teardown of 2nd laminator for build of final prototype		
04/06/19	Video script finalised, Internal CAD completed		Latch mechanism success
05/06/19	Compliance + business + ribbing discussion, CAD		
07/06/19	CAD intensive session		1st full CAD model
10/06/19	Assembly of first prototype iteration		1st casing iteration print
11/06/19	Natural history museum meeting w/ Rosie		
12/06/19	CAD, soldering, warning symbols design and print		1st full internals success run
14/06/19	Meeting w/ colourblind gardener		
15/06/19	Assembly video shoot		1st full product assembly
16/06/19	Debugging + more successful lamination tests		
17/06/19	Presentation practice + slide preparation		
18/06/19	Final product demonstration + presentation		It worked!

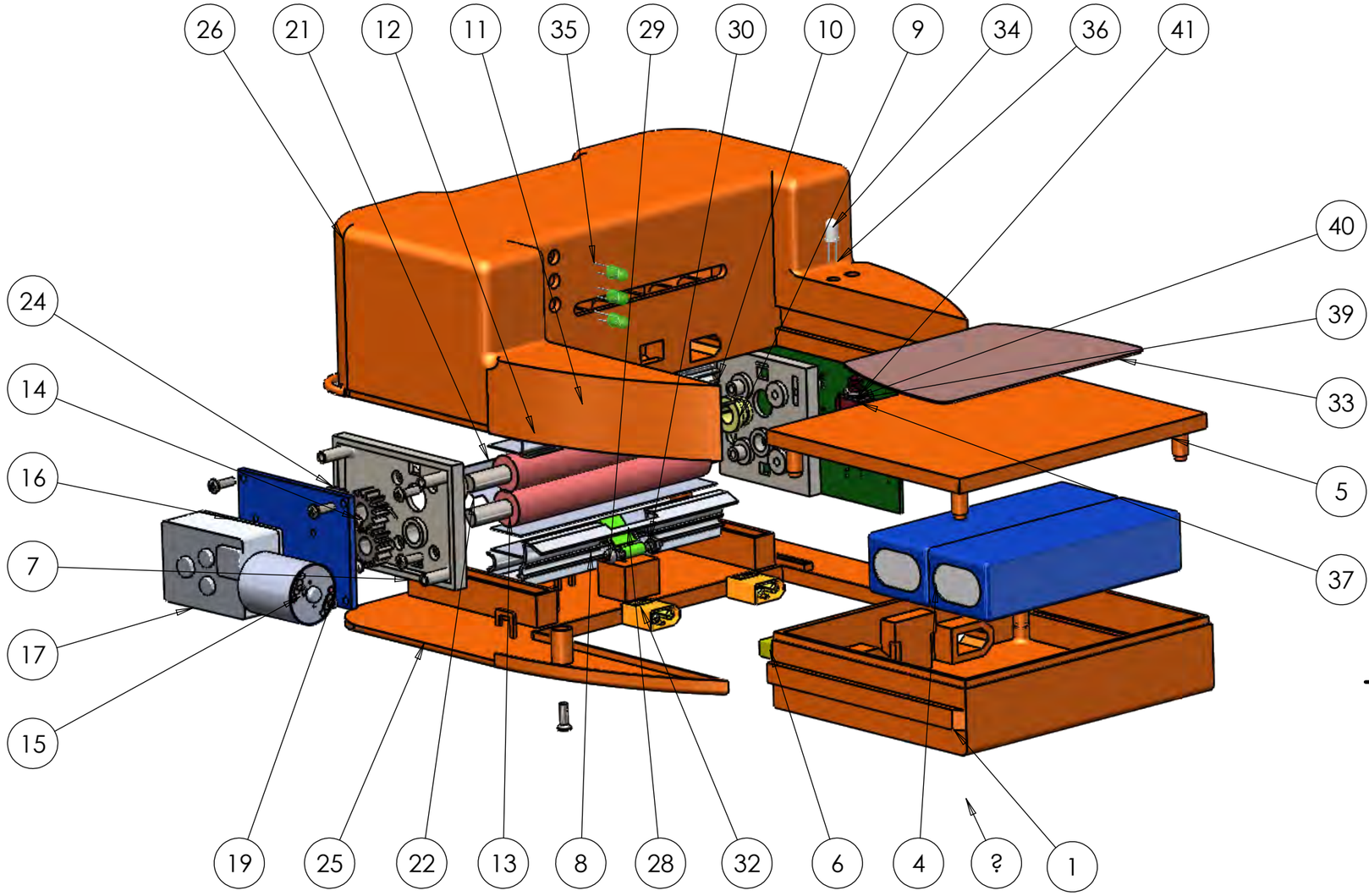


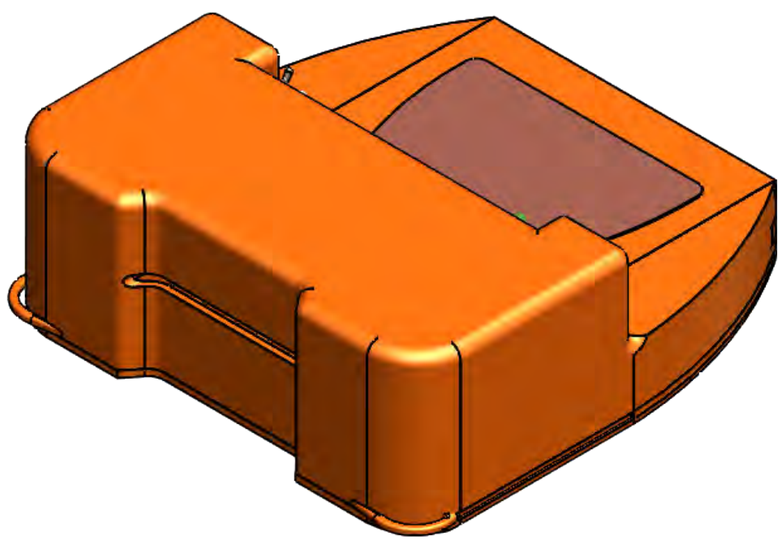


acknowledgements

With thanks to: Dominic Chadwick, Hanna Bollito, Rosie Copper Bowman, Nick Munroe, Victor Boddy, Richard Ibbotson, Ingrid, Francesca, Sadika and Amine

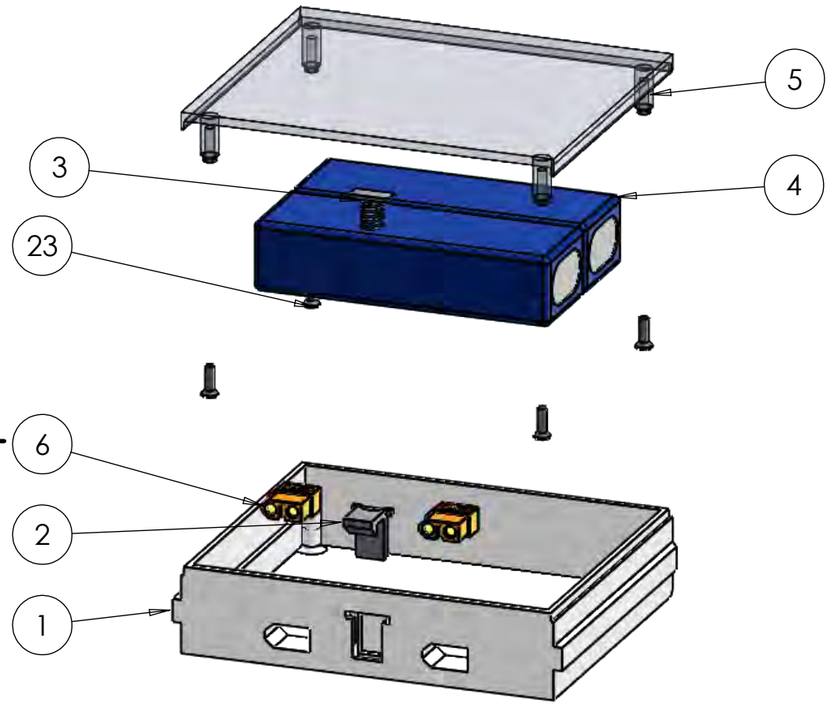
ITEM NO.	PART NUMBER	QTY.
1	battery body	1
2	hook	1
3	spring	1
4	Turnigy_2200mAh_3S_20C_Lipo_Pack	2
5	battery body cap	1
6	XT60 connector male	2
7	Side constraint	1
8	alligned top extrusion	1
9	laminator holder	2
10	right side costraint	1
11	metal base alligned	1
12	insulator	4
13	roller	2
14	Metric - Spur gear 1M 15T 20PA 6.9FW ---S15N75H50L7N	2
15	motor holder plate	1
20	Worm gear motor	1
21	guide_plate_bottom	1
22	guide_plate_top	1
23	B18.6.7M - M3 x 0.5 x 10 Type I Cross Recessed OHMS --10N	19
24	Metric - Spur gear 1M 30T 20PA 6.9FW ---S30N75H50L6N	1
25	main laminator body base plate	1
26	main laminator body	1
27	metal base plate	1
28	thermister PCB	1
29	BS EN ISO 7045 - M3 x 25 - Z - 25N	1
30	BS EN 24032 - M3 - W - N	1
31	TorsionSpring	1
32	XT60 connector female	2
33	copper plate 1	1
34	Green5mmLedHub	4
37	Body	1
38	Cap	1
39	Rubber Washer_01	1
40	Metal Washer_01	1
41	Nut_01	1



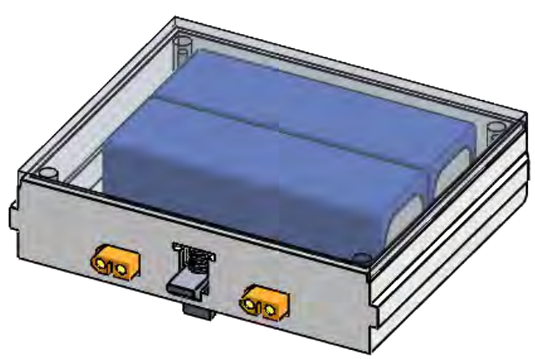


Material:	Finish:	Drawing Scale: 1:2	Title: **Full Petit Preserver assembly**
Weight: 1300g	Drawing Produced In Accordance With: **BS8888**	Drawn by: **Mohammed Elfadil**	Drawn Date: **20 June 2019**
Unless Otherwise Stated: Linear Tol.: **±0.2**, Angular Tol.: **0°15'** Surface Finish: **0.8µm** All Dimensions: **mm**		Description: Exploded view of Petit Preserver	
Projection Method: **THIRD ANGLE**		Part Number:	
		Drawing Number:	Sheet Size: A3 / Sheet: **1 of 21** / Revision: **v1.1**

SOLIDWORKS Educational Product. For Instructional Use Only.

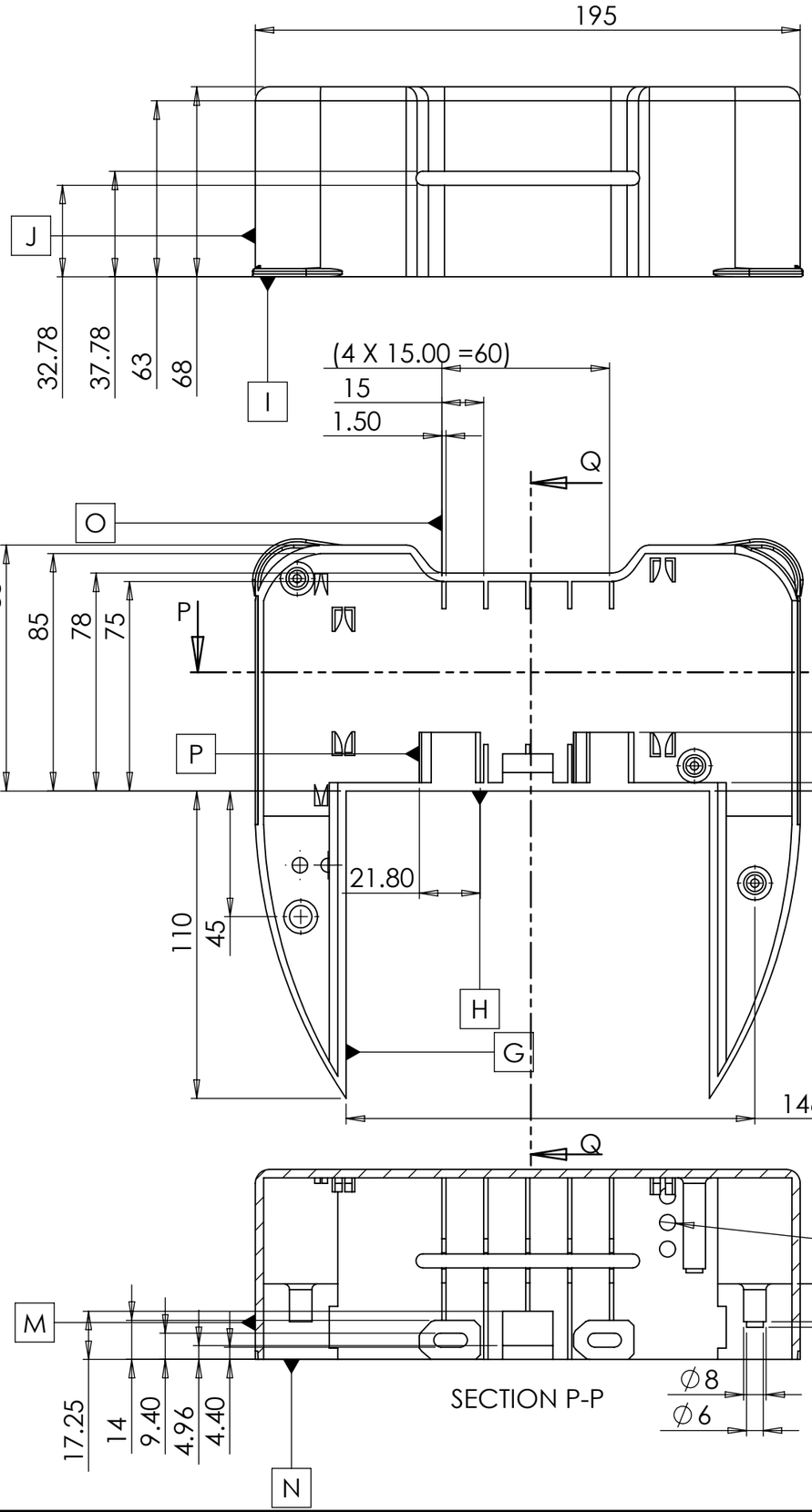


ITEM NO.	PART NUMBER	DESCRIPTION	Material	QTY.
1	battery body	main body of battery casing	ABS	1
2	hook	latching mechanism	ABS	1
3	spring	Part of latching mechanism	Steel	1
4	Turnigy_2200mAh_3S_20C_Lipo_Pack	LiPo batteries	Lithium Polymer	2
5	battery body cap	Top cap	ABS	1
6	XT60 connector	High current electrical connector	PA66 Nylon	2
7	B18.6.7M - M3 x 0.5 x 10 Type I Cross Recessed OHMS -- 10N	Fastener screws	Steel	4



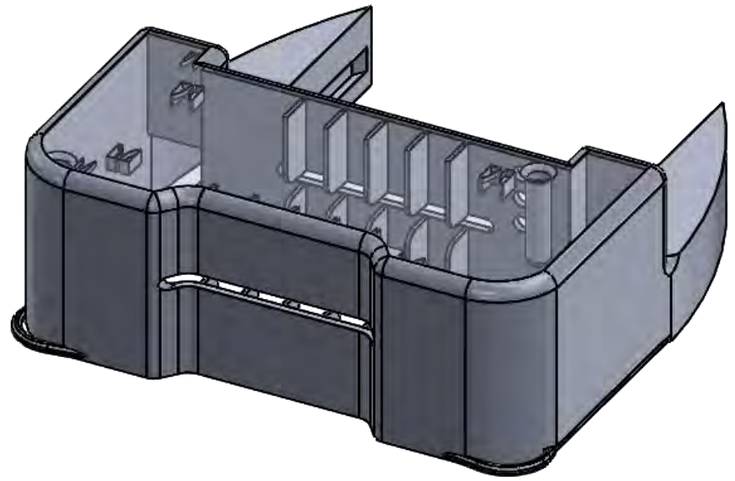
Material:	Finish:	Drawing Scale: **1:2**	Title: **Battery assembly**
Weight: 450g	Drawing Produced In Accordance With: **BS8888**	Drawn by: **Medad Newman**	Drawn Date: **20 June 2019**
Unless Otherwise Stated: Linear Tol.: **±0.2**, Angular Tol.: **0°15'** Surface Finish: **0.8µm** All Dimensions: **mm**		Description: Battery assembly	
Projection Method: **THIRD ANGLE**		Part Number:	
		Drawing Number:	Sheet Size: A3 / Sheet: **2 of 21** / Revision: **v1.1**

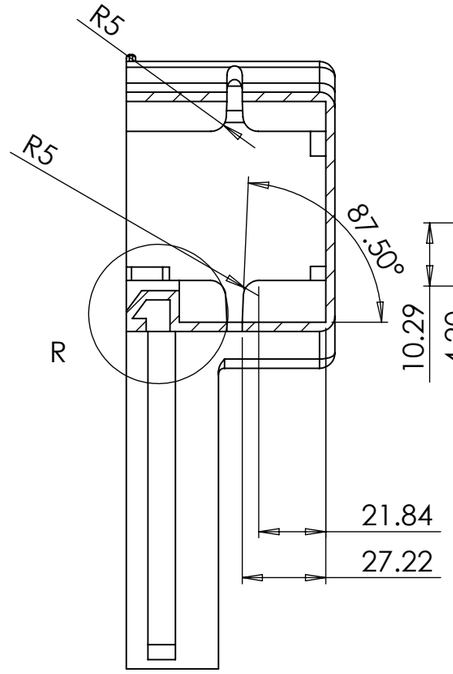
SOLIDWORKS Educational Product. For Instructional Use Only.



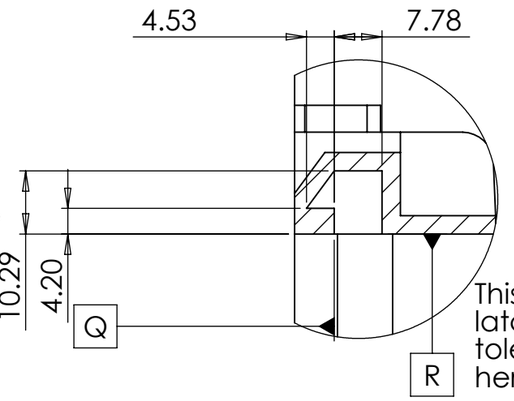
SECTION P-P

Note: Injection moulded ABS





SECTION Q-Q

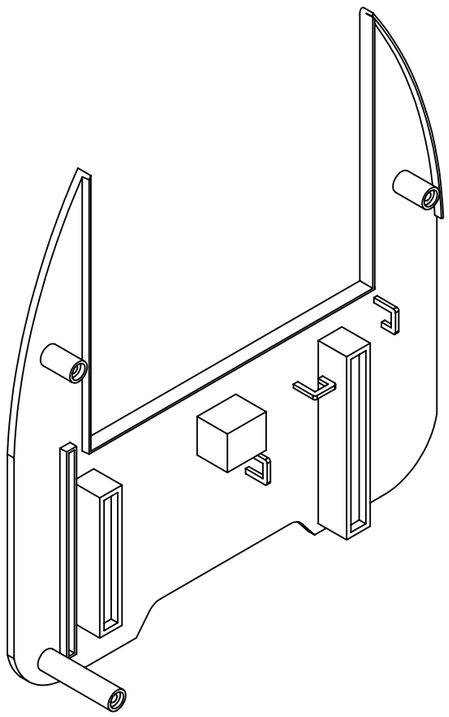


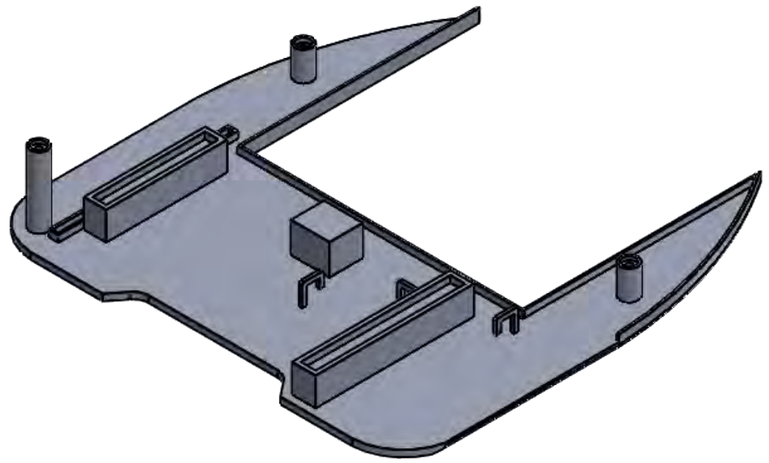
This is where the hook latches on. Linear tolerence is 0.1mm here

DETAIL R
SCALE 1 : 1

Material: PLA	Finish: NONE	Drawing Scale: **1:2**	Title: **Top case of laminator**
Weight: 203 g	Drawing Produced In Accordance With: **BS8888**	Drawn by: **Medad Newman**	Drawn Date: **24 April 2019**
Unless Otherwise Stated: Linear Tol.: **±0.2**, Angular Tol.: **0°15'** Surface Finish: **0.8µm** All Dimensions: **mm**		Description: This is the largest case component	
Projection Method: **THIRD ANGLE**		Part Number: TOPCASE34234	
		Drawing Number:	Sheet Size: A3 / Sheet: **3 of 21** / Revision: **v1.1**

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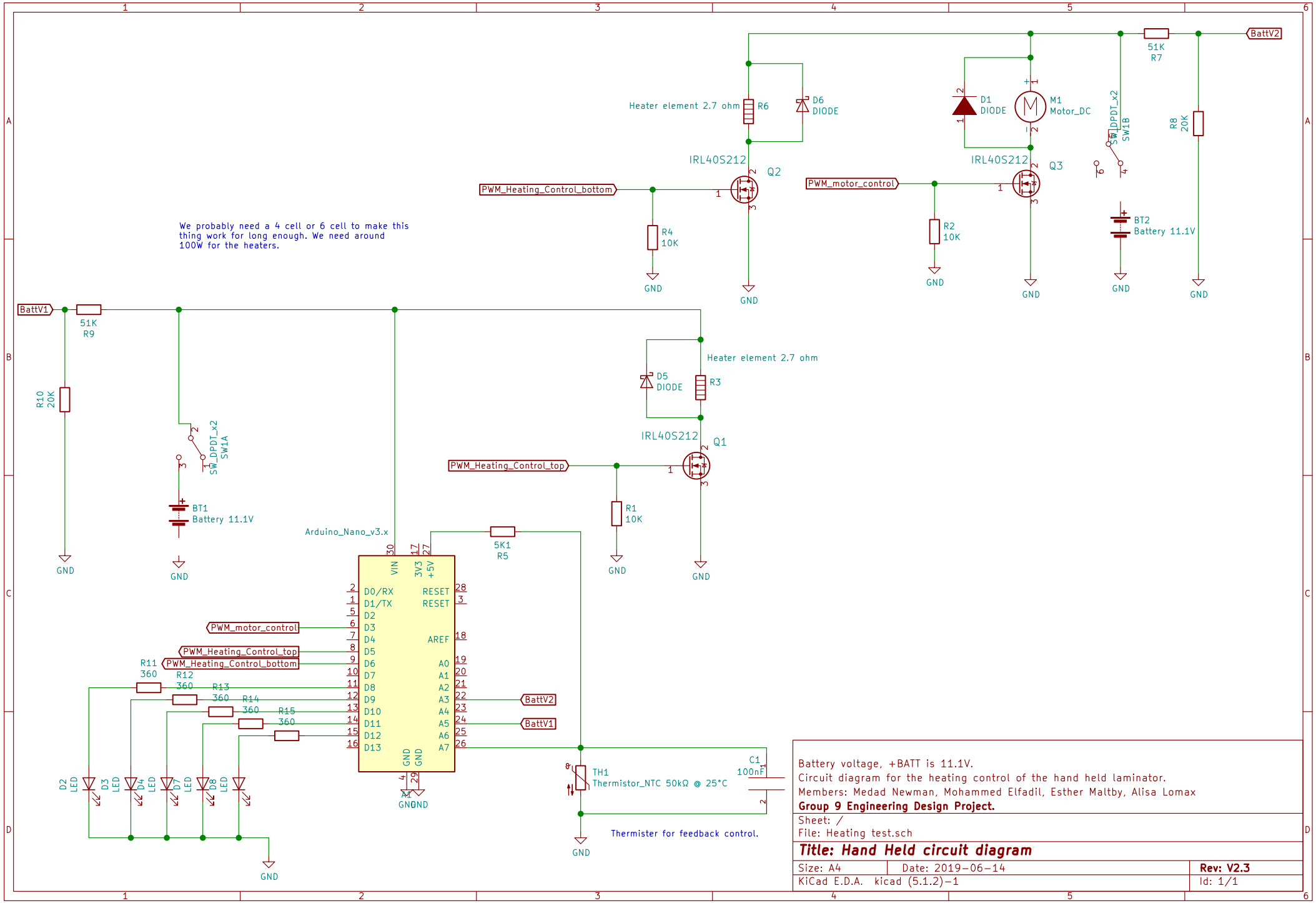




Note: Injection moulded ABS

Material: PLA	Finish: None	Drawing Scale: **1:2**	Title: **Base of laminator**	
Weight: g	Drawing Produced In Accordance With: **BS8888**		Drawn by: **Medad Newman**	Drawn Date: **20 June 2019**
Unless Otherwise Stated: Linear Tol.: **±0.2**, Angular Tol.: **0°15'** Surface Finish: **0.8µm** All Dimensions: **mm**			Description: This is the baseplate where the rollers are mounted	
Projection Method: **THIRD ANGLE**			Part Number: BASE23123BB	
			Drawing Number:	Sheet Size: A3 / Sheet: **4 of 21** / Revision: **v1.1**

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We probably need a 4 cell or 6 cell to make this thing work for long enough. We need around 100W for the heaters.
Heater element 2.7 ohm
R6
D6
DIODE
IRL40S212
Q2
PWM_Heating_Control_bottom
R4
10K
GND
D1
DIODE
M1
Motor_DC
IRL40S212
Q3
PWM_motor_control
R2
10K
SW_DPDT_x2
SW1B
51K
R7
BattV2
R8
20K
BT2
Battery 11.1V
BattV1
51K
R9
R10
20K
SW_DPDT_x2
SW1A
BT1
Battery 11.1V
Heater element 2.7 ohm
D5
DIODE
R3
IRL40S212
Q1
PWM_Heating_Control_top
R1
10K
5K1
R5
Arduino_Nano_v3.x
VIN
3V3
+5V
D0/RX
D1/TX
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
RESET
RESET
AREF
A0
A1
A2
A3
A4
A5
A6
A7
GND
GND
A1
PWM_motor_control
PWM_Heating_Control_top
PWM_Heating_Control_bottom
R11
360
R12
360
R13
360
R14
360
R15
360
BattV2
BattV1
D2
LED
D3
LED
D4
LED
D7
LED
D8
LED
TH1
Thermistor_NTC 50kΩ @ 25°C
C1
100nF
Thermister for feedback control.
Battery voltage, +BATT is 11.1V.
Circuit diagram for the heating control of the hand held laminator.
Members: Medad Newman, Mohammed Elfadil, Esther Maltby, Alisa Lomax
Group 9 Engineering Design Project.
Sheet: /
File: Heating test.sch
Title: Hand Held circuit diagram
Size: A4
Date: 2019-06-14
Rev: V2.3
KiCad E.D.A. kicad (5.1.2)-1
Id: 1/1