Eat, Sleep, Ride, CIC

# Brighthoof Biofuel

IGP MILESTONE 2 REPORT

Group 26: Mohammed Rafiq, Callum Reid, Ailsa Shaw, Craig Speirs

DM403 | April 2025

**Overall Word Count: 18,916**

**Statement of academic honesty**

We declare that this submission is entirely our own original work.

We declare that, except where fully referenced direct quotations have been included, no aspect of this submission has been copied from any other source.

We declare that all other works cited in this submission have been appropriately referenced.

We understand that any act of Academic Dishonesty such as plagiarism or collusion may result in the non-award of our degree.

Signed ………………………………………… Signed ………………………………………...

Signed ………………………………………… Signed ………………………………………...

Dated ……..…28/04/2025………………

# Contents

## Project Abstract:

Managing manure production is a challenge, but what if waste could become a powerful resource?

This project has involved creating a solution to convert horse manure into biofuel; to reduce waste, lower environmental impact and further emphasise the self-sufficient philosophy held by Eat Sleep Ride CIC, who benefit young people through horse-based activities such as equine therapy.

We discovered and utilised biofuel technology such as pressing and drying systems to assist in turning an overlooked resource into an innovative energy source.

## Critical Analysis on Milestone 1 Group Report

**Introduction**

Before presenting the progress and outcomes of Milestone 2, Group 26 conducted a critical analysis of the Milestone 1 report to identify strengths, weaknesses, and opportunities for improvement. This reflection is essential to optimize team dynamics, refine strategies, and ensure the delivery of a high-quality solution for Eat Sleep Ride CIC. By addressing what went well, what fell short, and how we will enhance our approach, we aim to strengthen our teamworking and collaboration skills, with the goal of producing the best possible solution for the client's problem.

**Reflections**

The approach to the project in Milestone 1 proved effective, particularly the thorough analysis of the initial brief and subsequent client discussions to clarify and understand the main issues the client had, and identifying what the group could do to solve them. These steps ensured alignment with the client's needs, such as reducing the economic burden of manure removal. This structured approach will continue in Milestone 2, with regular client feedback sessions being key as the concepts quickly advance to finalisation, and task reviews to maintain focus on delivering a practical biofuel system that meets the pre-set deliverables.

Feedback on the Milestone 1 report highlighted a lack of continuity, with sections like background research and market analysis occasionally overlapping (e.g., repetitive mentions of drying technologies). This stemmed from individual section drafting without sufficient integration and cross-checking. To address this, we will conduct more group meetings to review and plan progress and milestones, ensuring seamless transitions between sections (e.g., linking research findings to concept generation) and providing context for decisions (e.g., “Market research on solar dryers informed our modular design”). This will result in a clearer, more actionable report for the client, facilitating the implementation of the biofuel system.

The literature review in Milestone 1 demonstrated a robust understanding of biofuel production, supported by detailed competitor analysis. The group evaluated existing briquette makers and drying technologies, identifying features like scalability and durability that informed our objectives. Moving forward, we will ensure that research directly shapes concept development, using insights from products like Solar Dryers to design a system that meets critical demands, such as weatherproofing for coastal conditions, whilst working for the conditions on-site, also allowing for adaptability.

Teamwork was a strength, facilitated by tools like meeting minutes, a rotating project lead, and the Task Allocation Table which helped with accountability. The table, detailing tasks, owners, deadlines, and progress, was the most effective tool, providing a clear visual of responsibilities and fostering accountability. Initially used late in Semester 1, it has been adopted from the start of Semester 2, with tasks like concept evaluation already allocated. This proactive approach will enhance efficiency and ensure timely delivery of the project’s final deliverables.

**Conclusions**

This critical analysis has guided Group 26 in prioritizing successfully proven and high-value methods, such as the Task Allocation Table, to build on the Milestone 1 foundation of work. By implementing these improvements—monitored through consistent group meetings and client feedback—we will enhance teamwork, report clarity, and alignment with the client’s project goals. These efforts will culminate in a robust final outcome, delivering a practical, and functional, biofuel system that supports Eat Sleep Ride CIC's vision of self-sufficiency and environmental excellence.

## Project Overview

This project was created alongside Eat Sleep Ride CIC, who are an equine therapy organisation based near Berwick-upon-tweed. The organisation objectives are to offer social and wellbeing support through horse-based activities. The problem they are facing involves significant operational challenges in manging the volume of horse manure produced. The organisation has around 20 horses on-site, which was found out from the initial client meeting and are generating approximately 0.5 tonnes of manure each day. Currently, the organisation disposes the manure by fossil fuel powered equipment and transports the waste off site which is resulting in high costs and a substantial carbon footprint, both of which are directly conflicting with the organisations long term sustainability goals.

To solve this problem, the team created a practical, low-tech solution to convert manure into usable biofuel on site. The original project brief focused on delivering a fully functional solar powered system but after early meetings with the client, it was discovered that budget and time constraints were going to be limiting factors. The team decided to change the deliverables into developing a full design package that the client could go through and construct.

Figure 1 Manure Pile

This included detailed CAD models with exploded views, an operations guide to ensure proper use, construction guides to ensure proper building, a costing list and safety considerations.

The design process ensures the client was involved throughout and that each change we made was done with realistic constraints, user needs, and on-site limitations in mind. Supporting research included technical analysis of drying and pressing systems, environmental considerations specific to the Scottish Borders, and case studies of similar small-scale biofuel solutions. Key design decisions were made using a number of aspects like client feedback, concept evaluation matrices, and design-for-X (DfX) principles. The final concept is a practical and accessible system tailored to the client's needs, helping reduce emissions, cut costs, and support Eat Sleep Ride CIC's transition to a more sustainable, closed-loop operation.

## Project Deliverables:

In the beginning phase of the project the initial deliverables of the project were set as:

1. 'Fully Operational Solar-Powered Drying and Processing System': Establish a complete system for drying and processing horse manure into biofuel, powered. This could include the installation of solar drying units, processing equipment for briquette or pellet formation, and associated infrastructure.
2. Manure Biofuel Production Output: Produce and store a targeted quantity of biofuel (in the form of briquettes or pellets) from horse manure, ready for use or distribution, within a specified timeframe. This deliverable includes achieving consistent quality and moisture levels in the final product.
3. Carbon Reduction and Cost Savings Report: Generate a comprehensive report detailing the reduction in carbon emissions and cost savings achieved through the project. The report should compare the baseline data (pre-project) with post-implementation results, demonstrating progress towards net-zero goals and improved waste management efficiency.

The deliverables were tweaked from their original form, to improve the achievability of a useful outcome within the scope of the project, to become:

1. Detailed plan for the pressing and drying process

2. Physical prototype/ mock-ups of final design

3. A plan for this process to be assembled on site

4. A costing and materials list for the assembly

## Project Planning

For the design methodology, the group decided to use the Ulrich & Eppinger design process. This decision was made as the flow of the methodology was appropriate for the task, with a heavy emphasis initially, before moving on to the concept, which becomes more refined and specific as it progresses. The research is extremely important as it is used to inform the concept development process, learning from theoretical research and prior testing in other projects.

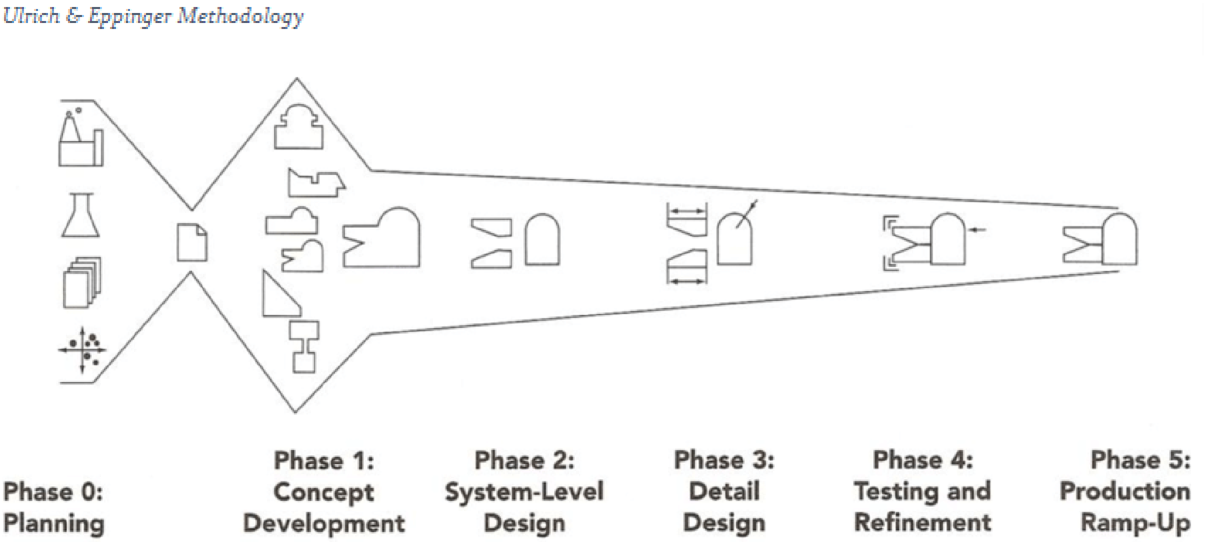



Figure 2 Design Methodology

The organisation of the project was initially set up with a Gantt Chart, as shown in *Appendix A,* however as the project moved forward it was decided that the project could be better controlled using a task list, shown in *Appendix B.* This was a much more reliable method and much simpler for all team members to understand.

## Project Management

**Meeting Minutes**

Just like in the first stage of this report, minutes were taken of all meetings as a way of progress tracking and accountability from the group. Meetings with just the group, meetings between the group and the advisor, and meetings between the group and the client were all recorded on the minutes document.

This document contained how long each meeting was, attendance of the meeting, the tasks completed in the meeting, and the next steps to follow from each specific meeting. From these 'next steps' set in each meeting, the Task List was then updated, with each task given a completion time, and allocated to a group member or multiple members.

Therefore, the minutes tracking was a very beneficial tool that contributed to the success and completion of the overall project, by ensuring accountability, and guaranteeing consistent progress over time.

*(See appendix C for the full minutes tracking document)*

**Team Rules**

At the start of the project, the team had established a set of rules which each member had agreed upon. These rules were created to ensure every member was on the same page and understood what was to be expected of them. The rules are:

1. Treat everyone with respect

2. Communicate openly

3. Give constructive feedback

4. Treat each other equally

5. Be time efficient

6. Acknowledge everyone's work

7. Ensure decision making

These rules were also applied to interactions with the clients, supervisors and any other people involved. Into semester 2 these rules were reviewed for their effectiveness and the team found that these rules continued to serve their purpose well. Communication stayed respectful and clear, and tasks had been completed to the deadline's majority of the time except where circumstances permitted (like other deadlines). Decision making was done collaboratively within the team leading to a smoother development process and as a result no changes were seen as needed to the rules.

**Leadership Roles**

The weekly leadership position was eventually let go as the team felt it was unnecessary to have a hierarchy each week. One team member continued to take responsibility of organising client and supervisor meetings and helped to keep the team on track for deadlines and deliverables. The team began working as a unit, sharing responsibilities, decision making and problem solving collectively. This helped to keep momentum for the two semesters even though leadership ended up becoming more flexible.

The team ended up developing a strong and supportive dynamic where members would step in to assist without needing delegated. We ended up seeing an improvement in efficiency as tasks were taken by individuals that wanted them.

**Project Planning**

To plan the project, a timeline was initially used to inform a Gantt Chart, as shown in *Appendix B* However, the Gantt Chart did not prove to be useful in the context of a group project with a large number of tasks, so a task list was created instead.

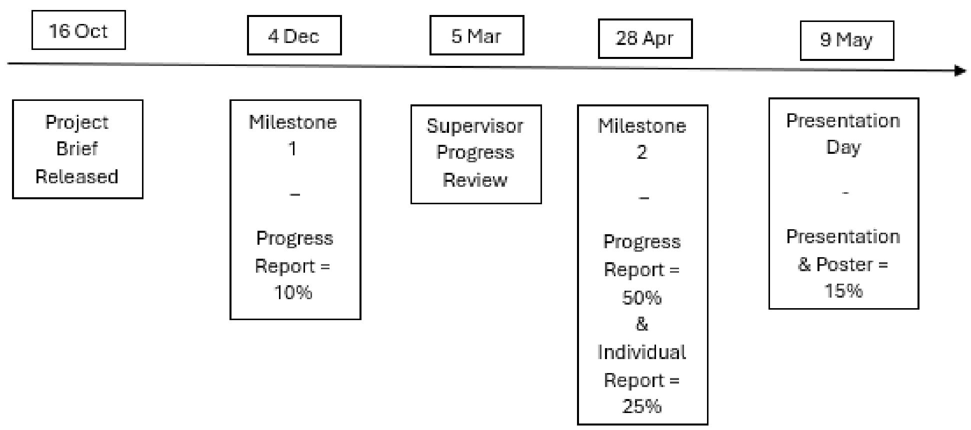



Figure 3 Project Planning

**Information Management**

# Risk Management

In Milestone 1, foreseen risks and their mitigation strategies were identified, as shown in the table below.

Table 1 Risk Management

| Risk | Mitigation Strategy (Accept, avoid, transfer, reduce) | Action Plan |
| --- | --- | --- |
| Client Drops Out | Reduce | Consistent communication, Professionalism, Address client needs |
| Team Member Drops Out | Accept | Cannot be prevented by the group, Role rearrangement required |
| Team Conflict | Reduce | Follow team rules, Open communication, Consider compromise |
| Technology Failure | Reduce | Back-up files regularly |
| Workload Imbalance | Avoid | Allocate tasks equally, Consistent communication within the team |
| Changes to laws/ regulations relevant to project | Accept | Cannot be avoided, Regular research required to stay informed |
| Ineffective communication | Reduce | Consider most efficient communication methods eg. Email, online meeting, face-to-face, group chat. Team should respond quickly |
| Team Member Illness | Accept | Discuss as a team how best to delegate roles |
| Missing Deadlines | Avoid | Refer to project plan and Gantt chart, balance of tasks between team members |

## Client Meetings

The first meeting with the client took place on October $2^{nd}$, 2024, on zoom. Danielle from Eat Sleep Ride CIC began with an overview of the organisation from how it operates to the current challenges they face surrounding horse manure management. Eat Sleep Ride produces a significant amount of horse manure daily that equates to roughly half a tonne which is collected and removed from site using tractors with trailers attached. Danielle went to explain that this process is not only costly but also contributes highly to their carbon footprint which is in direct conflict with the organisation's sustainability goals. She also shared details on an attempt she had made previously that involved converting the manure into biofuel using briquettes. This attempt had failed due the difficulty in drying she was facing as it had been problematic to fully remove the moisture from the briquettes. During the meeting, the group and Danielle reviewed the initial project brief that was given, this included a list of deliverables like a fully solar powered drying system, ensuring a significant production of biofuel was achieved and finally a report on carbon savings the organisation would have from such a system. This meeting was essential in establishing that initial conversation and introduction which then allowed an understanding from both parties of the project goals and priorities. The team now had a starting point and the correct context to begin background research and early-stage concept development.

The second client meeting took place on November $26^{th}$, 2024, also held via zoom. The team had a new set of deliverables for the client. After researching the topic of horse manure, the team found out that the original deliverables would be unrealistic in the time frame of the project. There was a lack of budget and issues around transporting a full-scale working system to the client's location. Instead, the team had proposed a slight shift in focus toward a comprehensive design package which would encompass a detailed concept for a drying and pressing system that would include mock-ups for visualisation, as step-by-step on-site assembly guide as well as a costing list that Danielle could use to build the system locally. Danielle responded positively to the changes understanding the practicality and value she would gain from the new approach. Also, during this meeting, she also asked about potential funding or grants that could help with producing the final design. The team didn't have the answer so directed Danielle to the module leader who would be able to provide the necessary guidance and resources on grant applications. This meeting was a turning point for the project with a new set of deliverables clarified the team could now adapt the project timeline to work with this new direction.

The third client meeting was held on March 19th, 2025, again on zoom. The group shared a screen and talked to Danielle about several developed design concepts for drying and forming systems. The team wanted to gather feedback from the client on ideas that she liked and disliked with reasons why. Danielle had provided clear and helpful input improvements that could be made and things that could be problematic based on the site and resources. This feedback is shown later in the report. This feedback was able to help the group refine and improve their concepts, ensuring the final design was practical and realistic and would fit well on site. The insight from this session aided in detail design and final developments.

The fourth client meeting was held on April 16th, 2025, on zoom. The group had shared with Danielle a screen showcasing CAD renders of the final design which we could get her thoughts on for final changes. The team walked her through the operation of both systems and mentioned how the instructions included with both systems would include supportive information on the construction and use of each and list preferred materials. Again, Danille provided great insight and challenged our thinking which highlighted four new areas that needed investigated further. These included things like re integrating legs for the forming system as Danielle preferred a system that was one piece so it could be easily stored and wouldn't have parts getting lost, conducting research into whether burning certain materials which could get mixed in with the manure from the site would cause issues in briquette forming and burning and we also obtained clearer guidance on how to store the briquettes once produced. This session allowed the team to finalise any final design tasks and create a detailed to do list based on Danielles input. Each team member had then been assigned responsibility to address the new tasks, ensuring everything would be wrapped up in line with the client's needs.

# Project Investigation

## Sustainable Development Goals

As Eat Sleep Ride CIC prides themselves on "environmental stewardship" (Eat Sleep Ride, 2025), the United Nations Sustainable Development Goals are a great tool to use to guide the project in a direction that meets with the ethos of the Client. The relevant STG's for this project were selected 'in the name of the planet, to spur economic growth, whilst tackling climate change' (United Nations, 2025).

**SDG 7: Affordable and Clean Energy**

The goal of SDG 7 is to create affordable, reliable, and sustainable energy – this project is working towards all three of these. The manure is produced year-round by the horses and can be produced with no external energy sources, making it sustainable. The self-reliance on supply makes it reliable, emphasised by it being manageable at smaller scales, and it will be affordable as the project aims to reuse a product that is otherwise a waste product.

**SDG 9: Industry, Innovation, and Infrastructure**

This goal links to some of the key deliverables that were mentioned by the client – this project would help the site become more self-reliant, by building up its energy-producing infrastructure. Innovation is the underpinning factor to this as well, utilizing technology such as solar-cells for heat production at smaller scales – something that is niche and innovative if successfully implemented. Additionally, the innovation here comes from the student team adapting current knowledge and skills to meet the client's needs, no matter the circumstances.

**SDG 13: Climate Action**

There are a few aspects of the project that link to climate action. Eat Sleep Ride CIC will be able to reduce their greenhouse gas emissions from the '15-

20 trailers every 4 months' by using the manure onsite instead of needing it removed. Additionally, this use on site also has the capacity to product energy if the briquettes are to be burned, possibly making the site even more self-sufficient (would require burning capabilities).

**SDG 15: Life on Land**

This project meets SDG 15 by disposing of horse manure in an environmentally safe way, which otherwise could have caused pollution if improperly disposed of or stored. The site is also working towards the circular economy goal of 'life on land', through use of waste biproducts of their horses. This is being taken further by the consideration of possible contamination of the manure and research into usability in relation to manure being mixed with sawdust, carpet fibre, and potentially hazardous materials.

**SDG 17: Partnerships for the Goals**

The final SDG, 17, is about groupwork and collaboration in the way in which other SDG's are achieved. Through the group working and collaborating with many different parties, such as lecturers, Eat Sleep Ride CIC, our supervisor, and others, a multi-stakeholder project has been completed, keeping everyone in mind for key decisions. Regular group and client meetings were pivotal in meeting this SDG and balancing it with effective work.

Successful implementation of these STG's will be achievable through reflection to them throughout the design process at various stages, as well as considering them during selection and analysis of concepts, to keep concepts that again, align with the client's environmental ethos. An actionable step to implement this is to update the PDS with these STG's informing new points where relevant.

## Background Research

Biofuel is a renewable energy production method that can be used as an alternative to fossil fuels. Renewable production methods are a much more sustainable approach to energy production which can help to reduce humans' impact on the planet.

Horses can produce up to 50kg of manure every day *(Anaerobic Digestion, 2022)* which means there is a lot of potential material which is currently going to waste. In order to prepare for biofuel production, the high moisture level of the manure, which is expected to be in the range of 45%-65% w.b. (wet basis), must be significantly reduced *(Da Lio et al., 2021)*.

Horse manure has been shown to not need any extra additions to be made suitable for burning, but the content of the manure can have an effect on the quality of the biofuel. Manure that contains straw, sawdust or wood shavings will have improved combustion capabilities because of the high calorific value of the material *(Da Lio et al., 2021)*. If the horses have a high fibre diet, the manure will have an increased mineral content, and this will produce more ash when burnt.

The client has expressed that there could be some contamination from carpet fibres in the manure because of the methods of collection and storage that are used. In the future, this contamination should be avoided by keeping manure that contains carpet fibres separate from the main heap. There would be a potential risk of burning polymer fibres because the majority of modern carpets are made up of wool, polypropylene, nylon, or polyester, or a combination of these *(Ashburn Carpets, n.d.)*.

## Market Research

In the early stages of the project, competitor analysis was completed to help gain an understanding about the products that currently exist on the market. The products were analysed to find features that would be successful within the scope of the project. The strengths and weaknesses of existing products informed the decision making within the concept generation phase of the project.

## Existing Product Analysis – Forming Systems:

| Product | Research | Analysis | |
|---|---|---|---|
|  | This briquette maker is designed for pressing newspaper into briquettes after it has been soaked in water. The paper briquettes can then be used as a fuel source. The reviews on Amazon. The reviews on Amazon suggest that this is an effective method. One reviews states that the metal is too thin and needs to be clamped to avoid the press from bulging. This product is available on Amazon for £16.95. | Strengths | Inexpensive, Easy to use, Takes up very little space |
| | | Weaknesses | Possibly not robust, Best for household use |
| | | Opportunities | Could use multiple of these for a slightly larger scale of production |
| AH Briquette Maker *(Amazon, n.d.)* | | Threats | May need to be adapted to be strong enough for required use |

| Product | Research | Analysis | |
|---|---|---|---|
|   | 'Multimate' manufactures a range of briquette pressing products. They are made from 2mm mild steel which will make them durable and long-lasting. There is a free-standing version as well as a range of smaller tabletop presses, and many accessories available such as extension handles, wall brackets, and removal blocks. The products cost between £130 and £160. There isn't currently any information about how much force they exert in comparison to other briquette makers, but the longer handles suggest a larger moment and therefore more force. | Strengths | Durable, Easy to use, Designed for a range of materials |
| | | Weaknesses | Makes one briquette at a time which is time-consuming |
| | | Opportunities | May be more powerful than other presses |
| Multimate Briquette Makers *(Multimate, n.d.)* | | Threats | More expensive than other manual presses |

| Product | Research | Analysis | |
|---|---|---|---|
|  | This briquette maker produces four briquettes at once for production that is slightly quicker and requires less manpower than a single press. The press is made from steel which is durable and robust. It is a very compact design. The dimensions are 380 x 310 x 180mm and it costs £85.05. | Strengths | Inexpensive, Easy to use, Compact design, Robust |
| | | Weaknesses | Designed for paper briquettes |
| | | Opportunities | This is similar to the press the client already has; Multiple could be used at once to upscale production |
| Tidyard Briquette Maker *(Amazon, n.d.)* | | Threats | Could require a lot of strength to press |

Table 2 Existing Product Analysis - Forming Systems

## Existing Product Analysis – Drying Systems:

| Product | Research | Analysis | |
|---|---|---|---|
|  | CONA is an Austrian company with a patented solar drying system for over 500 plants which go on to become 150 different products. The dryer produces 260kWh of electrical energy a day from 10 hours of sun. It is an active indirect solar dryer which uses a solar collector to heat a working fluid which transmits heat to the material being dried with a heat exchanger. The solar dryer can be used on a small commercial scale up to an industrial scale of manufacture and it seems to be available in a range of sizes. The price for this product is not currently available. | Strengths | More sustainable as it uses solar panels |
| | | Weaknesses | The scale of technology required suggest it is an expensive solution |
| | | Opportunities | Solar collector intensifies and redirects the light available |
| CONA Solar Drying *(Astecker, 2017)* | | Threats | Requires 10 hours a day of sun which is not viable in Winter |

| Product | Research | Analysis | |
|---|---|---|---|
|  | The OMY Solar Dryer is purchased as a kit to assemble yourself. It is designed for the drying of up to 4kg of fruit, veg, and plants. The company states that they will take from 6 – 48 hours to dry dependent on moisture level. It dries the material using a 1-watt solar panel which powers the electric ventilation system to dispel the moisture. The heat is provided by glass paneling, and it reaches 40-60 degrees C, however it will only work when there is full sunlight. The design also includes a flexible number of drying trays, a thermometer, and carry handles. The dimensions when folded are: 700 x 500 x 350 mm and it has a cost of 599.95 euros (£501). | Strengths | Modular design suggests that it is scalable |
| | | Weaknesses | Requires full sun which is not viable in Winter |
| | | Opportunities | Can be used off-grid |
| OMY Solar Dryer *(Solar Brother, n.d.)* | | Threats | Has been designed for drying food so would need to be tested with briquettes |

| Product | Research | Analysis | |
|---|---|---|---|
|  | LASCO Gill Plates are designed to dry a large volume of wood chips, but the company states that the product is suitable for drying almost any material. The plates work with a pressure chamber to dry material. The gill-shape means the material is prevented from falling into the chamber. The plates mean a large surface area can be used resulting in a large output volume of dried goods. The price for this product is not currently available. | Strengths | Flexible, Simple design, Good for large volumes |
| | | Weaknesses | Requires a pressure chamber which would use a lot of energy |
| | | Opportunities | Has potential to work with smaller pellets |
| LASCO Gill Plates *(LASCO, n.d.)* | | Threats | Briquettes may be too large to dry with this process |

Table 3 Existing Product Analysis - Drying Systems

The market research concluded that there were not any products available on the market that were designed for the mid-range level of production that the client requires. The briquette presses available most commonly only produce one briquette at a time whereas the research into drying methods mostly showed large scale solutions. These would be a very large investment and more suited to drying a larger content than would be initially necessary. The OMY Solar Dryer is a solution aimed at home drying; however it is an inexpensive method that showed how a similar solution could be scaled to the project requirements.

## Technology Review

To further understand the processes for currently producing biofuels and to also inform the concept generation in this project, the group researched the technology available for industry standard production.

Pelletising:

Drying Technology:

Traditional biofuel production is ordinarily completed at a larger scale than we have worked on within this project. To complete the biofuel drying process at a large scale, a dryer drum is used. Hot, clean air supplied by a furnace is blown around a rotary drum. Feeder screws then deliver the wet 'bio' material such as wood, into the drum which rotates and lifts the wet material into the air with lifting plates which line the inside. The hot air causes the moisture within the material to evaporate, and the now dry material can be released form the drum through a discharging hole.

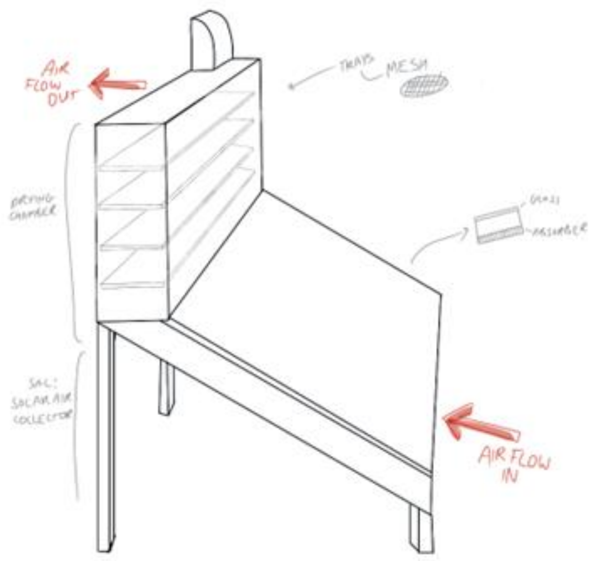
Figure 4 Wood Dryer-Drum (Biomass Pellet Machine, (n.d).)

Solar Drying:

One challenge we faced when finding a solution for processing the horse manure is the amount of power required. A large motivation behind this project is for the client to reduce their overall costs by eliminating the need for the horse manure to be collected from their site. This means that the chosen process must have a power requirement which as low as possible to ensure the ongoing costs to the company remain minimal. Because of this, research was done into drying processes which can be completed off-grid. Such a concept is the 'solar dehydrator'. There are two forms of solar dehydrator: a direct solar dehydrator, which is an enclosure with a clear lid that allows the air inside to be heated, and an indirect solar dehydrator, which uses solar energy to heat the air in a drying chamber.

Figure 6
Direct Solar Dehydrator (Ritik, 2025)

Figure 5
Indirect Solar Dehydrator (McCann, 2022)

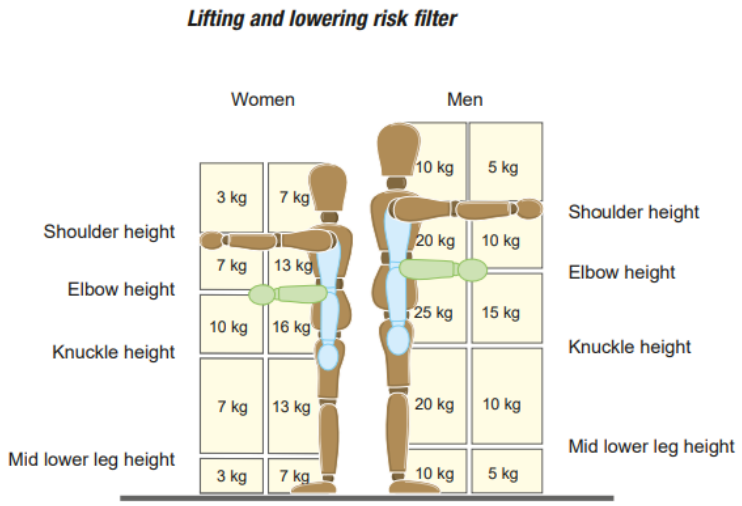



An indirect solar dehydrator has two main components: a solar collector and a drying chamber. The solar collector is made up of an absorber layer and an insulation layer. The absorber layer is usually a form of glass which will absorb solar radiation. A gap between these two layers allows for heated air to flow into the drying chamber. The air enters the base of the solar collector through an inlet. Experimental testing has been conducted on this method, and it concludes that the process is most effective on the middle of the day with only low levels of drying in the mornings and evenings. Temperatures in the dehydrator were shown to peak at around 3pm (*Ennissioui et al., 2023*).

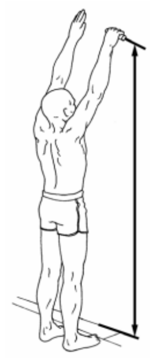
There are several methods that can be used to improve the performance of a solar dehydrator. These include mesh shelves to allow for air circulation, a solar fan or other forced convection method can be added, the drying temperature can be stabilised with the use of additional heat bulbs, and the drying chamber is insulated and painted black to absorb heat. The dehydrator could also be set up in a high up place such as a rooftop for more efficient energy consumption.

# User Research

The final designed outcome will be operated by volunteers. This factor has been taken into consideration during the design process to ensure the product is fully usable and easy to understand. Because there will not be one final user of the designed outcome, the sizing needs to consider a wide range of anthropometric data, so it can be usable by all people. To do this, we have considered the 5th to 95th percentile range of data for men and women. The anthropometric data considered was the hand size for any components the user would need to grip, height and vertical grip reach to work out the maximum height of the design, and the functional grip reach to ensure all components are easily reachable *(NC State University, 2006)*.

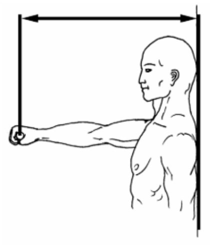



Another consideration when designing for this user group is the manual handling. This system will be used in a workplace environment which means official guidance should be referenced to keep the volunteers safe and to avoid injuries. The HSE guidance *(HSE, 2020)* suggests methods to avoid manual handling injuries including considering mechanisation. The lifting and lowering risk filter show where the risk of injury would be considered to be low. In the



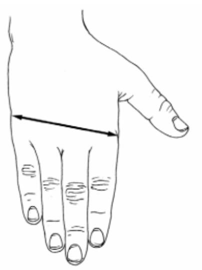
Vertical Grip Reach:

Female:
$5^{th}$ percentile = 180.83cm
$50^{th}$ percentile = 194.50cm
$95^{th}$ percentile = 209.44cm
Male:
$5^{th}$ percentile = 195.84cm
$50^{th}$ percentile = 210.59cm
$95^{th}$ percentile = 226.04cm



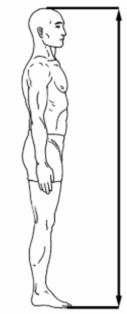
Functional Grip Reach:

Female:
$5^{th}$ percentile = 63.19cm
$50^{th}$ percentile = 68.51cm
$95^{th}$ percentile = 74.36cm
Male:
$5^{th}$ percentile = 69.28cm
$50^{th}$ percentile = 74.95cm
$95^{th}$ percentile = 81.31cm



Hand Breadth:

Female:
$5^{th}$ percentile = 7.34cm
$50^{th}$ percentile = 7.93cm
$95^{th}$ percentile = 8.56cm
Male:
$5^{th}$ percentile = 8.36cm
$50^{th}$ percentile = 9.03cm
$95^{th}$ percentile = 9.76cm



Stature:

Female:
$5^{th}$ percentile = 152.78cm
$50^{th}$ percentile = 162.72cm
$95^{th}$ percentile = 173.73cm
Male:
$5^{th}$ percentile = 164.69cm
$50^{th}$ percentile = 175.49cm
$95^{th}$ percentile = 186.65cm

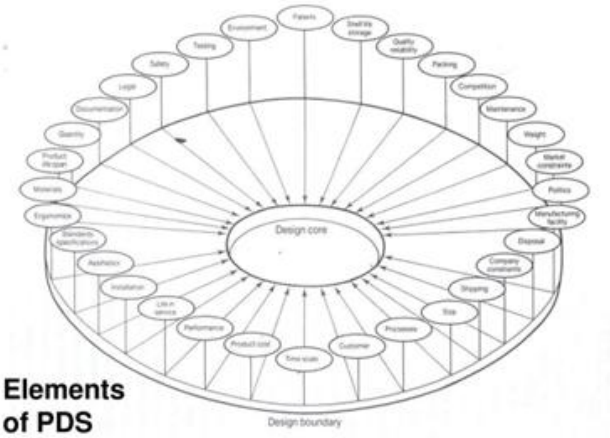
designed outcome, the weight of components involved in lifting and lowering will be below the limits, shown below in the diagram, so that a risk assessment does not need to be completed.

## Product Design Specification

The full Product Design Specification can be seen in *Appendix*

Before the group progressed with work in stage 2 of the report, firstly the PDS would be changed. Since the first version of the PDS back in stage 1, many changes have been made; more is now known about the project direction, more details about the product functionality have been discovered, and client meetings have informed the group on what their needs are.

The PDS has been updated to reflect these changes in knowledge and direction about the whole report. This revised version of the PDS will then be used to inform design decisions at key stages of development process. If the product has been designed to meet the needs of the client, informed through reflection to the PDS during the design process, then ultimately the final outcome should be a product that fulfils the identified needs of Eat Sleep Ride CIC.




Elements of PDS

## DfX (Design for X)

Design for X (Dfx) is a method which is used to make sure the system we design is not only functional but is also practical, safe and well suited to the environment it will be used in and to the users. The "X" stands for different areas that can be focused on like manufacturing, safety, weatherproofing and sustainability. In this project, Dfx was used to guide decisions during concept development and test ideas which would suit the conditions at Eat Sleep Ride CIC.

## Design for Manufacture, Assembly and Maintenance

The system has been designed to be constructed and maintained by the staff at Eat Sleep Ride CIC using basic hand tools. There are no powered systems in the design and the functionality relies on physical operations which makes the build simple and durable.

- Materials are standard, off the shelf items that can be sourced from places like B&Q keeping sourcing simple and costs low.
- The system design is modular with sectioned parts that can be assembled and repaired independently.
- All fixings used are common sizes and require basic tools like screwdrivers and wrenches.
- Features like pre-drilled holes and guides for alignment can be used to reduce errors in assembly.
- A manual which would include a parts list, diagrams for assembly with a checklist for upkeep.
- Access to hinges should be simple so they can be well maintained without needing to disassemble.

- Regular tasks like cleaning the trays and checking joints should be quick and require zero technical knowledge.

## Design for Safety

Safety is essential for the horse manure drying and briquette forming system and should focus on keeping the operators safe. Danielle's team work within an equine therapy environment and need a system that is safe to use and won't introduce risks that could interfere with daily tasks.

- Sharp edges are removed or covered to remove risk of cuts.

- Ensure safe handling of manure, with the proper PPE, proper briquette forming procedures and drying processes are followed

- Ensuring compliance with safety regulations is met. (ISO, OSHA, CE)

- Clearly labelling what buttons do with bright colours to reinforce correct handling procedures.

- Routine inspections should be conducted.

- Personnel will require proper training on the operation of the system.

## Design for weatherproofing

Eat Sleep Ride CIC is located in Lamberton, East Berwickshire. This location is exposed to rain, wind and winds from the coast. The system must be able to function and survive in such conditions without the need of heavy maintenance.

- Materials like treated timber and weatherproof coating on metals should be chosen which have corrosion and moisture resistance.

- Sloped surfaces should be used to reduce water pooling and components should be kept off the ground to avoid water seeping up through the soil.

- Any vents and storage solutions should use covers and lip joints to protect the inside.

- Moving parts are enclosed or treated to avoid rust from the salty coastal air.
- Modular construction would let parts to be moved or covered during winter months.
- A way to anchor the system to the ground to prevent movement from high winds.

## Design for Usability

The client's team has limited time due to other daily tasks that need to be done as well as little technical background. The system needs to be intuitive and fast to learn without disrupting their workflow.

- Manual levels and physical interfaces are preferred over digital and powered mechanisms.
- All steps should be clear with minimal setup and decision making.
- Working heights should be considered to reduce physical strain.
- Instructions should be clear and straightforward to be easy to follow.
- Loading and unloading the system with manure should be possible with gloves and PPE on.

    Design for Sustainability

    Sustainability is one of the main goals of the clients like reducing emissions, from there site as well as removing the need of unnecessary waste transportation. The system should work in multiple ways to support these goals.

    - All parts in the system can be reused with no materials being single use or having to be disposed at the end.
    - Materials can be sourced locally, and recyclable materials are prioritised to reduce carbon footprint.
    - Constructing and operating the system creates no secondary waste.

## PESTLE Analysis

There are external factors to consider that could influence how successful a manure to biofuel system is and the method it gets implemented. A PESTLE analysis can be used here to investigate the key areas: Political, Economic, Social, Technological, Legal and Environmental to ensure the design we create works well in real world situations on site and fits within the organisation's needs.

**Political Factors (Government policy and regulations)**

Biofuel systems can be directly influenced by environmental regulations and policies made for the public. The UK government provides strong political support for projects with aims to reduce carbon emission and to improve sustainability which are goals of Eat Sleep Ride CIC aim for but right now the client has limited access to funding and schemes. There is also rules in place from local councils to consider the type of system that can be installed and its location. These factors were considered when choosing a simple, low impact system that wouldn't need major planning permission or infringe into regulations.

**Economic Factors (Costs, funding, and financial viability)**

The project came to light due to the high cost of removing manure from site. Regular transport was done using tractors and trailers, but this created ongoing expenses. We designed a system which can stay on site and it self-contained and can offer savings in the long term. Here rises an issue as the client has a limited budget so funding a full-scale build wouldn't be possible. These points influenced the direction of the project to shift towards a design solution that could be built locally by the cline which would be affordable. The system would include detailed plans and a material list to make construction simple.

**Social Factors (Public perception, community and stakeholder impact)**

Eat Sleep Ride CIC is an organisation that is community based who work closely with the public and especially young people. A system that improves sustainability would be able to enhance the organisations reputation and could be used as an educational opportunity for the people involved. The project would also support social engagements between the university, the client and students involved in a collaborative design process. These points do align with the organisations values and can help strengthen its stage in the local community.

**Technological Factors (Available tools, systems and technical items)**

The site has no access to complex infrastructure or high energy outputs, so the design had to avoid industrial biofuel technology. We instead aimed to focus the project on a low-tech, passive system that worked off solar drying and manual briquette pressing. Such a system would be easier to build and maintain for the client and work well within the clients existing setup. This system is also an improvement of the clients last attempt which failed due to drying issues, which was a key lesson for the direction of the project.

**Legal Factors (Health, safety and compliance requirements)**

Handling manure does come with legal responsibilities around health and safety. The design reduces direct contact with waste and makes sure staff use PPE to stay safe as they would be using the system daily. The current setup is small scale, but expanding in the future could involve new regulations needing like planning permissions and safety certifications to be investigated. The design has taken this into account and ensures future compliance doesn’t hinder the system at this stage.

**Environmental Factors (Climate impact, sustainability and local conditions)**

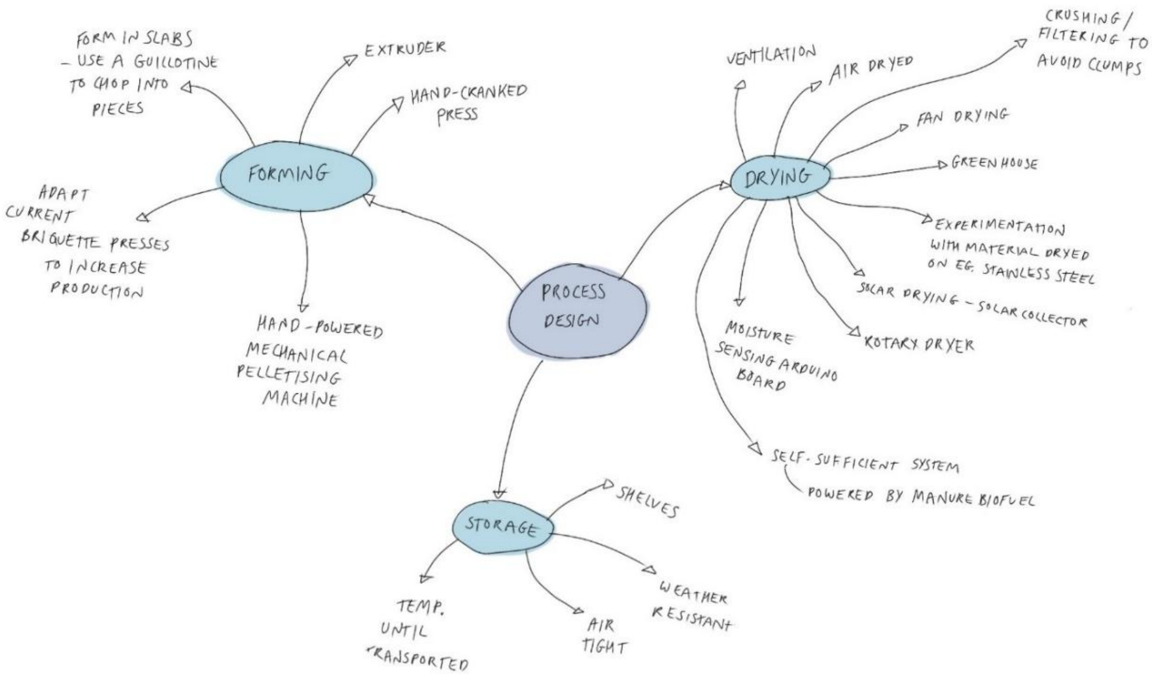
Environmental sustainability is essential to this project. By choosing to process manure on site instead of transporting it, we are already lowering carbon emissions. The system also supports a circular approach by turning waste into usable energy. With the area having frequent rainfall and the low sun in the winter seasons meant the system had to be adjustable and modular to combat these conditions.

# Project Exploration

## Concept Generation:

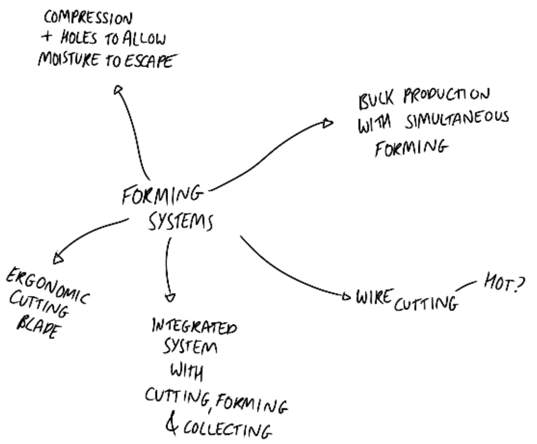
Before beginning concept generation, mind maps were produced to establish a foundation for sketching and ideas.

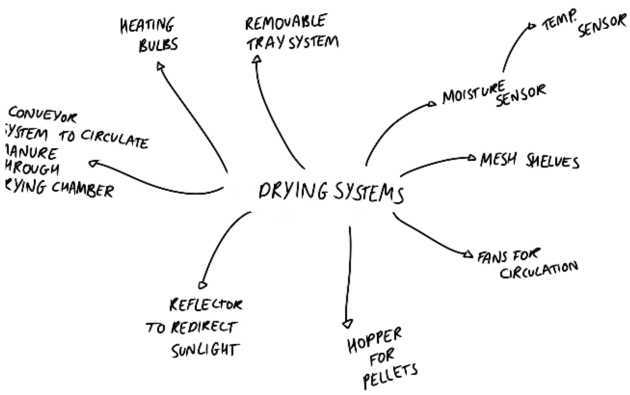
Initial Brainstorming:




The first mind map was made for identifying the fundamentals of the processes of forming and drying the manure as well as a baseline to establish appropriate storage later in the project. This mind map helped to establish the basic ideas of the forming and drying processes to carry forward into concept generation.

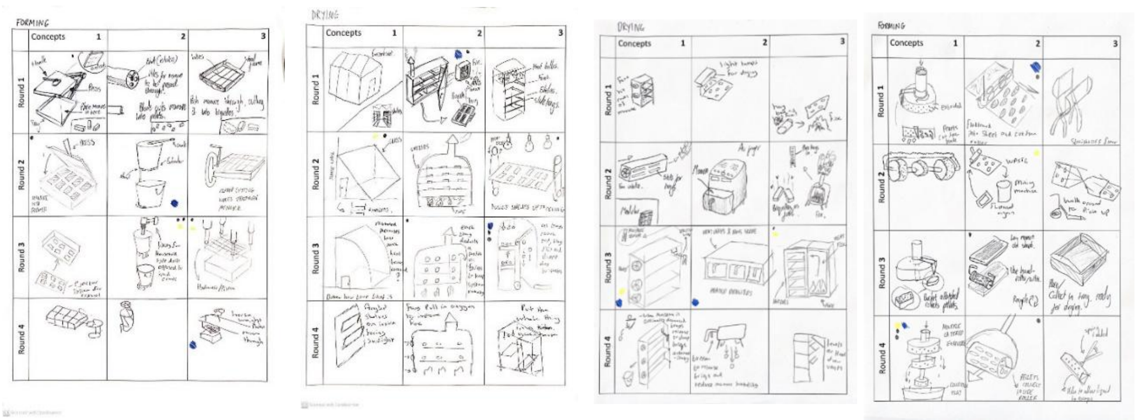
Idea brainstorming:



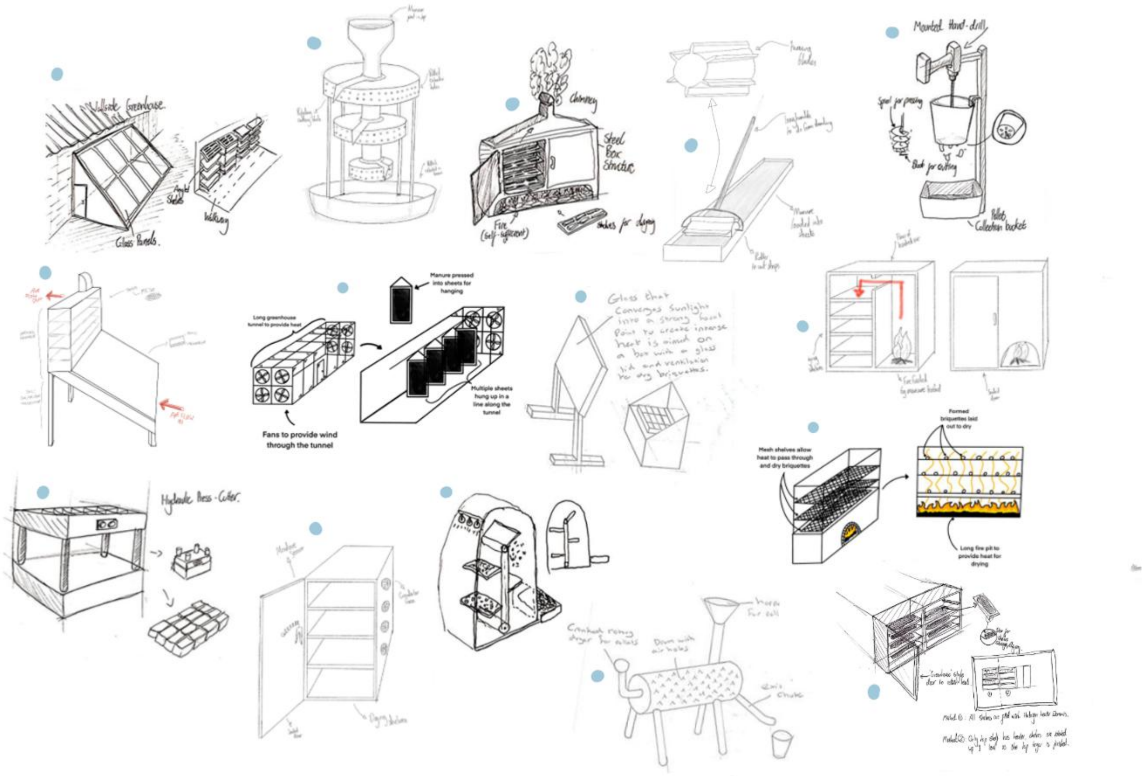




The second round of mind maps looked at possible ways the processes could be achieved and possible features to assist both the client and the features in achieving a desired outcome. These mind maps were often reflected and looked at when designing concepts to try and foster ideas in concept generation.

6-3-5:



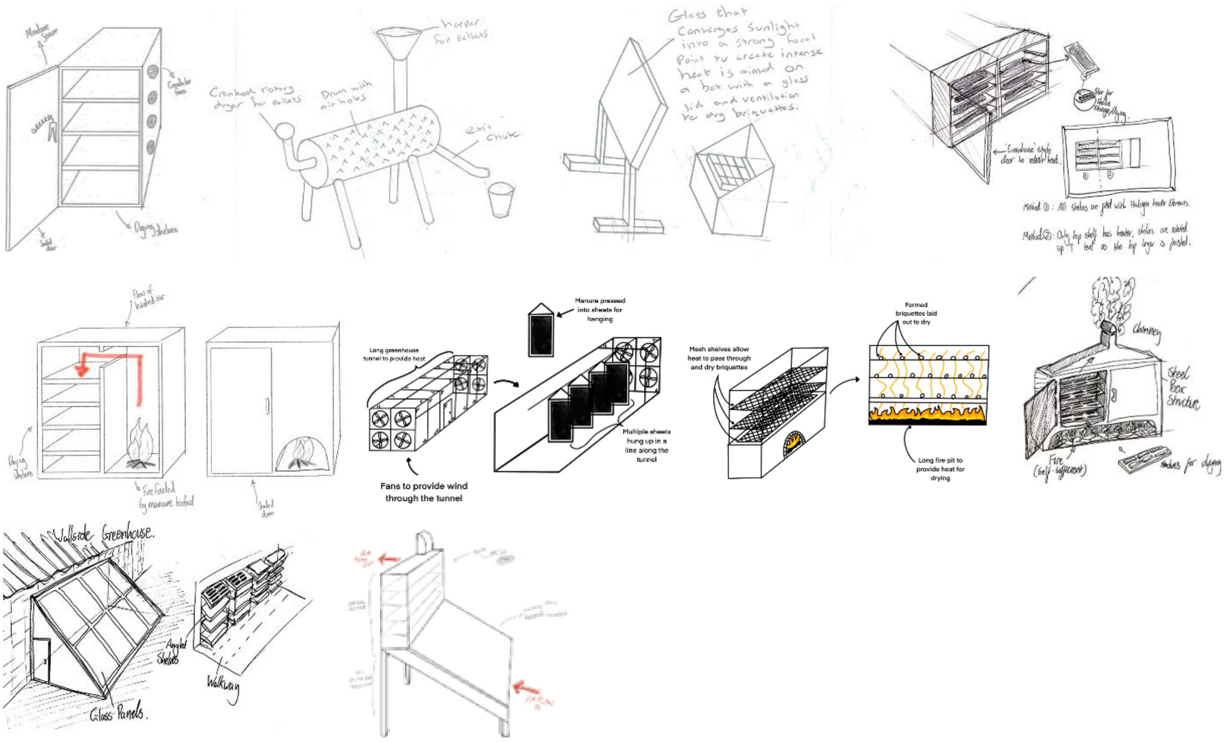
The group used 6-3-5 as a concept generation method which was a fast and efficient method for producing a large number of creative and diverse concepts.



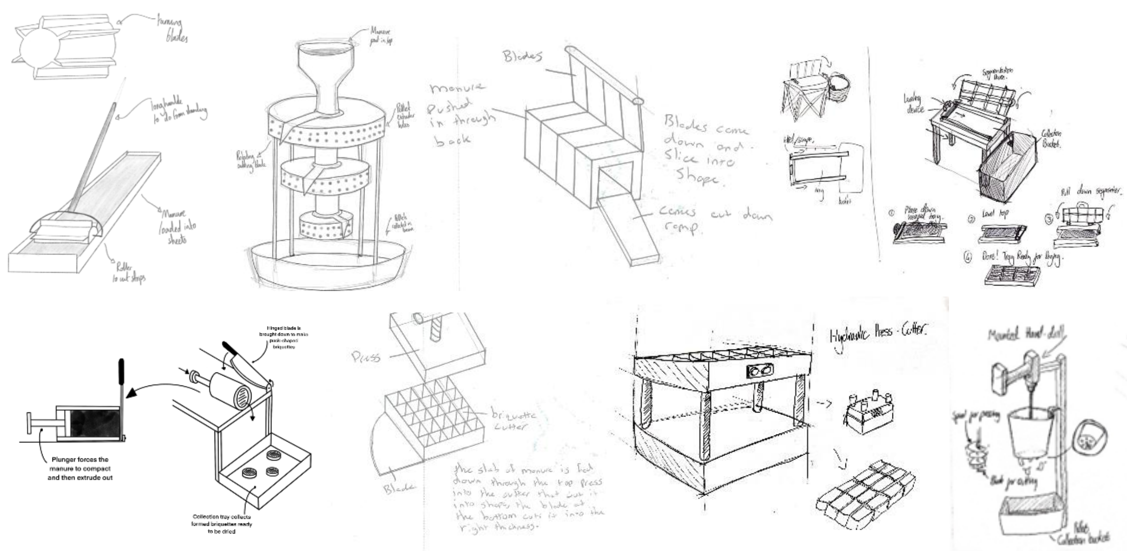

Following on from the concept generation, each team member selected eight drying concepts and eight forming concepts that they thought could be taken forward through dot-sticking. The concepts that were chosen by each team member were marked with a different colour dot. The selected concepts were spread quite evenly between the sheets, so each team member drew up the concepts from two sheets. Only concepts with at least two votes were taken forward to help focus down the development process.

Concepts taken forward from 6-3-5:

Drying Concepts:




Forming Concepts:



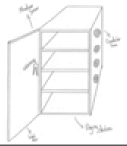
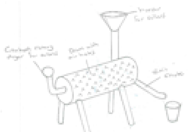
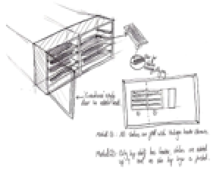
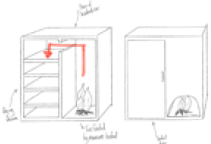
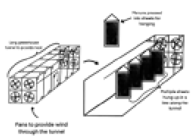
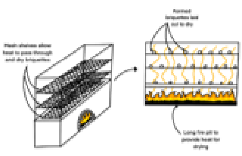
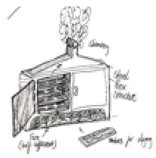
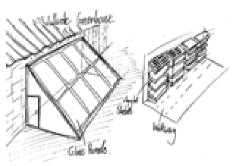
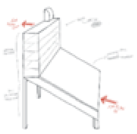
# Concept Evaluation

With a large pool of concepts generated, the chosen concept for forming and drying then had to be narrowed down effectively using various methods. This proved to be valuable as not only did it bring the group closer to identifying the strongest concept but narrowing it down also gave the client a smaller sample size to select from and provide feedback for which saved time during concept development.

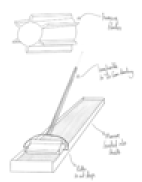
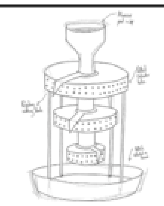
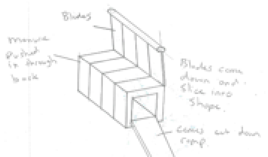
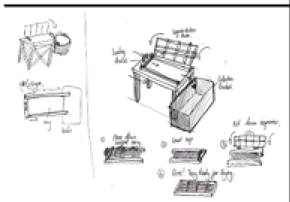
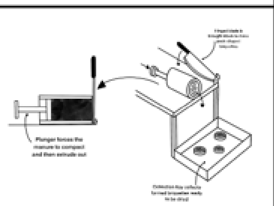
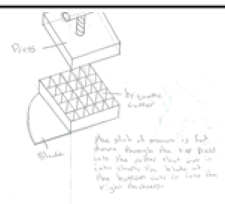
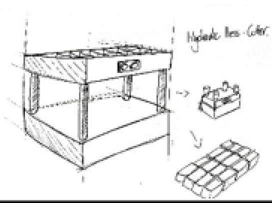
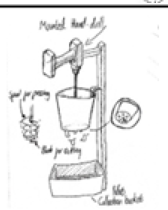
## Positive Minus Interesting Evaluation:

For the first round of evaluation, the concepts were added into a Positive Minus Interesting (PMI) table. During a group meeting the tables were discussed and filled in by the group members to establish not only what the immediately apparent strengths and weaknesses of each concept would be but also what was interesting about those specific ideas. This process of analysis helped the group to establish what concepts were already showing the most potential for development but also identified interesting features/processes that could be taken forward with concept development. It also served as the group's first round of evaluation and eliminated the weakest concept ready for further and more in depth analysis and evaluation.

Forming Concept PMI:

| Concept | Positive | Minus | Interesting |
|---|---|---|---|
|  | I like how the design is a box meaning you can easily stack multiple if you wanted to expand. | Maintenance could be an issue, like replacing fans and wear on the seal from the door.<br>No notable power source. | The sensor being able to accurately measure the moisture at any given time. |
|  | The hopper allowing uninterrupted use of the machine lessening the need to refill as often. | Being hand cranked can cause fatigue for the user for prolonged amounts of time.<br>Can be noisy. | Constant turning brings a high amount of air flow effectively drying the product. |
|  | Fast drying can occur depending on the sun's strength. | Having to move the sun visor to follow the sun throughout the day would get annoying.<br>A sun focal point can produce major safety risks if not calibrated properly | An out of the box utilisation of solar energy for drying |
|  | Large trays allow a high volume of manure to be processed.<br>Double heating – bulbs and greenhouse material – should be efficient in drying. | Trays may be too hot to touch, therefore unsafe for users without protective equipment.<br>Large doors would let out most of the heat if opened frequently, negatively affecting the drying process. | The dual drying effect is interesting – could be applied to other concepts to maximise efficiency. |
|  | Self-sufficient system minimises the amount of excess biofuel that is produced | Use of fire poses potential safety risks especially with the farm being open to the public | As heat rises, it would need to be considered how well the bottom layers get any of the heat |
|  | Wind and solar powered design align with client's sustainability needs | Wind through a "greenhouse" may cause the heat to escape/prevent it from heating | A conveyer like system allows for the possibility for continuous drying of sheets. |
|  | Self – sufficient method, using some of the produced biofuel to fuel the fire. | Fire hazards – may be difficult to manage, likely needing a person constantly on standby.<br>One input in the middle of fire pit could be difficult to get an even fuel spread | Reusing some of the produced manure to fuel the system is a good idea, aligning with the client's self-sufficiency goals. |
|  | Sturdy construction means it can withstand high winds and harsher weathers. | Open fire is a hazard, especially during warm and dry times. | The heat generated can have multiple uses, like if placed near a house it would transfer through the walls. |
|  | Fully utilising solar energy for heating – very environmentally friendly | Greenhouse would cause moisture to remain trapped without ventilation<br>Not using extra energy, such as from solar panels on site, is less efficient. | The sloped angle can allow for rain collection which could be used elsewhere on the site. |
|  | Method has been tested and shown to be effective.<br>Uses solar energy | Without modification, it can be difficult to dry in wet weather conditions | Various modifications can be made to improve drying |

Drying Concept PMI:

| Concept | Positive | Minus | Interesting |
|---|---|---|---|
|  | Minimal equipment required which would make it easy to use, store and maintain | Unlikely to create even briquettes and with this technique it would be difficult to compress the moisture out of the manure | Forming process can be done from a standing position which means more force can be used to cut the briquettes |
|  | This concept would allow for quite a large volume of pellets to be made in a small amount of time.<br>Extrusion allows for controlled production. | May require a lot of electricity or a large of amount of manual power to operate effectively. | The tiered system increases volume of production without any extra space needed. |
|  | Simple design, very user friendly and gets the job done | Less efficient as a continuous process than other concepts for large batches | Its design isn't limited by location |
|  | Quick and easy way to make briquettes. | Manual work may be tiring for users to do repetitively if there is a large volume to process.<br>Lifting the bucket at the end may be difficult | The manual method may be more suitable to the client's budget compared to more advanced alternatives. |
|  | Allows for various thicknesses of briquettes to be produced depending on user needs | Manual operation means the client may find difficulty repeating the process if they need many briquettes of a standard size.<br>One point for the hinge with a long blade may cause said blade to bend/flex . | It's a natural motion using a kitchen knife so it won't be awkward to use. |
|  | A large number of briquettes can be created at one time. | The pressures needed to compress a large slab would not be suitable for hand pressing. | The design can be incorporated into line production effectively. |
|  | It would be a quick and powerful method of forming briquettes. | Using hydraulics would require a large amount of power.<br>Expensive parts and running costs when compared to other methods/concepts | The shape of the former would create multiple briquettes in an efficient method. |
|  | Low use of energy, just need to charge the battery pack of the drill – possibly using solar power on site. | Could be quite loud.<br>The blade may revolve too quickly for intended pellet size.<br>Spinning blade may flick pellets everywhere. | Utilizing tools that may be on site anyway is an interesting idea, requiring less spending. |

Reflections:

The PMI analysis proved to be a useful stepping stone for further development and evaluation. As these concepts were still early, while still detailed enough to show how the concepts worked, the PMI tables were able to effectively narrow them down with group discussion - choosing 5 from each.

With 5 concepts from each being chosen, the evaluation of concepts was reduced from 18 to 10, nearly reducing the concepts that need further evaluation by half. These 10 concepts were then redrawn with more detail to further understand the concepts making the next round of evaluation more in depth as opposed to simple “positive” “negative” points.

The decisions made for which concepts were being taken forward were done as a group, where everyone was in agreement about the strongest concepts they were taken forward and where there was disagreement in what concepts were strongest, the group members with opposing ideas then had to make a case for the concept they thought should be carried forward with the other group members weighing in with their thoughts on the concepts. This then allowed for more detailed reasoning about some of the other concepts and instead of creating negative environments with disagreements instead allowed for every member to be included in the decision-making process with the concepts. It also ensured that the concepts taken forward were ones that were the absolute strongest ones to take forward in turn making the final chosen concepts the strongest from generation.

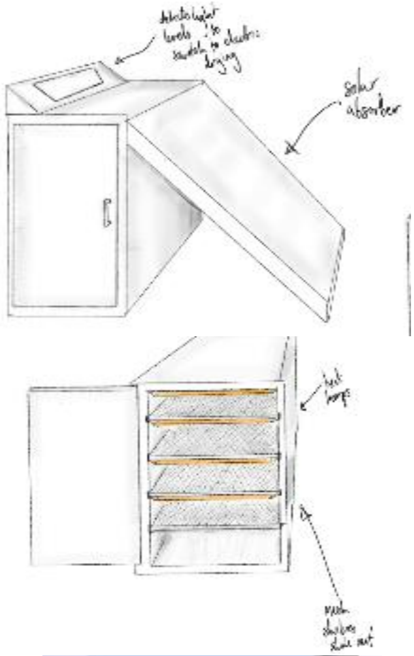
# Concept Development

After completing the PMI analysis of each concept, the next step was to narrow down the concepts for both the Drying and Forming part of the project. The decision of which concepts to progress was made together as a group during a meeting to ensure everyone was heard, and able to give their opinions, based on what everyone thought would be the best concepts to meet the needs of the client. The PMI table was a very useful tool in objectively deciding which concepts had potential for being successful in solving the identified user needs, and which concepts could be ruled out for various reasons, e.g. impractical to manufacture, unsafe, and noise pollution etc.

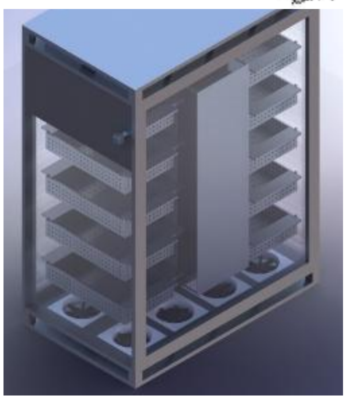
The selected concepts, 5 for each drying and forming, were then passed though separate rating tables for each. This method was chosen to allow a holistic and mostly objective way of comparing the concepts, eliminating any bias that the team members may have over their own concepts, again with the goal in mind of meeting the client's needs.

The criteria used for comparing the drying concepts were Drying Efficiency, Ease of Use, Energy Efficiency, Drying Volume, Ease of Manufacture, Maintenance, Cost, Safety, Durability, Weatherproof, and Drying Systems. These factors were selected as the most important factors in terms of the concept's functionality, both for the client's needs, and based on the location and conditions of the site. The PDS was also referred to as means of informing these decisions.

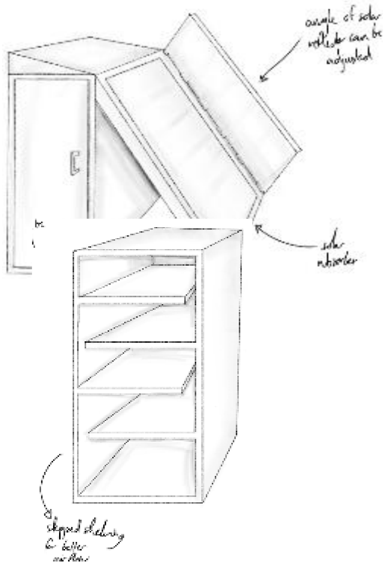
**Concept A:** This concept is a large container of individual shelves that contain briquettes, designed with integration with the forming concepts in mind, allowing easy integration between the two. Heat is generated by a large solar cell on the side of the product, which heats air, which is then used to dry out the briquettes. It also uses low-light activated sensors to switch on heat lamps for better drying.



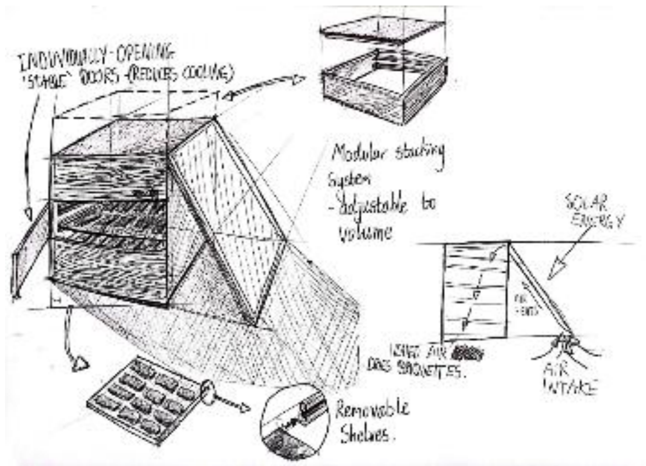
**Concept B**: Shelves are filled with briquettes, the are loaded from a door at the top, and rotated around the container whilst being dried from fans at the bottom of the product.



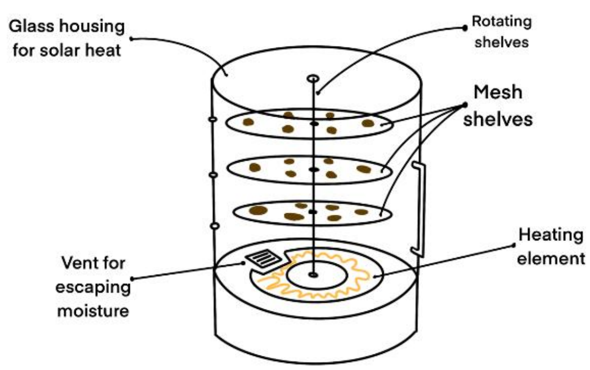
**Concept C**: Similar to concept A, this concept includes a path between shelves to allow for efficient airflow. The solar cell is also different here, having a secondary fold-out reflector panel that is able to be angularly adjusted to gain maximum solar exposure by reflecting light onto the solar cell.



**Concept D**: Again, similar to concept A, this product is different due to the modular design. The product size can be changed based on the client's needs, adapting to hold more or less manure, through additional layers.




**Concept E**: This concept includes rotating drying shelves for manure to be placed on, within a cylindrical glass container. Mesh shelves allow for hot air to effectively dry the manure.



| Criteria | A | B | Justification | C | Justification | D | Justification | E | |
|---|---|---|---|---|---|---|---|---|---|
| Drying Efficiency | D | = | Heaters would have consistent drying results; a fan can have better results in warm weather | - | This concept will only produce results when there is enough light | - | This concept doesn't have any additional features to supplement solar drying | = | Has a heating element for consistent drying |
| Ease of Use | | - | The rotational system adds a little extra user work | - | The solar reflector has to be manually adjusted | + | Modular system and removable shelves increase ease of use | = | Shelves slot into place for ease of use |
| Energy Efficiency | A | - | Motors and fans have to be constantly running | + | This concept does not require electricity | + | This concept does not require electricity | = | Uses a heating element which would require a power source |
| Drying Volume | | = | Both have a scalable volume of shelves/ trays | = | They both have a scalable volume of shelves | + | The modular design means more shelves can be added as necessary | - | The glass exterior would only be suitable for smaller scale manufacture |
| Ease of Manufacture | T | - | More electronic components and moving parts are harder to manufacture | + | This does not require any wiring as there are no electronics | = | Similar level of complexity as datum | - | It would be challenging to manufacture a cylindrical glass casing |
| Maintenance | | - | Moving parts will be more difficult for a user to fix themselves | + | There are no electronic components that would need replacing | + | Modular design means part can be replaced instead of whole system | = | The heating element would require replacing |
| Cost | U | - | More electronic components and mechanical parts will increase cost | + | It is made of relatively low-cost materials | + | Does not require any high-cost parts | - | The glass casing would be expensive to manufacture |
| Safety | | + | Unlikely to be less safe than the heat lamps in the datum | + | It has no features which could be unsafe | + | It has no features which could be unsafe | - | The combination of the glass and heating element could cause issues |
| Durability | M | = | Fans will have to be replaced similarly to the bulbs in the datum | + | No electronics means all features of this concept will be long-lasting | + | No electronics means all features of this concept will be long-lasting | - | The glass could be damaged and difficult to fix |
| Weatherproof | | = | Both concepts are comparable due to electronic components | + | This has no features which would be affected by weather/ an outdoor set up | + | This has no features which would be affected by weather/ an outdoor set up | = | The heating element is protected by exterior casing |
| **Total** | **0** | **-4** | | **5** | | **7** | | **-5** | |

**Reflections:**

Rating the concepts in a screening matrix was a useful activity to see how well each would perform against a range of criteria. The results that the matrix produced need to be critically considered to avoid any of the concepts being eliminated despite having strengths that could be utilised in the final design.

The concept that was rated the best in the screening matrix was a modular solar dehydrator. This design would suit the client in terms of its ease of use, its inexpensive manufacture and low running costs. However, it was given a poor score in terms of drying efficiency. The drying efficiency is the most important feature and the rating of each concept in this category should be considered first. The higher total score of the modular concept comes from its comparatively simple design as there are no additional features to manufacture or maintain. The modular features would be beneficial but when taking this concept forward the drying efficiency would need to be improved.

With a total of 5 points, the solar dehydrator with adjustable solar reflector was rated second best overall. Similarly to the first concept, its high score comes from a lack of additional features to be manufactured or maintained but it also does not perform well in terms of drying efficiency. The solar reflector may increase drying results to some degree, but it would need to be regularly manually adjusted to be effective.

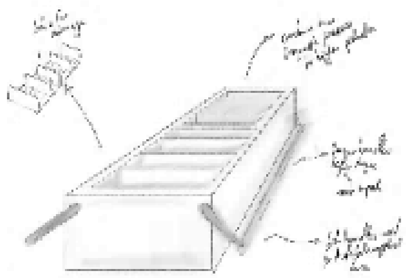
The datum concept would most likely perform the best in terms of drying efficiency as the heat lamps guarantee drying even at nighttime or in cloudy weather conditions. However, the drying capabilities come at the cost of high-power consumption, more regular maintenance, and reduced durability which is why it has performed more poorly than other concepts in this screening matrix.

The concept given the lowest score is a drying system with a rotational conveyor belt and intake and outtake fans. This design is the most mechanical out of all the concepts which is why it has performed the worst in the screening matrix. It requires moving parts and a constant power supply which would give it high running costs as well as an expensive manufacturing process. These moving parts make it less durable and likely more difficult to maintain than other concepts. This concept has been highly rated in terms of drying efficiency but would need to be tested to fully understand its capabilities.

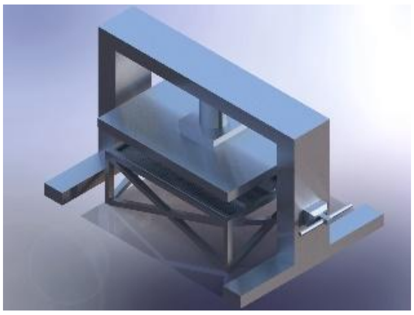
Overall, this matrix shows that a compromise between drying efficiency and designing a low-cost product with minimal upkeep needs to be found. These concepts may need to be combined to find the correct compromise.

The criteria used for comparing the forming concepts were; Ease of Use, Volume, Efficiency, Manual Labour, Ease of Manufacture, Quality of Outcome, Maintenance, Cost, Safety, Weatherproof, and Durability. Again, these criteria were selected based on what was learned from the client during meetings with the group. Choosing concepts to progress based on scoring highly against these criteria will enable a product to be made that is effective in meeting the client needs.

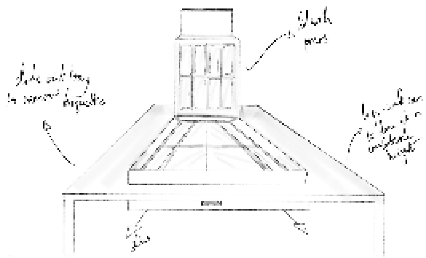
**Concept A**: This is a length-modified version of an existing product. Manure is filled in to each container/pocket. The handles clamp down and compact the manure into briquettes.



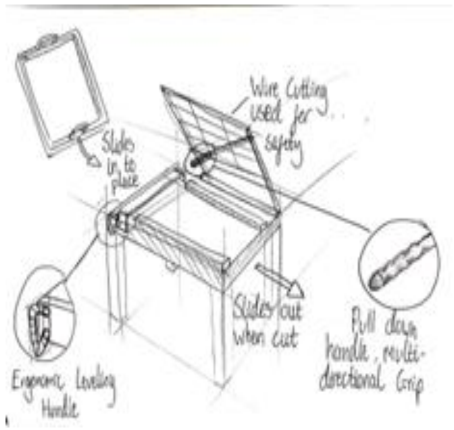
**Concept B:** This is a large-scale pressing and forming device that uses a manually wound lever at the side to press down and compact many briquettes at a time.



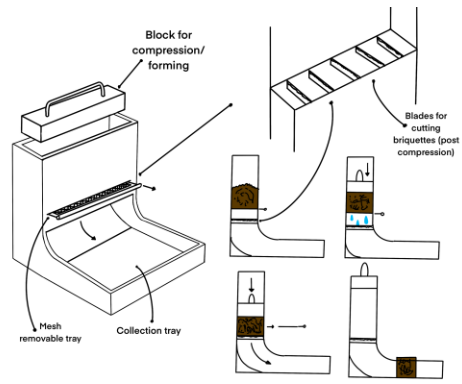
**Concept C:** This table with a leverage based cutting system allows for manure to be placed in the centre, which is then cut into formed briquettes. The 'floor' of the table is then removed with the formed briquettes on it like a shelf, ready to be dried.



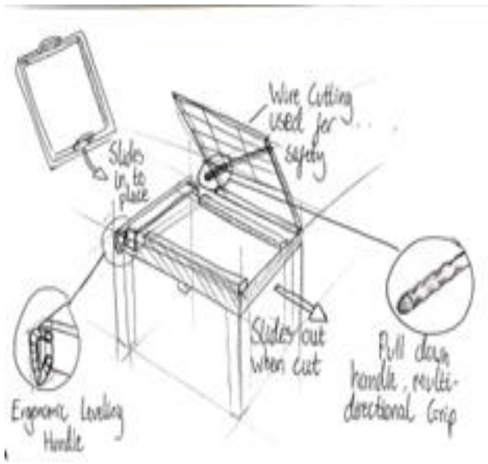
**Concept D:** This concept acts as an all-in-one tabletop system that integrates with the drying shelves to optimise the whole process. Shelves are slid into the centre guides, which also act as levelling parts, followed by a similar pressing action as concept C.



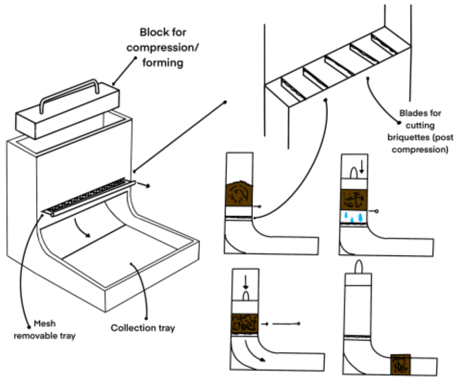

**Concept E**: This concept allows for manure to be loaded in to the top, which is manually compressed down, a solid tray is then slid away which exposes the blades, allowing the manure to be pushed down further, cutting it into briquettes.



**Concept D:** This concept acts as an all-in-one tabletop system that integrates with the drying shelves to optimise the whole process. Shelves are slid into the centre guides, which also act as levelling parts, followed by a similar pressing action as concept C.




**Concept E**: This concept allows for manure to be loaded in to the top, which is manually compressed down, a solid tray is then slid away which exposes the blades, allowing the manure to be pushed down further, cutting it into briquettes.



| **Forming** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Criteria** | **A** | B | **Justification** | C | **Justification** | D | **Justification** | E | **Justification** |
| Ease of Use | D | + | More mechanisms in place help the user, making the job easier | = | Similar scale and effort as datum | + | Simple & intuitive process | + | Briquettes fall straight through so are easier to pick up |
| Volume | | + | A larger machine has the capacity to process more material at a time | = | Different layout but the same as datum | + | Larger batches, suitable for transfer to drying concept(s) | = | Can produce six briquettes |
| Efficiency | A | + | Larger batches are more efficient | + | Easier to load and unload manure/briquette s | + | Larger volume in similar time is more efficient | + | The forming process has a more efficient flow and structure |
| Manual Labour | | - | The manure still needs to be transported into the machine to be compacted, and handles need to be turned | + | Tray underneath allows briquettes to be easily collected | - | More steps are slightly more complicated; filling, levelling, cutting, removing | - | Briquettes would need forming and cutting which would require more force to complete |
| Ease of Manu-facture | T | - | Large, technical, and heavy | - | More technical parts such as hinges | - | Much more moving parts are more complicated to build | - | It has more moving parts, the blades would also make manufacture more complex. |
| Quality of Outcome | | + | More precise briquettes, higher pressure. | + | More precise cutting and forming from compression and wires | + | More precise briquettes, forming and cutting, ready for transfer | + | The briquettes would be more precise |
| Main-tenance | U | - | Technical nature of product requires advanced technician & more expensive parts | = | Same number of moving parts, relatively simple | - | More moving parts are worse for maintenance | - | Blades may need sharpening as they will go blunt over time |
| Cost | | - | Materials, scale, parts will be more expensive | - | Larger scale, more materials used | - | More parts and material types, complexity | - | There will be more materials and parts involved which will increase cost |
| Safety | M | - | Higher forces and limb-crushing potential hazards | - | Cutting is more dangerous than compression | - | Cutting is more dangerous, possible risk to user(s) | - | Sharp blades decrease the overall safety |
| Durability | | + | Higher quality build, tougher materials | - | Hinges could seize up, moving parts | - | Moving parts, hinges etc could have faults | = | There are no small parts and materials will be durable |
| Weatherproof | | + | Metal will resist rain, winds etc. | = | Similar overall, possible rusting | = | Same as datum, materials will cope with rain and wind. | = | Materials will be weatherproof |
| **Total** | **0** | **1** | | **-1** | | **-2** | | -2 | |

**Reflections**

The matrix was again a useful evaluation tool for the forming concepts. The factors of the criteria were chosen carefully in order to analyse each concept in respect of what the group had decided on being most important. The criteria were informed through research and from client meetings, understanding what was most important to both the user. This process should result in producing concepts that meet the client needs.

Although scoring just 1 point, the first concept does have some potential and useful ideas that could be taken forward or combined in detailed design of other concepts, such as mechanisms. This concept scored poorly in the matrix because of its overall complexity and scale. It is quite an industrial concept that would be highly effective; however, it doesn't meet the requirements for feasibility, cost, safety, and manufacture that would is required by the client. The use of mechanical parts could be successful, but on a smaller scale, allowing the design to benefit from the assistance provided to the user, without costing too much for the client.

The second of the concept scored lower than the datum, with -1 points. It improved on the datum with qualities such as efficiency and the quality of the outcome, utilising precise mechanisms to more accurately form and cut the briquettes. The drawbacks of this design in comparison to the datum were factors such as the moving parts, which would be more expensive, more difficult to manufacture, and would require more maintenance. The overall score doesn't tell the whole story, and the group actually did like this concept, agreeing that although more difficult/expensive that the datum, it was still feasible and therefore should still be considered. This analysis as well as looking at the score is important to use intuition and design understanding in the context of the project to make the correct decisions and not to discard concepts because of matrix scoring.

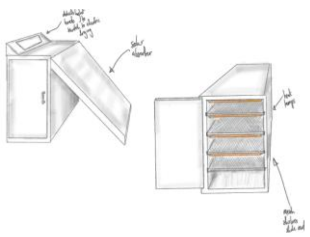
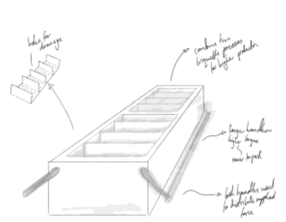
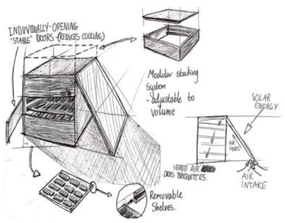
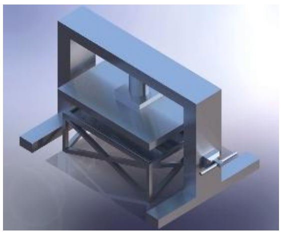
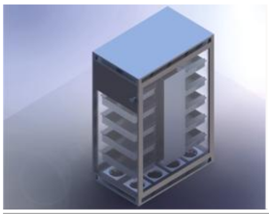
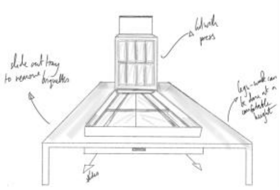
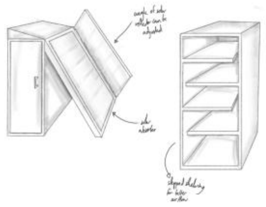
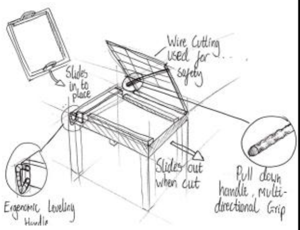
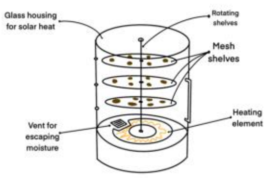
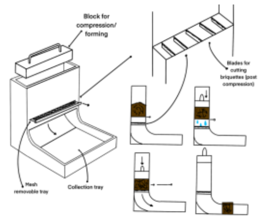
The third concept scored the worst of the 3 concepts that were evaluated against the datum, with -2 points. Much like concept 2, this concept lost points to the datum due to the overall complexity of the design, however it was still considered by the group to be feasible in its current state, unlike the first concept. The potential issue with this design is the reliance on manual labour, which would have to be sufficient to the demand of volume from the drying design. The user would also have to be trainer on how to use the concept and given safety briefings, however it should be quite intuitive. One of the main benefits of this concept, not scored on this matrix, was the fact that the holder of briquettes also becomes the shelf for the drying section of the process. This is something that would be beneficial to be implemented on any concept going forward, streamlining the whole process.

Overall, the scoring was very close between the concepts, showing both benefits and negatives of each of the concepts, informing the detailed design process going forwards, redesigning and combining concepts to take the best parts of each concept, creating the best possible concept from these 4. As previously mentioned, at the discretion of the group, designs can still be taken forwards despite not scoring highly within the matrix if they still offer potential.

Both groups of concepts, forming and drying, will also be presented to the client in a meeting in order to get feedback and insight into if they like the concepts, if they don’t like any, possibly leading to valuable information being gained that couldn’t come from a matrix.

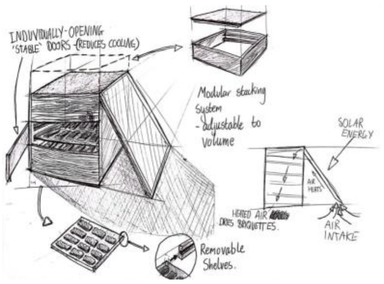
## Client Feedback:

We met with the client to further discuss our final concepts. The feedback gained from this meeting was invaluable to the outcome of the project and allowed us to focus on developing a system which would meet expectations. The feedback has been expressed in a table as seen below.

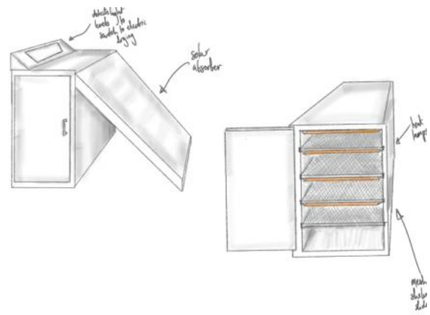
| Drying Concept: | Feedback: | Forming Concept: | Feedback: |
|---|---|---|---|
|  | The client has experience with infrared heaters and has recently removed them because of the amount of energy they consume. The idea of having a self-sufficient solar dehydrator was interesting though. |  | This is similar to the existing solution which was a simple technique that even kids could do but it was a lot of work to mix the manure with water and load into the press. It might be slightly more successful if it was a more robust material |
|   | This would fit well in the current location, based on size and has good durability. Also, likes the idea of being able to start small and seeing if it works, then scaling |  | Really likes how this would be less labour intensive because of the pressing technique and the more robust material choice. Uses Innovative technology but again this causes issues with the cost to manufacture |
|  | Really likes the innovation in this design but cost and technology would be an issue. |  | The mechanism where the briquettes fall into a container for transporting makes sense. Would be useful for taking to the drying system and would mean less contamination |
|  | Has the same positive aspects as the other solar dehydrators because it doesn't require a power source |   | There is a good connection between the forming and drying process which makes the whole system easier for volunteers to run. The size would also be good for storage in the 1.5m^2 hut currently there. |
|   | Likes how this design looks but glass is a definite no because of the severity of storms they experience. It is also a risk around the children and horses |   | Likes how this design looks but glass is a definite no because of the severity of storms they experience. It is also a risk around the children and horses |

Conclusions:

From the meeting, we were able to establish the most suitable concepts for the project. For the drying component of the system design, the most favoured design was a modular dehydrator. This was because it does not require any external power source which means there would not be the issue of laying down new power cables. The modular factor was seen as a positive because it will allow the process to be tested on a smaller scale first and then expanded. Because of this, we continued to use the idea of a modular design going forward through the finalisation of the design process. In terms of aesthetics this design was also successful because the wood panelling is in line with the material used across the farm. For the forming system, the most successful designs were those which fully considered the process flow of forming the briquettes. These deigns included a forming design where briquettes slide through a system once formed and another where briquettes are formed directly on a tray so they can be placed straight into the dryer. They also included positive aspects which will were taken forward including the ability to shovel the manure straight in and ensuring the design is compact enough to fit into an existing shed on site.



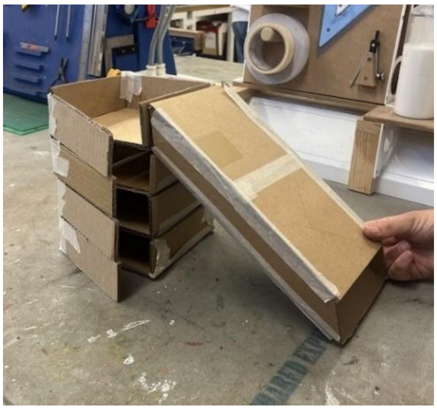

| Drying Concept: | Feedback: | Forming Concept: | Feedback: |
|---|---|---|---|
| | The client has experience with infrared heaters and has recently removed them because of the amount of energy they consume. The idea of having a self-sufficient solar dehydrator was interesting though. | | This is similar to the existing solution which was a simple technique that even kids could do but it was a lot of work to mix the manure with water and load into the press. It might be slightly more successful if it was a more robust material |
| | This would fit well in the current location, based on size and has good durability. Also, likes the idea of being able to start small and seeing if it works, then scaling | | Really likes how this would be less labour intensive because of the pressing technique and the more robust material choice. Uses Innovative technology but again this causes issues with the cost to manufacture |
| | Really likes the innovation in this design but cost and technology would be an issue. | | The mechanism where the briquettes fall into a container for transporting makes sense. Would be useful for taking to the drying system and would mean less contamination |
| | Has the same positive aspects as the other solar dehydrators because it doesn't require a power source | | There is a good connection between the forming and drying process which makes the whole system easier for volunteers to run. The size would also be good for storage in the 1.5m^2 hut currently there. |
| | Likes how this design looks but glass is a definite no because of the severity of storms they experience. It is also a risk around the children and horses | | Likes how this design looks but glass is a definite no because of the severity of storms they experience. It is also a risk around the children and horses |



# Prototyping Developments:

## Initial Prototypes:

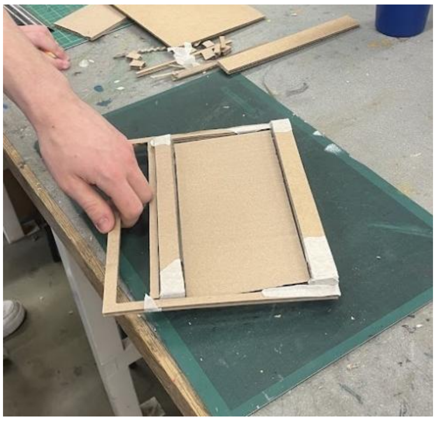
The group decided to build some physical prototypes to better understand the concepts, in order to better inform both the detailed design phase of the project, and gain understanding of their functionality through basic testing.

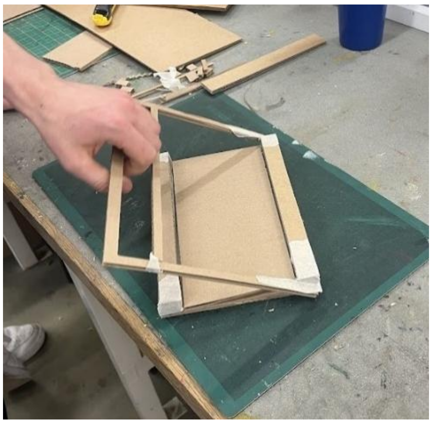


The first prototype/sketch model mase was of the drying system. The modular design concept was investigated, using different doors for different sections. This model allowed the team to realise that the multiple-door design was inefficient and overcomplex. This lead to the redesign of the door(s), to have a larger main door, and individual sections within the main body of the device to allow for different closed off sections – making airdrop more effective.

The next prototype made was of one of the final two forming concepts. By prototyping this concept it was easier to understand how it would be manufactured and assembled as well as get a better understanding of user interaction due to the manual pressing of the manure to form the briquettes. This helped the team to realise that as simple as the concept was, it wouldn't be ideal for bigger batches of briquette production as larger versions would be harder to manage and operate for a single user.

The final of the two forming concepts that was investigated using sketch models was the tabletop design – in particular the cutting/forming/pressing mechanism. Making the model informed the layout of different components as to not collide when pressing down. Additionally, the hinged design was refined. The overall concept of manually pressing to form the briquettes was rethought after seeing the real model. It was decided that it would be very labour-intensive to do this repetitively, and that a different mechanism should be considered. There would also be issues regarding the force from the user and strength of the part – with the leverage applied, this would be a weak part of the product, so the team decided to redesign it. The changes would involve





# CAD Developments

Forming Concept Development 1

To continue with development, we used insights from the final client meeting and prototyping to create a CAD model. This design had consisted of a tray which would be slid into slots of varying heights so that the client could have some customisation on briquette height, the tray would then be slid back out and taken onto the other side which had the same slots to be pressed. The press which was flat would squeeze excess water moisture out and create a slab. The cutting mechanism was yet to be added here as this iteration was focusing on function.

From this model we could visualise what the concept would look like and it allowed us to question some functional problems. Firstly, it was pointed out that when a tray was slid in on the top rail for example, it would break the mesh when pressed as there wasn't anything supporting it from the bottom. Secondly, the team decided on removing the legs to create a smaller frame of the design as we wanted to keep it as simple and usable for the client so they would just secure it to their own table they had available on site. The handle was threaded and would twist to push the press down to squeeze out the excess but the width of the supporting beams holding the press up was questioned as to if it could withstand the pressure of pressing down. The third thing we thought could be improved on was the unnecessary action of needing to pull the tray out and take it to the other side to press, so we decided on removing this part and changed the method of moving the tray. We then discussed these points to be changed and took these iterations into secondary CAD development.

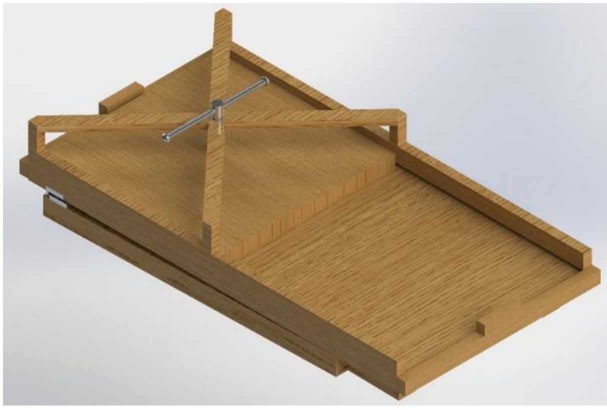
Forming Concept Development 2

Below you can see the changes mentioned before being implemented, now there is only one slot that the tray slides into and it goes all the way across so the client can take it out from any end they like. The beams supporting the press had been made thicker and side doors were added so the tray could have something to hold against while extra manure was being scraped of and to also help align it with the press. This development stage was then taken to the client where we had a vital piece of feedback in that the client would prefer legs combined with the forming system instead of having to attack it to a table as this meant everything was kept together for easier storage and that no parts would end up missing. We also added a scraper that is sitting on top against the press ready to remove excess manure off the top.

Forming Concept Development 3

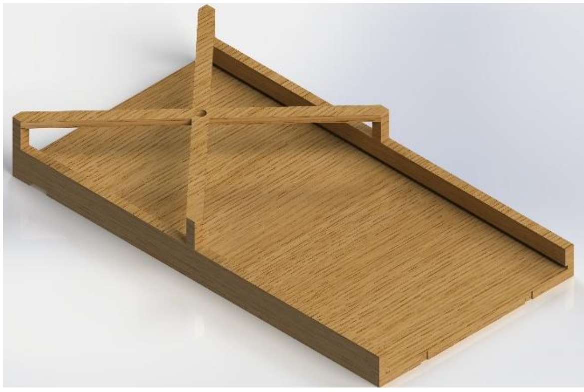
The 3rd concept's changes had involved reinstating legs which could hinge down and compact the system for better storage, as well as a handle on the doors to make it easier to open and close. Below is also a set of visual explanations for better understanding of how the system works alongside each component.

Here is the full system with all the changes, one in the opened view ready to use and one in the closed position ready to store away.



Here is the underside of the closed

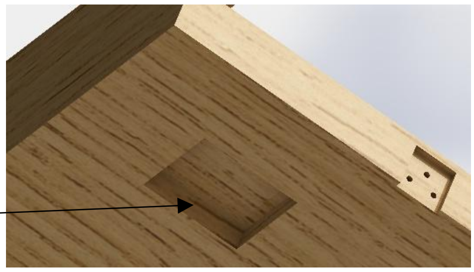
The base is the piece which houses the trays. There is now a single slot that it slides down through both sides. There are holes which are drilled in and cutouts made on the bottom side to show where the hinges would go. The hinges can be any standard component you want to use as long as its durable and for outdoor use. The hinges on the side doors must ensure the door shuts flat to keep the tray in the proper position. The beams come up from the base on one half and meet at a middle point where it will have a threaded hole for the pin and plate to move along.



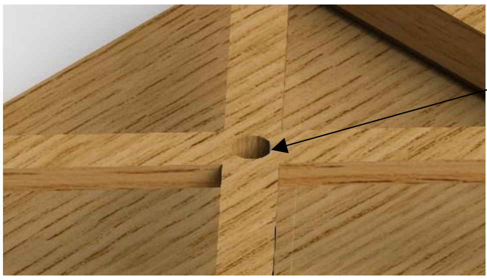
Slot for Tray

Side Door Hinge

Bottom Hinge Slot



Support beams for press



Threaded Hole

The cutting plate and pin would need to be fabricated for the correct size of briquette. Here you can see how the cutter functions; it has a pin which is attached to the cutting base and runs on a thread. This piece is known as the pin and plate which gets threaded into the hole of the base. A handle is inserted in the hole of the pin which allows the user to turn it to move the press up and down. The material is a wooden exterior with an aluminium frame on the interior.

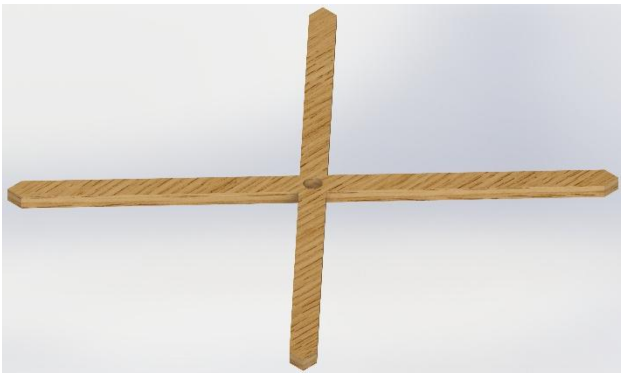
Now that the base has been explained on its function, the construction of this part can be talked through. There are different pieces shown below and an exploded of how they assemble to make construction easier. The Base bottom goes first, then the two side walls are joined, then the support beams are joined and final the cross beam on top.


Base bottom

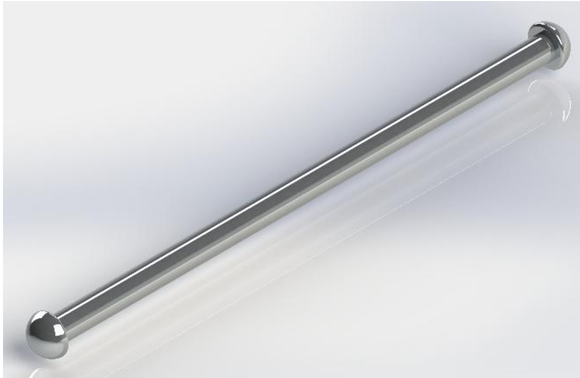
Support Beams

Side walls

Cross Beam

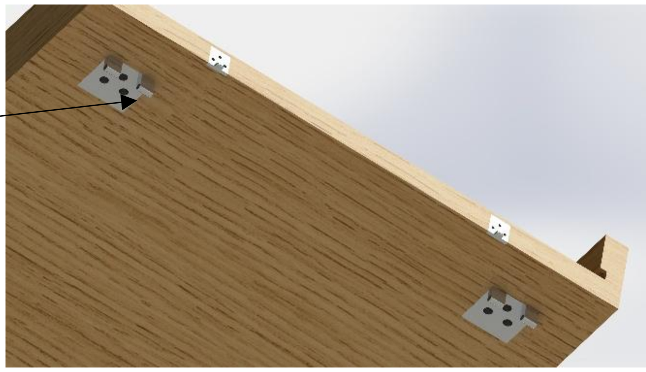


The handle fits in the hole of the pin and plate section and is shown as a separate component. The handle can be purchased as a standard component or fabricated. This will slot into the pin and plate and be welded in place.

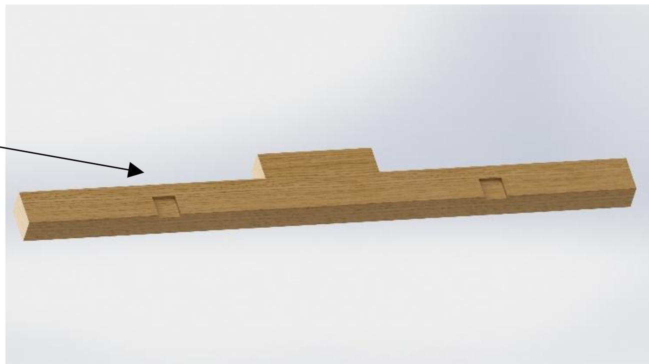


Here you can see how the side hinge looks when it is connected to the base, which then connect the side doors (the same is on the other side).

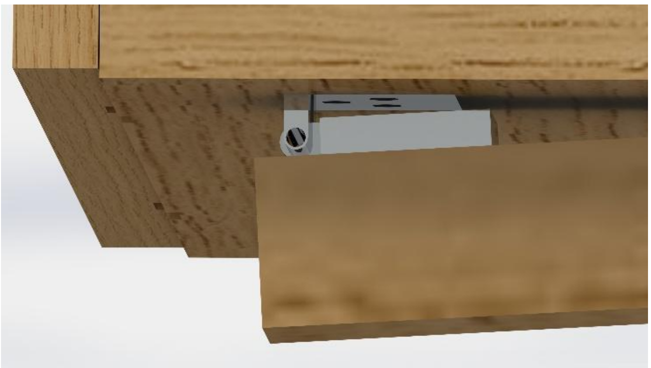
Here you can see how the hinges connect to the underneath of the base which then connect to the legs.

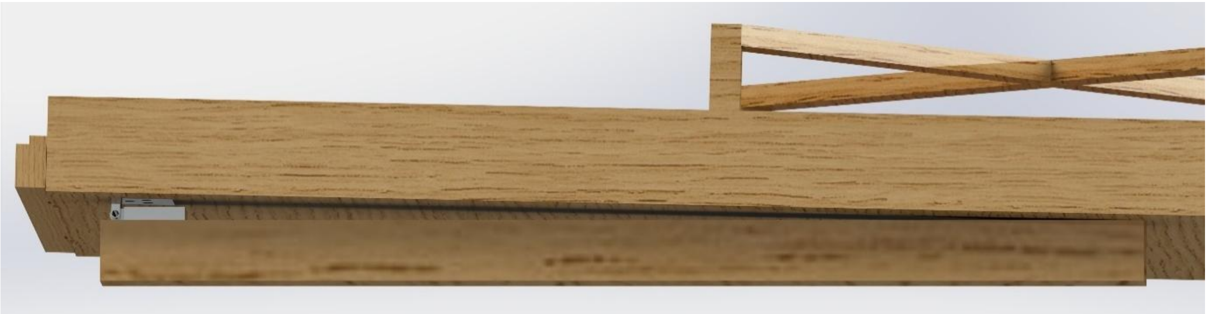


Here you can see the side doors on their own.



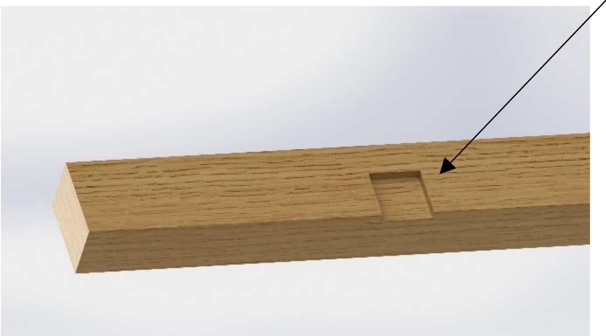
Here is a close up view of the leg hinge attached to the base in the open and close position. It must also be noted that the legs on one side are placed more towards the centre of the bottom of the base so when it closes, they won't collide and will sit flatter.

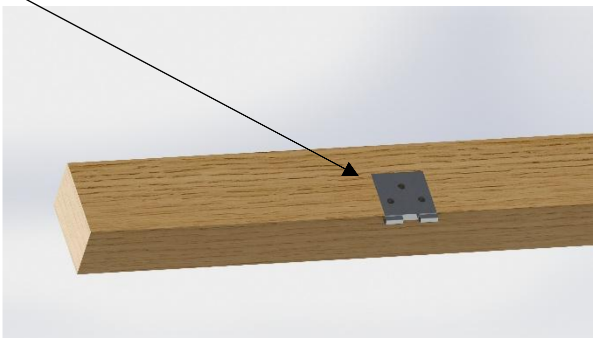


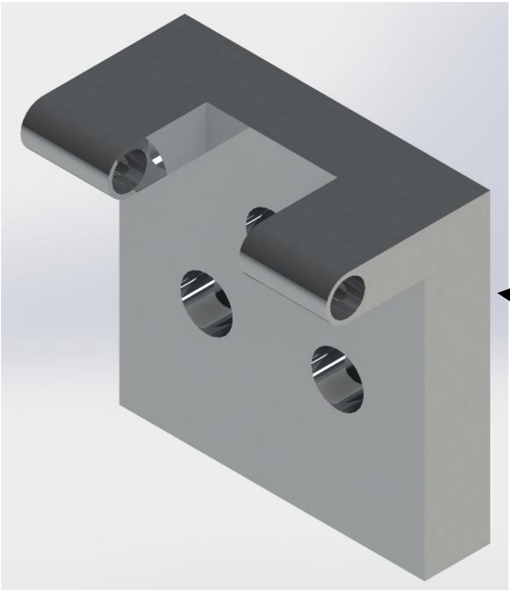


Here are the legs closed showing them sitting next to each other, so they fold tighter.

Here you can see the side doors with hinges attached and without.

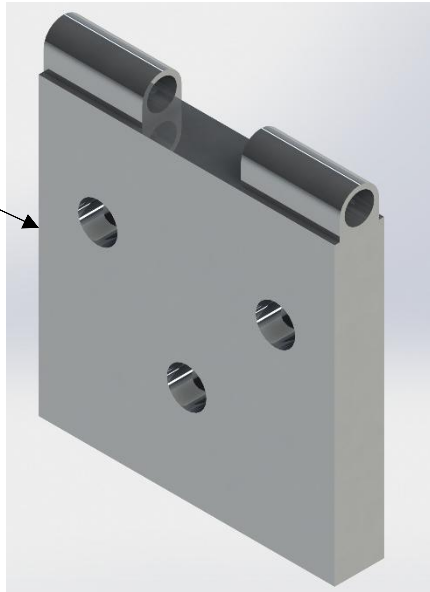




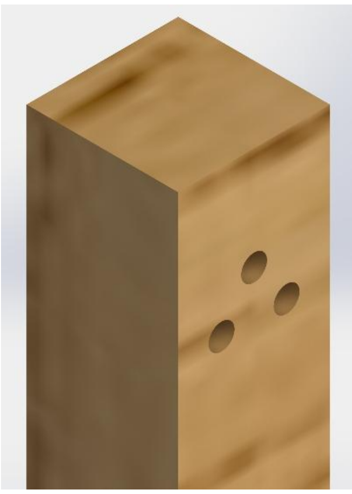


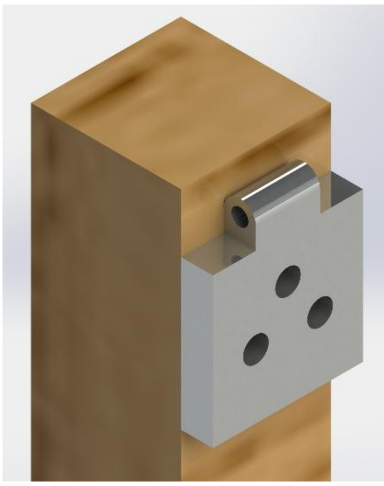
Here is the hinge for the side door.

Here is the hinge that connects to the legs underneath.



Here you will find the leg and a close up of the pilot holes that the hinge screws into. Another image is also shown with the hinge attached to the leg.

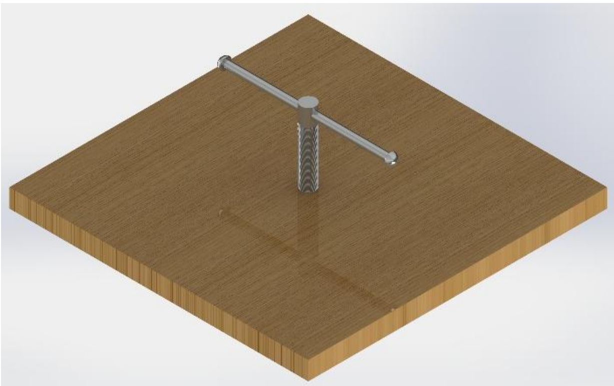


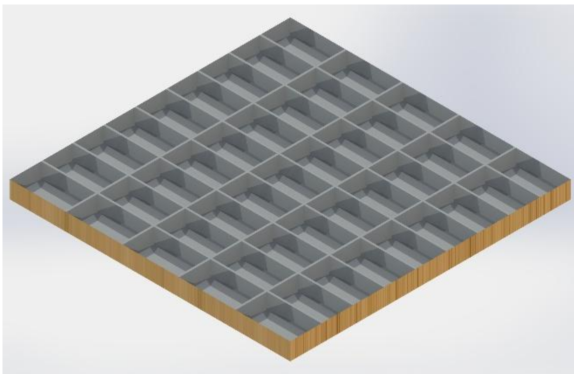


Here is an image of the tray that is used which slots into the press and the drying system.

Here is the scraper which is used to remove excess manure off the tray before it gets pressed.

Here you can see how the press works. It has a section of wood that had been hollowed, and an aluminium frame has been inserted which included the cutters for forming. The threaded pin is attached to the base plate alongside the handle.

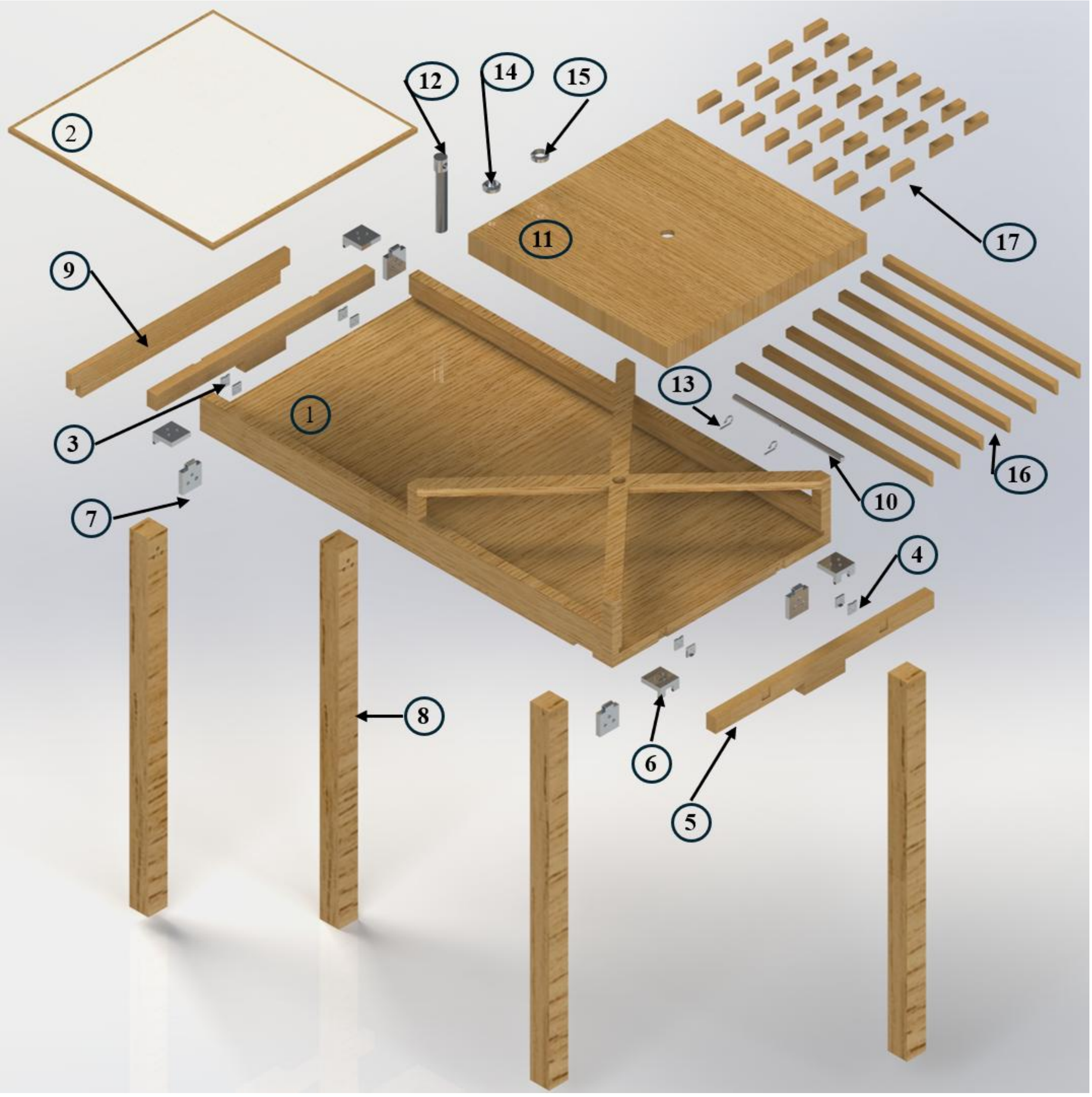




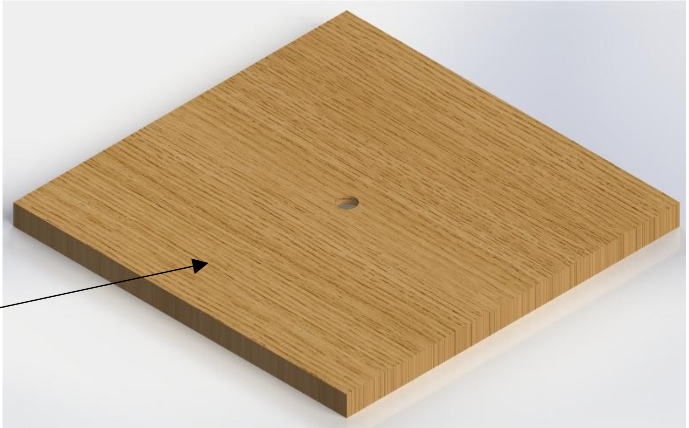
Forming Concept Development 4

Here is an exploded view of all the parts that have been used in the construction of the system alongside a bill of materials to allow better understanding of the next parts. Following will be detailed visuals of each component and design choices made in hopes to make the construction easier to understand

| ITEM NO. | PART NUMBER | QTY. |
|---|---|---|
| 1 | Base | 1 |
| 2 | Tray | 1 |
| 3 | Side Door Hinge | 4 |
| 4 | Side Door Hinge 2 | 4 |
| 5 | Side Door | 2 |
| 6 | Hinge Leg | 4 |
| 7 | Hinge Leg 2 | 4 |
| 8 | Leg | 4 |
| 9 | Scraper | 1 |
| 10 | Handle | 1 |
| 11 | Press Base | 1 |
| 12 | Threaded Pin | 1 |
| 13 | Handle Pin | 1 |
| 14 | Bottom Base Stopper | 1 |
| 15 | Top Base Stopper | 1 |
| 16 | Long Cutting Piece | 7 |
| 17 | Short Cutting Piece | 32 |

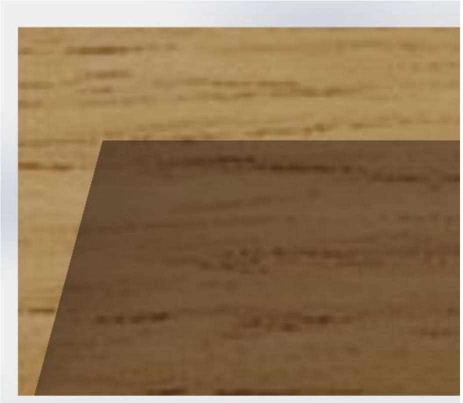


For the fourth development of the forming system, it was uncovered during an in-person team meeting that the press had to be revisited as the construction and fabrication of this part was going to be too advanced if it was metal. We opted to change it all to be wood and the cutting pieces would be inserts that get screwed onto the base. There is also now a hole in the press so the pin can swivel in. There are two stoppers on either side of the pin to allow it to sandwich the press allowing the pin to move up and down moving the press piece as well. The stoppers are components that can be bought online. The handle has been changed to being a rod so that it can slide in with pins that hold it in place.



Here is the new press base plate

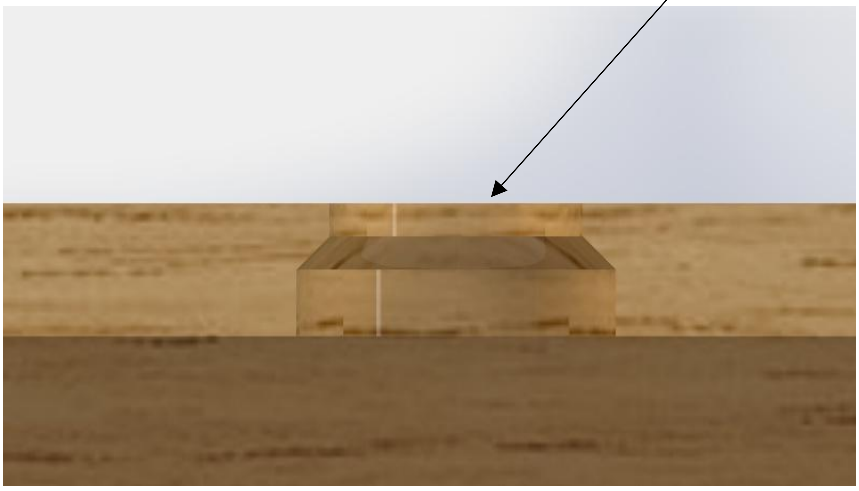
Here you can see a sectioned view where the base plate has been cut in half so you can see how the interior is empty and how the side walls are angled so when it presses down on the briquettes it will form properly.



Draft angle on sides

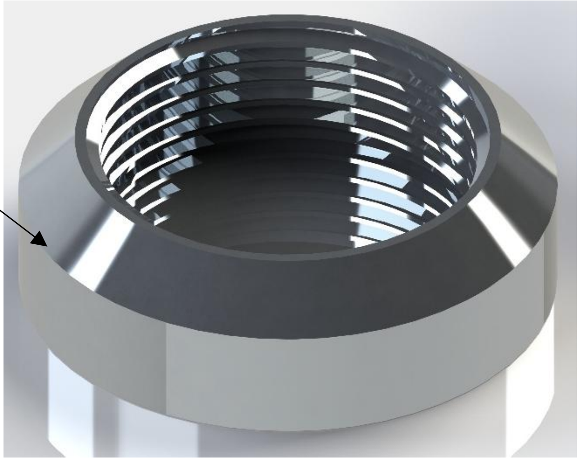
Here you can see again a sectioned view this time of the hole where the new threaded pin will sit and a countersunk section on the underside of the base plate so the bottom stopper sits flush with the base plate.

Countersunk hole so bottom stopper sits flush



Here you can see the threaded pin that goes in the hole of the base plate.

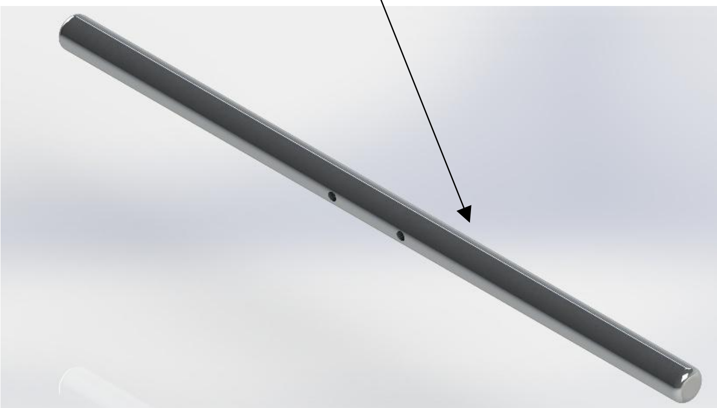
Here you can see the stopper which sits on the bottom side of the threaded pin.

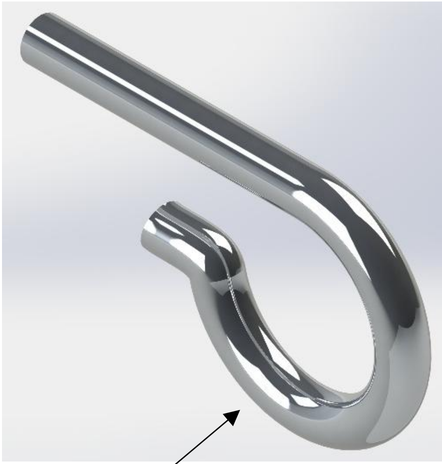


Here you can see the top stopper that sits on top of the base plate on the threaded pin to sandwich the base place.

The mateiral for these parts would be alumium and can be boughtr as standard components later mentioned in the report.

Here you can see the new handle





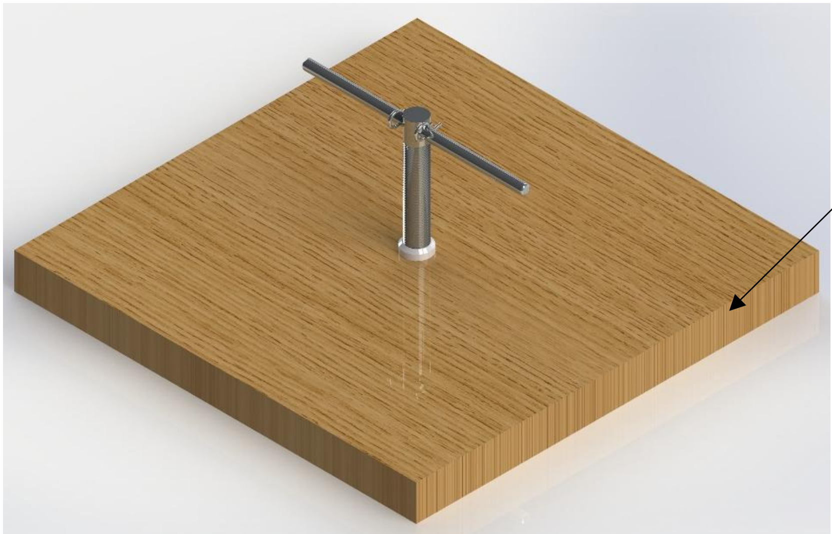
Pin

The next part to look at is the cutting grid for the briquettes, it is made of multiple long pieces of wood that are angled on two sides. There are two different lengths that need to be cut, the longer angles are the same but the angle it is chopped to length is different.

Longer cutter piece

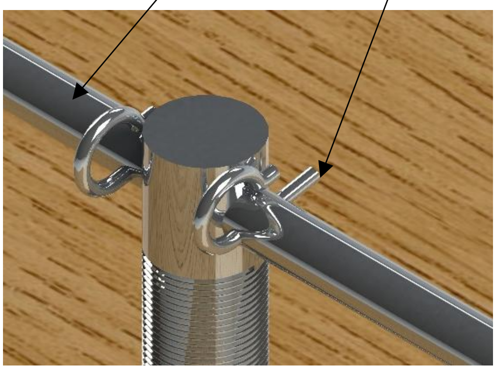
Small cutter piece.

The next images that follow are of the whole press put together from different viewpoints to better understand how it is build.



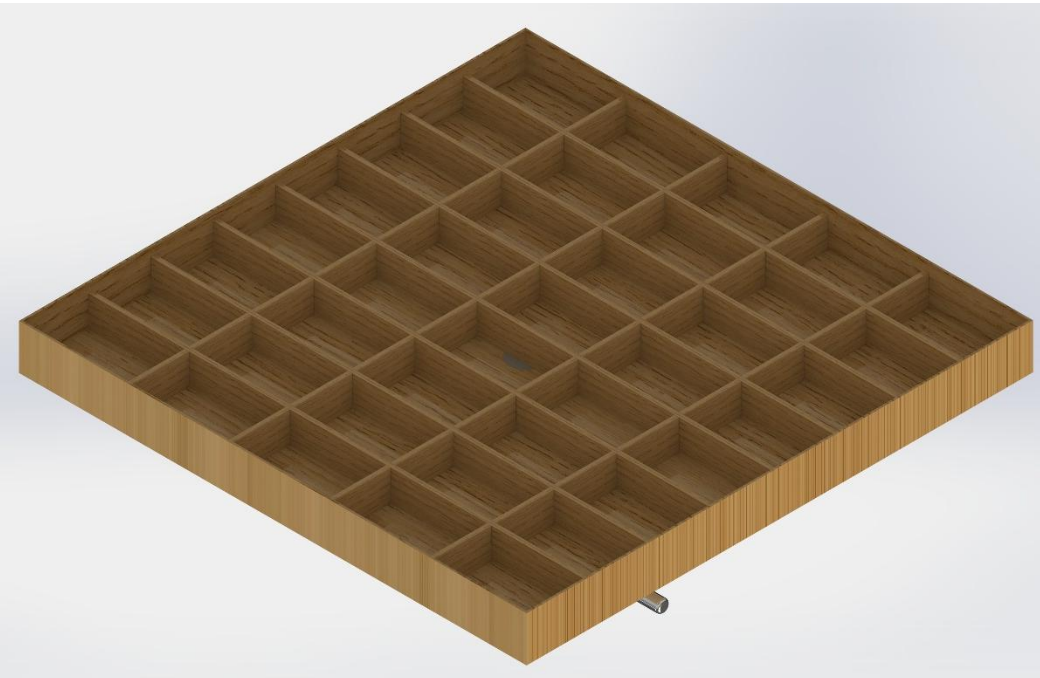
Full view of new press

Bottom Stopper Threaded pin Handle handle pin



Here you can see a cross-section view of how the parts fit together on the press. The thread is inserted into the base plate, then the bottom stopper comes from the bottom and screws on then the top stopper screws in from above then the handle is inserted then pins are put in place.

Here you can see the bottom view of the base plate showing how the cutters are placed in to form the briquettes.



Drawing sheets

There has been drawing sheets made of all the parts mentioned int the forming system to further help with manufacturing, see appendix E. The next section involves how the whole forming system works, going through it step by step.

Step 1: Take the system out from storage and set up the legs and raise the press.

Step 2: Open the first side door and insert a tray then close the door.

Step 3: Add manure and use the scraper to remove any excess.

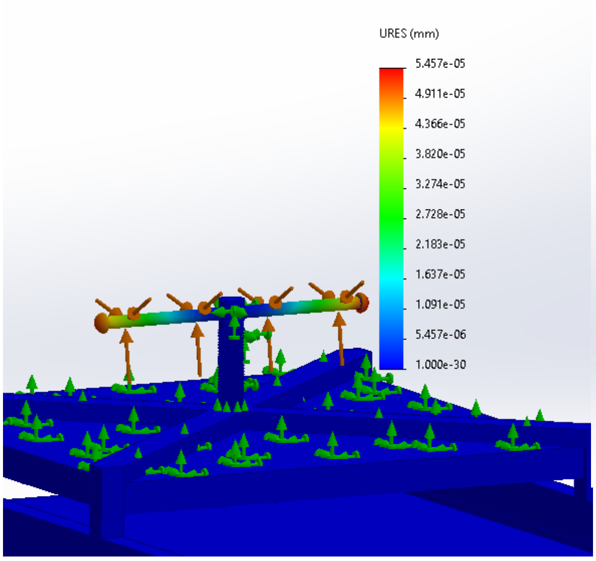
Step 4: Slide the tray over to the press side and use the handle to press down firmly on the manure to form briquettes.

Step:5 Turn the handle again to raise the press and open the door on the press side to slide the tray out fully to then be put in the drying system.

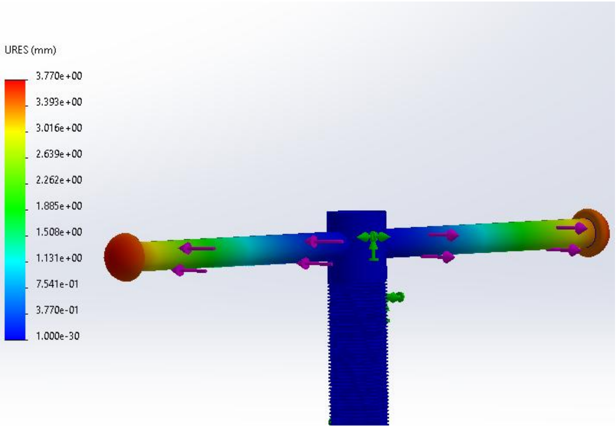
Step 6: Close all the doors, lower the press and collapse the legs when finished and store away.


## FEA

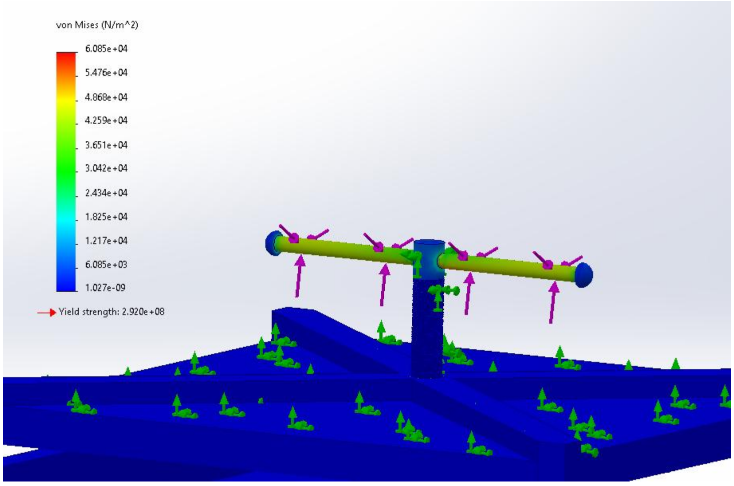
The finalised CAD model allowed for us to do simulated testing on the design, this shows us how much force the handle can take and the pressing system overall.




Force




Torque




Drying Concept Development 1:

The first draft for the CAD model was derived from a detailed sketch of the concept with rough estimations on sizes. The original draft involved air vents at every rack, a dehydrator that went to halfway of the housing unit's height and the airflow carried up through to the roof. Upon reflection these were the main things that needed to be changed in the second draft.

Drying Concept Development 2:

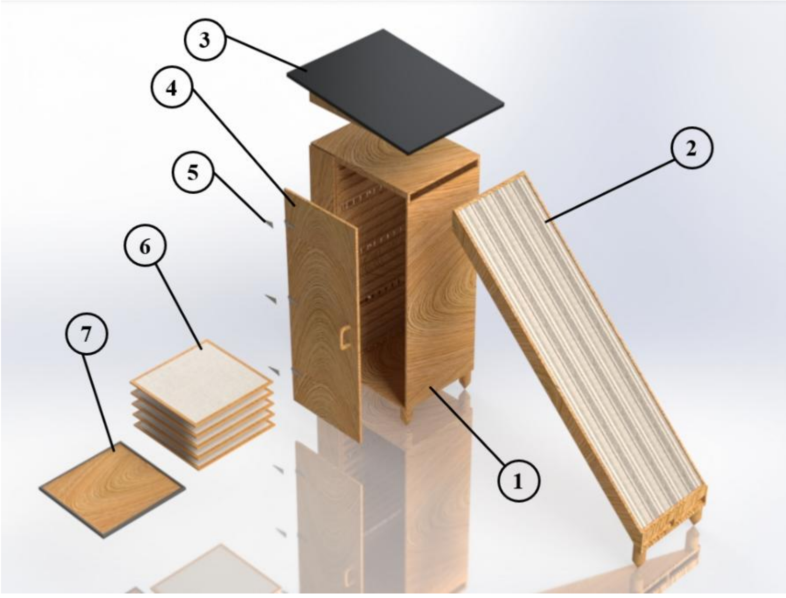
For the second draft the Dehydrator was extended to match the whole height of the housing unit to provide more surface area for the sun to heat producing more hot air. The housing unit was then given a flat ceiling and the in and out vents were lowered to be a part of the housing unit as opposed to the roof. Other minor changes were made such as increasing the size and the angle of the roof for to provide any rain with a better run off and the number of vents in between each tray was reduced from one per slot to one every 5 slots. An air blocking tray was also added to reduce to the space needed to be heated for smaller batches of briquette drying.

Drying Concept Development 3:

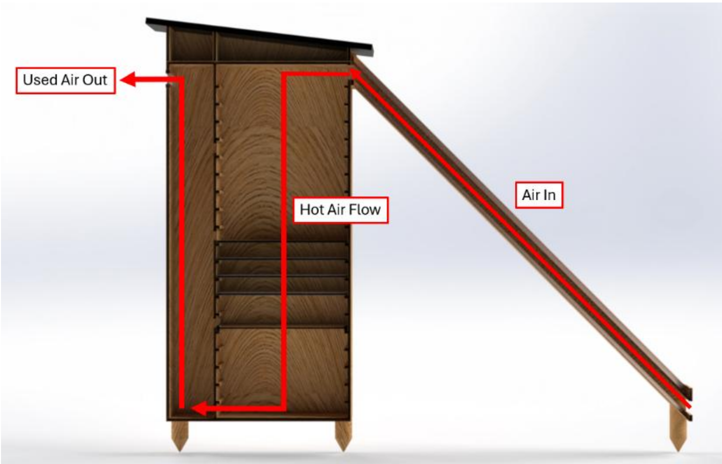
The third draft remained mostly unchanged, the only difference being that rather than using wooden sliding vent covers, the vents were instead installed with metal sliding vents. This was the last change made for the final design of the Drying Concept.

Below is an exploded view of the different sections of the drying system with an accompanying bill of materials to show what and how many of each component is required to construct the system.

| ITEM NO. | PART NAME | QUANTITY |
|---|---|---|
| 1 | Housing Unit | 1 |
| 2 | Roof Unit | 1 |
| 3 | Solar Dehydrator | 1 |
| 4 | Door | 1 |
| 5 | Door Hinge | 3 |
| 6 | Tray | 19 |
| 7 | Air Blocker Tray | 1 |




The design of this concept allows for 19 trays of manure to be dried within the system with shut off vents and an air blocking tray to allow for smaller batches to be dried out rather than having the system heating up excess space. A drawing pack has been provided in appendix X detailing the sizes of the internal dimensions of spaces and overall dimensions of size.




The CAD model and proposed material costing used 18mm plywood to base the design however the client made the group aware of wood available on sight that Eat Sleep Ride would be able to make use of when constructing the drying system, so long as the inner dimensions and spaces of walls and racks for the drying trays are kept the same, the design will still work as intended.

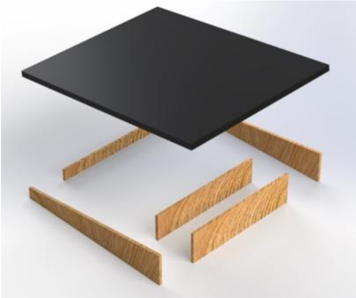
The following images are exploded views of the Housing Unit (Part No. 1), Roof Unit (Part No.2), Solar Dehydrator (Part No.3) and Door (Part No.4) to further illustrate how the different units are assembled.

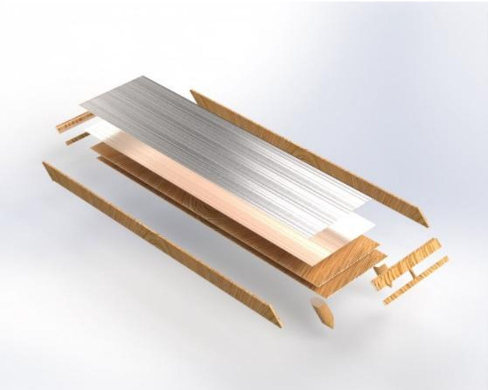
Housing Unit:

The housing unit is composed of 5 vertical panels to create the walls of the unit, a ceiling and floor panel and four spiked feet to keep the unit planted and stable in the ground.

Roof Unit:

The roof unit is composed of 5 vertical panels, two of which being the front and back panels that share the same dimensions and three parallel panels that vary in height to follow the angle of the back and front panels. The roof also has a roof panel that overhangs for rain runoff.





Solar Dehydrator:

The solar dehydrator is composed of two side panels of the same dimensions as well as two 3mm plywood sheets of the same dimensions spaced apart on the underside of the dehydrator. The main elements used to heat the airflow are a clear acrylic sheet and a sheet of solar absorbing material to heat up the air that flows into it. Similar to the housing unit there are also two spiked feet to keep it secure

Door:

The door is made of two sheets of 18mm thick sheets of plywood screwed/nailed together with a sealant over the perimeter of where the two sheets meet to provide an airtight seal preventing air from escaping out the door instead of the vents. The door in the cad model is designed with 3 door hinges which is sufficient in holding the weight of the door as it pivots. A handle has also been designed from another piece of wood however the client may choose to redesign the handle however they choose.

Final Solutions

## Design Decisions

The key design decisions that were made to give us the final outcome are summarised below.

**Drying System:**

Solar Collector – The solar collector is the exterior panel of the dehydrator system. It allows for the air to enter the system and for it to be warmed by the sun to increase the rate of moisture removal from the briquettes.

Mesh Shelves – The shelves inside the dehydrator have a mesh interior to improve the air flow through the system. By allowing the air to flow in between the shelves the drying efficiency will be greater.

Capacity – Each shelf in the system has been designed to be 750 x 750mm. We wanted to maximise the capacity per shelf, while still ensuring that shelves would be manageable to carry between the forming and drying systems. There are 19 shelves in the system and each shelf has the space available for 45 briquettes to be formed and dried on.

Capacity Adjustments – With 19 shelves and 45 briquettes per shelf, the system has a maximum capacity of 855 briquettes. It was decided that a more modular system would be beneficial. This was achieved through a false floor and vents between every fifth shelf. Once a shelf has been filled it is placed at the top of the system. The false floor is then placed below the first vent, which is opened, to concentrate the air flow towards the briquettes which need drying at that time. This also allows for scalability because the initial testing can be done with a couple of shelves, so as to not waste any additional time or resources.

Roof – The roof is angled with an overhang to direct rainfall away from the main body.

Air Flow – As this product is an indirect solar dryer, it allows for more uniform drying than direct solar drying methods. A key requirement for an indirect dryer is the effective flow of air through the system. To ensure the entire system remains self-sufficient, this solution uses natural (convection) air flow. The air enters the system through the base of the solar collector component, flows from the base of the drying chamber to the top where it escapes through an external vent.

Air Sealing – For the best briquette drying possible, the system must be airtight. To make it more airtight, sealants will be used around the joints.

**Forming System:**

Briquette Sizing – The briquette press has been designed to form briquettes which are 142mm x 76mm x 30mm at their largest points. The sizing of the briquette had to consider a larger surface area to reduce the drying time, whilst also considering how this would affect the burn time for the production of biofuel. The large and flat shape also will be ideal for stacking in storage once the briquettes have dried.

Press – The press was designed to minimise the amount of strength required to form multiple briquettes at once. To do this, a turning mechanism to force the moisture out of the manure was used.

Tray System – The press is part of a larger table, so that there is space for the tray to be loaded before pressing. The tray will slide through a groove in the side of the table to improve the ease of use of the system.

Folding Legs – The legs of the table were made to be hinged, so that the table can fold away into the 1.5m x 1.5m shed which is currently available on site. This was done because the table would be too large to fit in the shed when upright.

## Materials

There were a range of requirements to consider when finalising the material choice for the design. The system will be based outside so the materials need to be durable and weatherproof, but the choices must also be accessible to allow for ease of construction, by Eat Sleep Ride CIC, on their site.

Materials can be substituted to use what is currently on hand

Table Legs – Source: Wickes, PSE Redwood Timber - 69 x 69 x 2400mm was selected as it's a redwood timber which is known to be strong, durable and easy to work with, all criteria that's needed for simple construction onsite.

https://www.wickes.co.uk/Wickes-PSE-Redwood-Timber---69-x-69-x-2400mm/p/236388?gclsrc=aw.ds&&utm_source=google&utm_medium=cpc&utm_campaign=PMAX%20Shopping%20-%20Timber&gad_source=1&gbraid=0AAAADs4IsaVajRvm2ZVOxxhhcDYm_tdL&gclid=CjwKCAjwwqfABhBcEiwAZJjC3gjnCGqaN9h9aG8KHXnVEB50dPZL6rH8tgUorKSvyaGduWcsrveBghoCGJ0QAvD_BwE

For the door handle we have chosen cast iron as it is weather resistance and a robust material making it suitable for outdoor use and longevity.

https://www.diy.com/departments/cast-iron-hot-bed-handle-100mm-black-japanned-finish-with-screws-ideal-for-garden-gates-shed-doors-indoor-outdoor-use/5056040876506_BQ.prd

Dryer Panels - Source: Chiltern Timber – Structural CE2+ Plywood Sheet – 18 x 1220 x 2440mm, this material was chosen as it can offer high strength and stability, and it can also be easily treated to withstand outdoor environments.

https://www.chilterntimber.co.uk/product/plywood-elliottis-shuttering-ply-plywood/

Stakes - Source: B&Q - 10 x Round Wooden Fence Posts Stakes HC4 Pressure Treated 1.2m tall x 50mm Diameter were chosen as they have a resistance to rotting and can be easily driven into the ground for a secure fixing.

https://www.diy.com/departments/10-x-round-wooden-fence-posts-stakes-hc4-pressure-treated-1-2m-tall-x-50mm-diameter/5060955593212_BQ.prd

Folding Brackets for Table Legs – Source: Solmer - Folding Bracket for Tables and Benches 38 x 38 mm (Pack of 2) we chose this design to allow the system to collapse for easier transport and storage and to ensure it has a strong support when in use.

https://www.solmer.co.uk/connectors-fittings/folding-bracket-for-tables-and-benches-38-x-38-mm.html

Latches for side doors used drawbolt latches as their known for their strength and reliability, ensuring the side doors are securely closed and easily usable is key.

https://www.thomann.co.uk/adam_hall_1600_drawbolt_medium.htm?gad_source=1&gbraid=0AAAADuDMCUknQViJaeRpAxIMa5-kX1DS&gclid=CjwKCAjwq7fABhB2EiwAwk-YbDqogyJaD1BNrBcpCF0PqdOhy9Yt5IxW6fbWi-pv1ak-wywd70ReTxoCr_EQAvD_BwE

We chose galvanised mesh over stainless steel because it offers rust resistance and price savings compared to stainless steel: (Would need 7 sheets – Price per sheet inc. vat is £20.52)Mesh – Source: F. H. Brundle. Shaped expanded pre-galvanised metal sheet 1250 x 2500mm, Specifications**:** Sheet size: 1250 x 2500mm, Mesh size LW: 6.15mm, Mesh size SW: 3.69mm, Strand width: 1.50mm, Strand thickness: 0.70mm, Open area %: 49

https://www.fhbrundle.co.uk/products/0202846664__Expanded_Galvanised_N6664F_1250_x_2500mm_

Pressing System Metal Rod is made of stainless steel as this part needs to have a  high strength and corrosion resistance. – Source: rapidmetals.co.uk, Stainless Steel (304) 30mm Round, cut to 250mm, Threading and drilling would have to be completed at a later stage.

https://www.rapidmetals.co.uk/product/stainless-304-round-30mm/

Softwood plywood has been chosen for the pressing tabletop because it is lightweight, easy to cut and strong enough for the pressing operation. – Source: B&Q. Softwood Plywood (L)2440mm (W)1220mm (T)12mm. Sheet no. 1 of plywood. Cut tabletop size (1510 x 800) from sheet

https://www.diy.com/departments/softwood-plywood-l-2440mm-w-1220mm-t-12mm/1169637_BQ.prd

Scraper again made of softwood plywood for the same reasons as well as keeping fabrication simple. – Source: B&Q. Softwood Plywood (L)2440mm (W)1220mm (T)12mm. Sheet no. 1 of plywood. Cut scraper size (91 x 800) from sheet

https://www.diy.com/departments/softwood-plywood-l-2440mm-w-1220mm-t-12mm/1169637_BQ.prd

We chose a vice replacement handle as our press handle because it's strong, ergonomic and has removable end caps to it would be easy to maintain or replace. – Source: Wilkes Engineering & Machinery. Using a replacement vice handle for the press because of the removable end caps. Size 5/8 x 12 inch (15.8 x 300mm).

Pressure treated timber battens were chosen for the briquette forms as they are resistant to rot and decay ensuring they last long. – Source: B&Q. Treated Timber Batten. 10 Pack: 3m x 38mm x 25mm. Pressure treated to resist rot and decay.

https://www.diy.com/departments/snowdon-timber-garden-b253810-treated-2x1-batten-l-3-0m-w-38mm-t-25mm-10-pack/5060893865822_BQ.prd

Pine Stripwood was chosen for the shelving Supports because its affordable, easy to work with and lightweight which is ideal for building shelving structures. - Source: Wickes. Pine Stripwood Moulding - 20 x 20 x 2400mm. On offer with 10 for £62.

https://www.wickes.co.uk/Wickes-Pine-Stripwood-Moulding---20-x-20-x-2400mm/p/121271?gclsrc=aw.ds&&utm_source=google&utm_medium=cpc&utm_campaign=PMAX%20Shopping%20-%20Mouldings%2C%20Claddings%20%26%20Stairparts&gad_source=1&gbraid=0AAAAADs4IsbqtutyVU4bW0InCVe-r5QOp&gclid=Cj0KCQjwiLLABhCEARIsAJYS6unNZwhyt5F2BHMYVtduAj5u51c2YnBliScyHL5vSjXBG-RjzpWxLfIaAhxgEALw_wcB

Adjustable stainless steel trickle vents were sourced for out air vents as we needed to allow control of the airflow to balance the temperature and ventilation of the system. – Source: juststainless.co.uk. Adjustable Interior Trickle Vent. Decided on 425mm length to balance size and cost. £21.83 each. Stainless steel flymesh can also be provided.

https://juststainless.co.uk/product/adjustable-interior-trickle-vent-2/

Acrylic was chosen instead of glass as it’s lightweight, shatterproof and has great UV stability when exposed outdoors. Acrylic Sheets – Source: Wickes. Durable Clear Acrylic Sheet - 600 x 1220mm

https://www.wickes.co.uk/Wickes-Durable-Clear-Acrylic-Sheet---600-x-1220mm/p/210001

Solar Absorber Material – For best solar heat trapping, the solar collector will contain an absorber material. Studies have shown that 6 layers of steel lath is the most ideal *(Scanlin, 2022),* however the number of layers can be reduced to lower costs.

Steel Lath. Source: Wickes - Galvanised Metal Mesh Lath - 2.5m x 700mm

https://www.wickes.co.uk/Wickes-Galvanised-Metal-Mesh-Lath---2-5m-x-700mm/p/104089?gclsrc=aw.ds&&utm_source=google&utm_medium=cpc&utm_campaign=PMAX%20Shopping%20-%20Plaster&gad_source=1&gbraid=0AAAAADs4IsZGOJMsti1QpXmUlYIl5zEvu&gclid=Cj0KCQjwiLLABhCEARIsAJYS6ukpEbScxGwZLfhnidYJxBLWZjs7LeTC7ibuDmSWK8gHGugtMrLVaSEaAtR9EALw_wcB

9mm Softwood Plywood were selected as it’s lightweight and ideal for secondary structures, offering a good balance between strength, cost and ease of use. – x2 1220x2440mm boards. Source: DIY Building Supplies.

https://diybuildingsupplies.co.uk/products/softwood-shuttering-plywood-9mm-x-1220mm-x-2440mm?srsltid=AfmBOopTF6B4E9-MxpP9gF-3CMDMjwffhd9JF4ZKsKmOLvtO_ZVvU-C3

Protective finishes like varnish and sealant were chosen to give the wood weatherproof properties and black paint was chosen for the interior of the solar collector to help improve absorption

Stainless steel fire door hinges were selected as they have a high strength and are rust resistance which ensures longevity and reliability in performance on the doors– Source: Toolstation. 10mm x 76mm x 3mm. Stainless steel fire door hinges

https://www.toolstation.com/grade-13-ball-bearing-fire-door-hinge/p73733?store=G5&utm_source=googleshopping&utm_medium=feed&utm_campaign=googleshoppingfeed&gad_source=1&gad_campaignid=17808153481&gbraid=0AAAAAD-vLcXzwrkHiUcWxNzxsFoVm37Yr&gclid=CjwKCAjwq7fABhB2EiwAwk-YbGDFliv46JmMdBBVcyYQqqiK5llaor0lruu-Rv6MktfCn2XYnl3KaxoCU4wQAvD_BwE

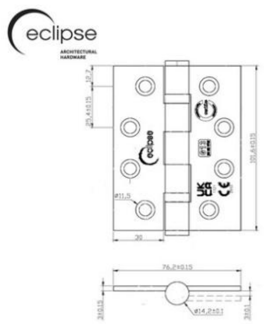
# Mechanisms

The specified mechanisms were chosen as suitable examples; however, replacements and/or suitable other mechanisms that are functionally identical are also appropriate to be used instead. Links for all the mentioned mechanisms are in the materials section, found above.

The mechanisms required for the system to function include:

Door hinges:

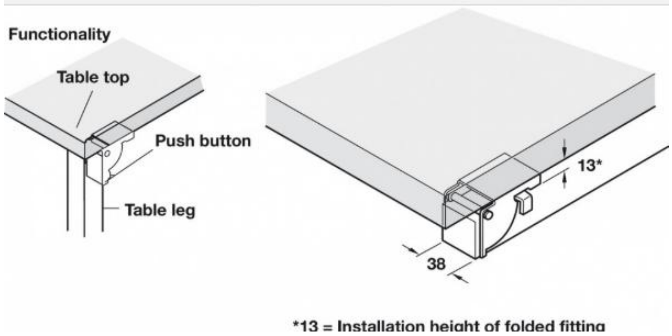
Heavy duty fire-door hinges would be used for the main door of the drying system. This would be to ensure a smooth mechanism and support the door fully – no flex in the door means it will be able to form a tight seal, which is important for heat retention and moisture control. Standard Phillips head screws are used to attach the hinges securely to the door. Stainless steel for the material is appropriate to be corrosion resistant, as the site often experiences harsh weather conditions as it's on the coast. The hinges are high quality, using ball bearings, allow for a smooth pivoting joint between the door and the main body of the system.




Door latches:

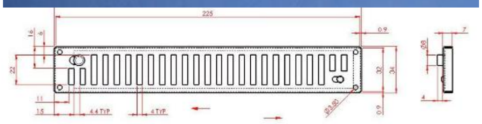
Also, heavy duty door latches would need to be used for keeping the side doors secure and clamped fully shut to ensure the tray stays in the correct place.

Leg Folding Bracket:




The mechanism used for the table legs needs to be a proven, sturdy, and secure mechanism to meet the intended function of the table. The legs of the table should be able to fold away, to reduce the required storage space for the table in the shed. The legs should then be able to be quickly folded out and securely fixed in place for use of the briquette forming system. These folding brackets successfully do both required functions, additionally being sized for 38mm x 38mm table legs, which is a perfect size for a balance between stability and bulkiness. The mechanism of the hinge allow the legs to fold flat against the body of the table and are made to lock at 90 degrees when in the upright position. Additionally, he galvanised steel finish makes these hinges highly resistant to corrosion as well, further showing the suitability of these hinges. Screw Clamp Mechanism:

Sliding Vents:



The mechanism for the vents is highly important one, as this allows the whole airflow of the drying system to be managed, simply by opening and closing certain vents depending on the number of shelves used. The hinges are positioned every few shelves or so, at locations suitable to be closed off at, making a smaller and more efficient drying section from the larger system. The vents are always fixed in place within the walls of the drying system and can be very simply opened or closed by sliding a small handle over by 10mm or so. This moves all of the individual vent covers at the same time, quickly and efficiently blocking off any air flow, or allowing it to pass through.

Screw Mechanism:

From the mechanisms used in these products, this one is the most unique as it is a modified version of other existing mechanisms for the unique purpose of the briquette forming system. The goal for this mechanism is to allow the user to compact the manure into briquettes, without using all of their own strength, as this would be tiring and labour-intensive. This mechanism utilises leverage to make the compacting easier, and more effective at the same time. The screwing motion also allows the press to move only in the vertical plane, minimising waste and maximising efficiency – earlier prototypes had this mechanism hinged from one side with a handle for the user to press down on. More detail can be found within the 'forming concept development 4' section The users spins the handle which rotates the centre column which is fixed to the forming plate (still free to rotate). This then lowers or raises the plate whilst keeping it aligned to the guides. The longer handle allows the user to turn it from the ends, which uses leverage to apply for force than the user could generate on their own. This allows for more user ease, higher forces applied, and higher quality briquettes to be produced.

## Construction plan (Technical drawings (appendix E))

## Part List and Costing

| Part | Material | Frequency | Dimensions (mm) | Cost (£) |
|---|---|---|---|---|
| **Drying System:** | | | | |
| **Back Panel** | 18mm Structural CE2+ Plywood Sheet | 1 | 2054 x 1054 | £26.50 |
| **Door** | 18mm Structural CE2+ Plywood Sheet | 1 | 2012 x 780 | £26.50 |
| **Base** | 18mm Structural CE2+ Plywood Sheet | 1 | 1054 x 786 | £26.50 |

| | | | | |
|---|---|---|---|---|
| **Inner Ceiling** | 18mm Structural CE2+ Plywood Sheet | 1 | 1018 x 750 | - |
| **Side Panel (2254mm)** | 18mm Structural CE2+ Plywood Sheet | 1 | 2254 x 786 | £26.50 |
| **Side Panel (2129mm)** | 18mm Structural CE2+ Plywood Sheet | 1 | 2254 x 786 | £26.50 |
| **Roof Panel** | 18mm Structural CE2+ Plywood Sheet | 1 | 1301 x 1026 | - |
| **Solar Collector** | 9mm Softwood Shuttering Plywood | 1 | Refer to technical drawings | £30.00 |
| **Mesh Shelves** | Raised Stainless Steel 304 Expanded Metal Sheet | 19 | 750 x 750 | £143.64 |
| **Shelf exterior frames** | 18mm Structural CE2+ Plywood Sheet | 19 x 4 | 25 x 750 (Cut from plywood offcuts) | - |
| **Stakes** | Wooden Fence Posts Stakes HC4 Pressure Treated | 6 | - | £39.99 |
| **Handle** | Component Outsourced | 1 | - | £4.99 |
| **Shelving Supports** | Pine Stripwood | 38 | 20 x 20 (Cut into lengths of 750mm) | £86.90 |
| **Air Vents** | Component Outsourced | 5 | 425 x 34 | £109.15 |
| **Acrylic Sheets** | Acrylic | 2 | 1220 x 600 | £52 |
| **Solar Absorber Material** | Steel Lath | 6 | 2500 x 700 | £108 |
| **Door Hinges** | Outsourced Components | 3 | 102 x 76 | £20.04 |
| **Total** | | | | £618.02 |

| Part | Material | Frequency | Dimensions (mm) | Cost (£) |
|---|---|---|---|---|
| **Forming System:** | | | | |
| **Table Legs** | Redwood Timber | 4 | 1200 x 69 x 69 | £45.50 |
| **Folding Brackets** | Component Outsourced | 4 | 38 x 38 | £16.40 |
| **Rod** | Stainless Steel (304) | 1 | 30 dia x 250 | £22.12 |
| **Tabletop** | 12mm Softwood Plywood (Sheet 1) | 1 | 800 x 1510 (Cut from 1220 x 2440 sheet) | £33 |
| **Scraper** | 12mm Softwood Plywood (Sheet 1) | 1 | 800 x 91 (Cut from 1220 x 2440 sheet) | - |
| **Handle** | Component Outsourced | 1 | 15.8 x 300 | £24.95 |

| | | | | |
|---|---|---|---|---|
| **Crossed beams** | Spruce Timber | 2 | 2.4 x 50 x 25 | £6.47 |
| **Side panels** | 12mm Softwood Plywood (Sheet 1) | 2 | Refer to technical drawings (Cut from 1220 x 2440 sheet) | - |
| **Side doors** | Spruce Timber | 2 | 2.4 x 34 x 27 | £6.97 |
| **Briquette Former Timber (718mm)** | Pressure Treated Timber (10 pack) | 7 | Refer to technical drawings (Cut from 3m x 38mm x 25mm) | £43.96 |
| **Briquette Former Timber (83.4mm)** | Pressure Treated Timber (10 pack) | 32 | Refer to technical drawings (Cut from 3m x 38mm x 25mm) | - |
| **Total** | | | | 199.37 |

## User manual

One of the key discoveries from the client meetings was that a set of instructions on how to use the produced products would be an extremely helpful addition.

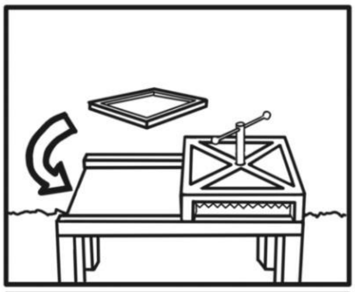
One of the key parts of the instructions was the final step – knowing when the briquettes were sufficiently dry to be able to remove from the drying system, ready for storage, sale, or immediate use. The client should use a moisture meter to measure the levels in the briquette, for example the 'Dryzone Moisture Meter'. The briquettes have been sufficiently dried when they reach a moisture content of between 10-15% *(Wzorek et al., 2021)*.

The user manual will include both written and visual instructions, to enable the most possible users to understand the required steps.

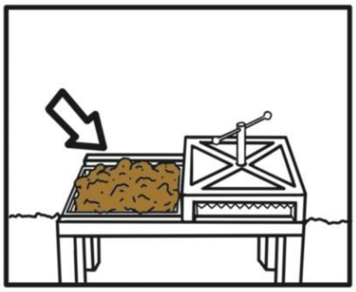
# Instructions for Briquette Forming and Drying

Manure containing sawdust, straw, hay, and grass is acceptable to be used in the biofuel making process. Manure containing carpet fibre should not be used in the forming of briquettes (unless carpet is 100% wool), due to dangers of toxic-fume inhalation.

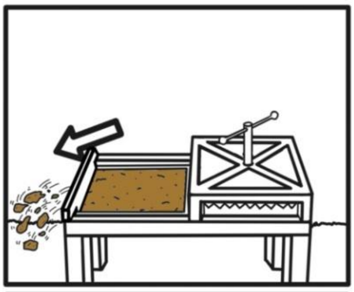
The manure should be malleable enough to form into briquettes, yet firm enough to hold its shape. A combination of water and sawdust can be used depending if the manure is too runny or too thick (depending on weather conditions and/or time spent in manure pile).



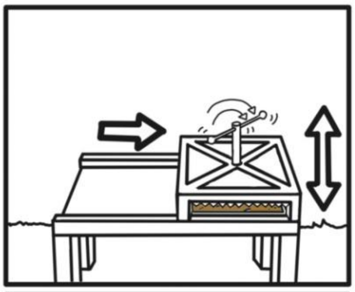
Slide the tray between the guide rails



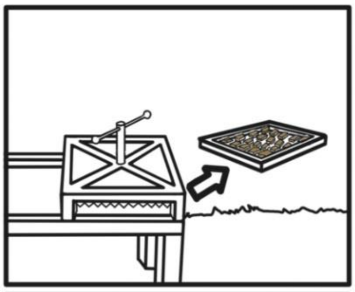
Fill the tray with manure (could be done beforehand)



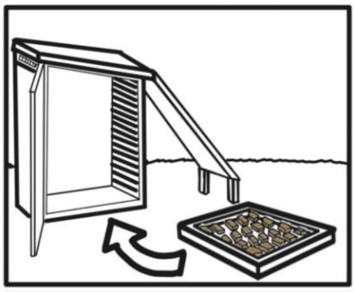
Slide is used to level the manure in the tray



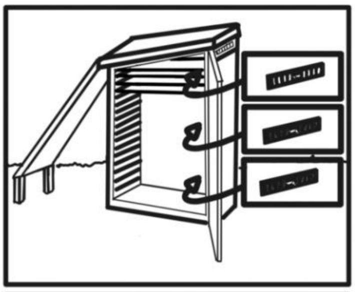
Tray put under press, spin handle to lower and raise press



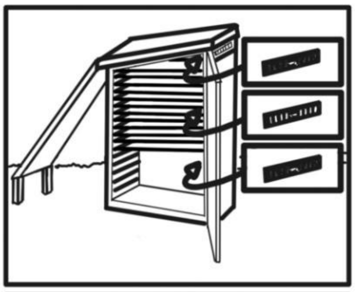
Tray with formed briquettes is removed from forming device



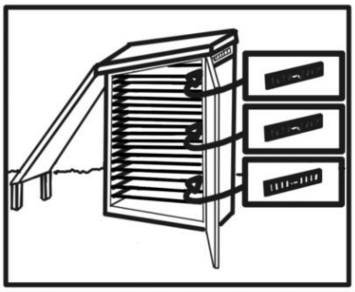
Briquette tray can then be placed in the drying system



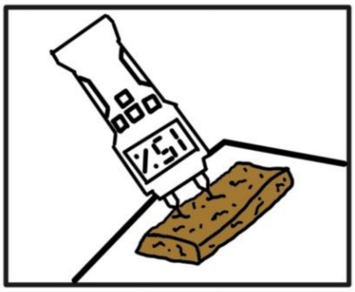
Filling from the top, open just the top vent for 1/3 full.



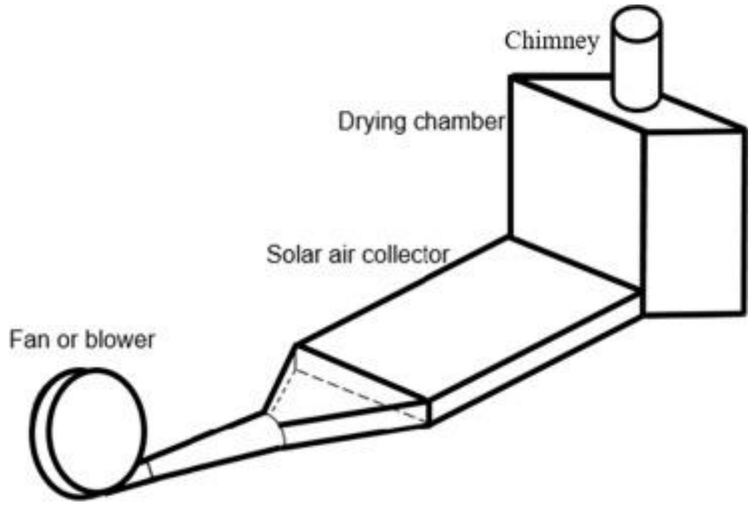
Filling from the top, open just the middle vent for 2/3 full.



Filling from the top, open just the bottom vent for all full.



Briquettes are ready with moisture between 10-15%




*Solar Dryer with Forced convection – (Lingayat et al., 2019)*

## Methods to Improve Efficiency After Initial Set-up

The system will reach peak efficiency during the summer months, however, in the Winter, the drying period of the briquettes will be much longer. There are systems which could be used to increase this efficiency. The air circulation in the dryer has a significant impact on the removal of surface moisture from the briquettes. Currently the air circulates through the system naturally. To fully understand the current efficiency of the designed system, it will need to be put to use for a trial period, so that the moisture levels of the briquettes can be measured directly. If the colder months have a severe impact on drying ability, a forced convection system could be retrofitted. This would require connecting the drying system to a power source which would require a larger investment than using natural convection methods.

A study *(Hidalgo et al., 2021)* into convection methods in solar dryers had experimental results which showed that the average efficiency of natural convection versus forced convection was 34.2% and

38.3% respectively. Using a forced convection method can also add a further element of control to the drying process. Forced convection can be achieved with connection to a blower fan.

# Conclusions

As previously discussed, the project deliverables were:

1. Detailed plan for the pressing and drying process
2. Physical prototype/ mock-ups of final design
3. A plan for this process to be assembled on site
4. A costing and materials list for the assembly

We believe that we have meant the clients requirements by providing an outcome that meets each of these deliverables. Deliverable 1 was met through continuous concept generation and development which led us to our final design of a pressing table and an indirect solar dehydrator. These designs have been fully established, so that they are ready for construction on site.

At this stage, prototyping for the project has been done through CAD with detailed virtual models designed. However, due to time constraints a physical prototype has not yet been constructed. This will be developed in time for the presentation day, so that we can deliver our solution with a physical model to fully communicate our proposal.

The third deliverable was a plan for the design to be assembled on site. One of our key criteria for choosing our final design was the ease of manufacture. Because of this, the systems should be simple to construct with materials that will be accessible to the client. Since the project started, the client has a new volunteer with construction experience who is interested in being involved with the project. This will also help to simplify how the systems will be constructed because contractors won’t be required.

The final deliverable that was agreed at the beginning of the project, was a costing and materials list for the project. This has been completed and will be sent to the client for their use when construction begins. Care was taken when choosing the suppliers to make sure these were options the client could easily access. The client has also mentioned that they have spare materials on site, and we have made it clear that any of the materials can be substituted for similar options in order to reduce costs.

Overall, the team believe that we have had a positive outcome to this project with the system that has been designed.

# Reflections

This project has been a learning experience for all team members, and it has been a brilliant opportunity to develop our professionalism, team-working skills and communication. The teamwork was developed throughout the project by sticking to our team rules and allowing for open communication. The division of work also became more successful as we became more aware of each other's strengths and weaknesses. To improve our teamwork, we had held more regular group meetings and kept reviewing each other's work, this helped creating the report to being smoother and more cohesive.

The task list system worked a lot better than the Gantt chart as it was an ever-evolving document that allowed us to keep organised and make changes easily compared to the over complicated planning tools of the Gantt chart. Also losing the weekly rotation of leadership also helped by making the teams dynamic less hierarchical and more collaborative which ended up boosting morale and kept the team engaged.

Theres one major thing we could improve in the future and that would be to do more prototyping. The sketch models were useful at the beginning, but we noticed late into the design process that physical prototyping was useful in uncovering practical issues early on.

It has been an exciting opportunity to work with a client in industry on a real problem and solution, and it will be interesting to see how our proposal will be taken forward.

Client feedback was important throughout the whole process, and through discussion in meetings the group was able to maintain a consistent focus for the project on the needs of the client.

Overall, we believe we have met the criteria of delivering a solution that forms and dries manure into briquettes effectively and have created systems that are useful and can be easily constructed by the client while keeping in line with sustainability goals and including all four of the deliverables. The team is looking forward to meeting the client in person on presentation day and to present all our hard work.

# References


Amazon, (n.d.). *AH Briquette Maker, Black Iron DIY Recycle Newspaper Eco-friendly Paper Log Brick Home Heating Fire Stove Environmentally Friendly Useful Shredded Paper Log Brick Maker Fireplace Recycle Log Maker.* Available at: https://www.amazon.co.uk/Briquette-Newspaper-Eco-Friendly-Environmentally-Fireplace/dp/B0BSH7FCQH/ref=asc_df_B0BSH7FCQH/?tag=googshopuk-21&linkCode=df0&hvadid=696352102746&hvpos=&hvnetw=g&hvrand=9762724749921271879&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1007336&hvtargid=pla-2088974116267&psc=1&mcid=6d7e8b0944883604aeb20fc2e342b0f7&gad_source=1 (Accessed 27th November 2024)

Amazon, (n.d.). *Tidyard Paper Log Briquette Maker Eco Briquette Maker for Fireplace Newspaper Fuel Heat Stove Steel 38x31x18 cm Black and Red.* Available at: https://www.amazon.co.uk/Tidyard-Briquette-Fireplace-Newspaper-38x31x18/dp/B0CKH5M48S?source=ps-sl-shoppingads-lpcontext&ref_=fplfs&psc=1&smid=A32L6WU753UHHF (Accessed 27th November 2024)

Ashburn Carpets, (n.d.). *Carpet Fibre Types and Properties.* Available at: https://www.ashburncarpets.co.uk/carpets/carpet-fibre-types/ (Accessed 18th April 2025)

Astecker, J., (2017), *Solar Drying.* Available at: https://poweringthefuture.un.org/content/documents/CONA_SOLAR_DRYING_AUSTRIA_theGRANT_2017_eng.pdf (Accessed 27th November 2024)

B&Q, (2025). *10 x Round Wooden Fence Posts Stakes HC4 Pressure Treated 1.2m tall x 50mm Diameter.* Available at: https://www.diy.com/departments/10-x-round-wooden-fence-posts-stakes-hc4-pressure-treated-1-2m-tall-x-50mm-diameter/5060955593212_BQ.prd (Accessed 25th April 2025)

B&Q, (2025). *Cast Iron Hot Bed Handle 100mm - Black Japanned Finish with Screws - Ideal for Garden Gates, Shed Doors & Indoor Outdoor Use.* Available at: https://www.diy.com/departments/cast-iron-hot-bed-handle-100mm-black-japanned-finish-with-screws-ideal-for-garden-gates-shed-doors-indoor-outdoor-use/5056040876506_BQ.prd (Accessed 25th April 2025)

B&Q, (2025). *Snowdon Timber Garden B253810 Treated 2x1" Batten (L) 3.0m (W) 38mm (T) 25mm 10 Pack.* Available at: https://www.diy.com/departments/snowdon-timber-garden-b253810-treated-2x1-batten-l-3-0m-w-38mm-t-25mm-10-pack/5060893865822_BQ.prd (Accessed 25th April 2025)

B&Q, (2025). *Softwood Plywood (L)2440mm (W)1220mm (T)12mm.* Available at: https://www.diy.com/departments/softwood-plywood-l-2440mm-w-1220mm-t-12mm/1169637_BQ.prd (Accessed 25th April 2025)

Biomass Pellet Machine, (n.d). *Large Wood Dryer-Drum Type*. Available at: https://www.biopelletmachine.com/product/biomass-material-dryer/large-wood-dryer.html (Accessed 27th November 2024)

Chiltern Timber, (2025). *Plywood – Elliottis (Shuttering Ply) Plywood CE2+ 2440 x 1220mm x Various Thickness*. Available at: https://www.chilterntimber.co.uk/product/plywood-elliottis-shuttering-ply-plywood/ (Accessed 25th April 2025)

Da Lio, L., Castello, P., Gianfelice, G., Cavalli, R., Canu, P., (2021). *Effective energy exploitation from horse manure combustion.* Available at: https://www.sciencedirect.com/science/article/abs/pii/S0956053X21002336 (Accessed 18th April 2025)

Eat Sleep Ride. (2025). *Eat Sleep Rides*. [online] Available at: https://www.eatsleeprides.org/ (Accessed 24th April 2025)

Eat, Sleep, Ride, CIC, (n.d.). *Eat, Sleep, Ride, CIC.* Available at: https://www.eatsleeprides.org/ (Accessed 3rd December 2024)

Ennissioui, J., Benghoulam, E., Rhafiki, T. (2023). *Experimental study of a natural convection indirect solar dryer.* Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC10632706/#:~:text=Indirect%20solar%20dryer%20(ISD)%20is,products%20were%20disposed%20%5B17%5D (Accessed March 19th 2025)

F. H. Brundle, (2025). *Expanded Galvanised N6664F 1250 x 2500mm.* Available at: https://www.fhbrundle.co.uk/products/0202846664__Expanded_Galvanised_N6664F_1250_x_2500mm_ (Accessed 25th April 2025)

Hidalgo, F. H., Candido, M. N., Nishioka, K., Freire, J. T., Veira, G. N. A., (2021). *Natural and forced air convection operation in a direct solar dryer assisted by photovoltaic module for drying of green onion.* Available at: https://www.sciencedirect.com/science/article/pii/S0038092X21001754#b0050 (Accessed 25th April 2025)

HSE (2020). *Manual Handling at work.* Available at: https://www.hse.gov.uk/pubns/indg143.PDF (Accessed 16th April 2025)

Juststainless.co.uk, (2025). *Adjustable Interior Trickle Vent.* Available at: https://juststainless.co.uk/product/adjustable-interior-trickle-vent-2/ (Accessed 25th April 2025)

LASCO, (n.d.), *Gill plates – drying floor – perforated floor.* Available at: https://www.lasco.at/en/drying-trays-drying-floor/ (Accessed 27th November 2024)

Lingayat, A. B., Chandramohan, V. P., Raju, V. R. K., Meda, V., (2019). *A review on indirect type solar dryers for agricultural crops – Dryer setup, its performance, energy storage and important highlights.* Available at: https://www.sciencedirect.com/science/article/pii/S0306261919316927 (Accessed 25th April 2025)

McCann, R., (2022). *Community Solar Dehydrator Plans.* Available at: https://extension.usu.edu/sustainability/research/community-solar-dehydrator-plans (Accessed March 19th 2025)

Multimate, (n.d.). *Multimate Briquette Maker.* Available at: https://www.multimatebriquettemaker.com/ (Accessed 27th November 2024)

NC State University, (2006). *Anthropometric Data.* Available at: https://multisite.eos.ncsu.edu/www-ergocenter-ncsu-edu/wp-content/uploads/sites/18/2016/06/Anthropometric-Detailed-Data-Tables.pdf (Accessed 16th April 2025)

Rahman, M. Z., Hasanuzzaman, M. (2022). *Chapter 8 – Solar drying system.* Available at: https://www.sciencedirect.com/science/article/abs/pii/B9780128239599000106 (Accessed March 19th 2025)

Rapid Metals Ltd, (2025). *Stainless Steel (304) 30mm Round.* Available at: https://www.rapidmetals.co.uk/product/stainless-304-round-30mm/ (Accessed 25th April 2025)

Ritik, N., (2025). *Solar Dehydrator: The Complete Buying Guide.* Available at: https://www.arkaenergy.com/learn/solar-dehydrator?srsltid=AfmBOorgaVNabz9TFMQHqtjtg8Z9791SNZfl_B5P0y-6RZ5aRXS-KmPI (Accessed March 19th 2025)

Scanlin , D., (2022). *DIY Solar Food Dehydrator Plans.* Available at: https://www.motherearthnews.com/diy/solar-food-dehydrator-plans-zm0z14jjzmar/ (Accessed 26th April 2025)

Schekata, G. D., Tibba, S. G., Baheta, A. T., (2024). *Recent Advancements in indirect solar dryer performance and the associated thermal energy storage.* Available at: https://www.sciencedirect.com/science/article/pii/S2590123024011320#:~:text=Indirect%20solar%20dryers%2C%20in%20particular,indirectly%20heat%20the%20drying%20air. (Accessed 24th April 2025)

Solar Brother, (n.d.). *OMY solar dryer – M.* Available at: https://www.solarbrother.com/en/buy/solar-dryer-omy-m/ (Accessed 27th November 2024)

Solmer, (2025). *Folding Bracket for Tables and Benches 38 x 38 mm.* Available at: https://www.solmer.co.uk/connectors-fittings/folding-bracket-for-tables-and-benches-38-x-38-mm.html (Accessed 25th April 2025)

Svanberg, M., Finnsgård, C., Flodén, J., Lundgren, J., (2017). *Analyzing animal waste-to-energy supply chains: The case of horse manure.* Available at: https://www.researchgate.net/publication/315961829_Analyzing_animal_waste-to-energy_supply_chains_The_case_of_horse_manure (Accessed 18th April 2025)

ToolStation (2025). *Dryzone Moisture Meter.* Available at: https://www.toolstation.com/dryzone-moisture-meter/p35221?store=null&utm_source=googleshopping&utm_medium=feed&utm_campaign=googleshoppingfeed&gad_source=1&gbraid=0AAAAAD-vLcXDrsCsJOWaB2FkB4Cs3Eawx&gclid=CjwKCAjwq7fABhB2EiwAwk-YbB5c57DSi-M0R4WWAEUTB24TPMNztoN4ANIRc-HWRCHkRnO1gvNrvRoCzdcQAvD_BwE (Accessed 27th April 2025)

ToolStation (2025). *Grade 13 Ball Bearing Fire Door Hinge Satin Finish.* Available at: https://www.toolstation.com/grade-13-ball-bearing-fire-door-hinge/p73733?store=G5&utm_source=googleshopping&utm_medium=feed&utm_campaign=googleshoppingfeed&gad_source=1&gad_campaignid=17808153481&gbraid=0AAAAAD-vLcXzwrkHiUcWxNzxsFoVm37Yr&gclid=CjwKCAjwq7fABhB2EiwAwk-YbGDFliv46JmMdBBVcyYQqqiK5llaor0lruu-Rv6MktfCn2XYnl3KaxoCU4wQAvD_BwE (Accessed 26th April 2025)

United Nations (2025). *The 17 Sustainable Development Goals*. [online] United Nations. Available at: https://sdgs.un.org/goals

Wickes (2025). *Wickes Pine Stripwood Moulding – 20 x 20 x 2400mm.* Available at: https://www.wickes.co.uk/Wickes-Pine-Stripwood-Moulding---20-x-20-x-2400mm/p/121271?gclsrc=aw.ds&&utm_source=google&utm_medium=cpc&utm_campaign=PMAX%20Shopping%20-%20Mouldings%2C%20Claddings%20%26%20Stairparts&gad_source=1&gbraid=0AAAAADs4IsbqtutyVU4bW0InCVe-r5QOp&gclid=Cj0KCQjwiLLABhCEARIsAJYS6unNZwhyt5F2BHMYVtduAj5u51c2YnBliScyHL5vSjXBG-RjzpWxLfIaAhxgEALw_wcB (Accessed 25th April 2025)

Wickes, (2025). *Wickes Durable Clear Acrylic Sheet – 600 x 1220mm.* Available at: https://www.wickes.co.uk/Wickes-Durable-Clear-Acrylic-Sheet---600-x-1220mm/p/210001 (Accessed 25th April 2025)

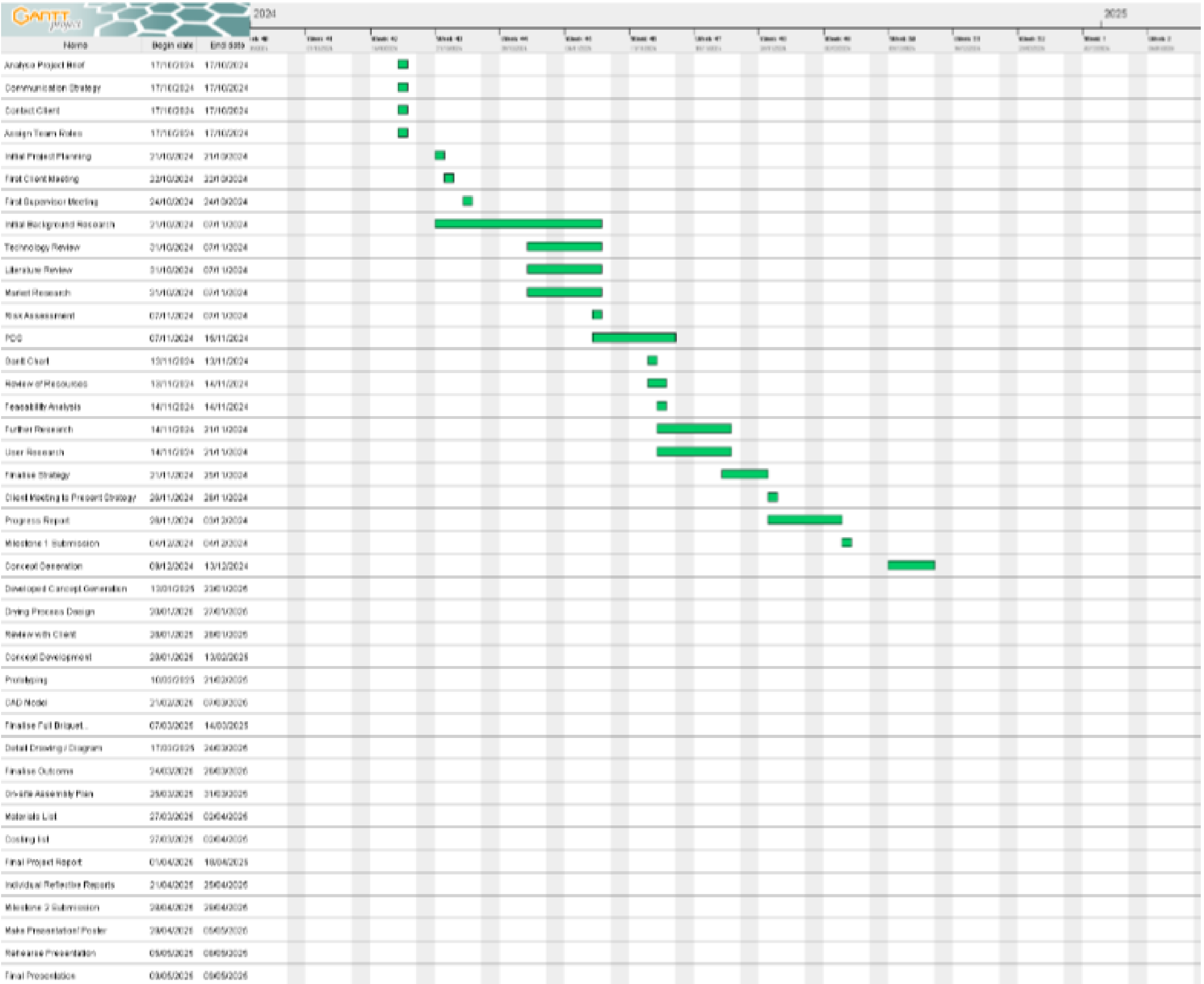
Wickes, (2025). *Wickes Galvanised Metal Mesh Lath – 2.5m x 700mm.* Available at: https://www.wickes.co.uk/Wickes-Galvanised-Metal-Mesh-Lath---2-5m-x-700mm/p/104089?gclsrc=aw.ds&&utm_source=google&utm_medium=cpc&utm_campaign=PMAX%20Shopping%20-%20Plaster&gad_source=1&gbraid=0AAAAADs4IsZGOJMsti1QpXmUlYIl5zEvu&gclid=Cj0KCQjwiLLABhCEARIsAJYS6ukpEbScxGwZLfhnidYJxBLWZjs7LeTC7ibuDmSWK8gHGugtMrLVaSEaAtR9EALw_wcB (Accessed 25th April 2025)

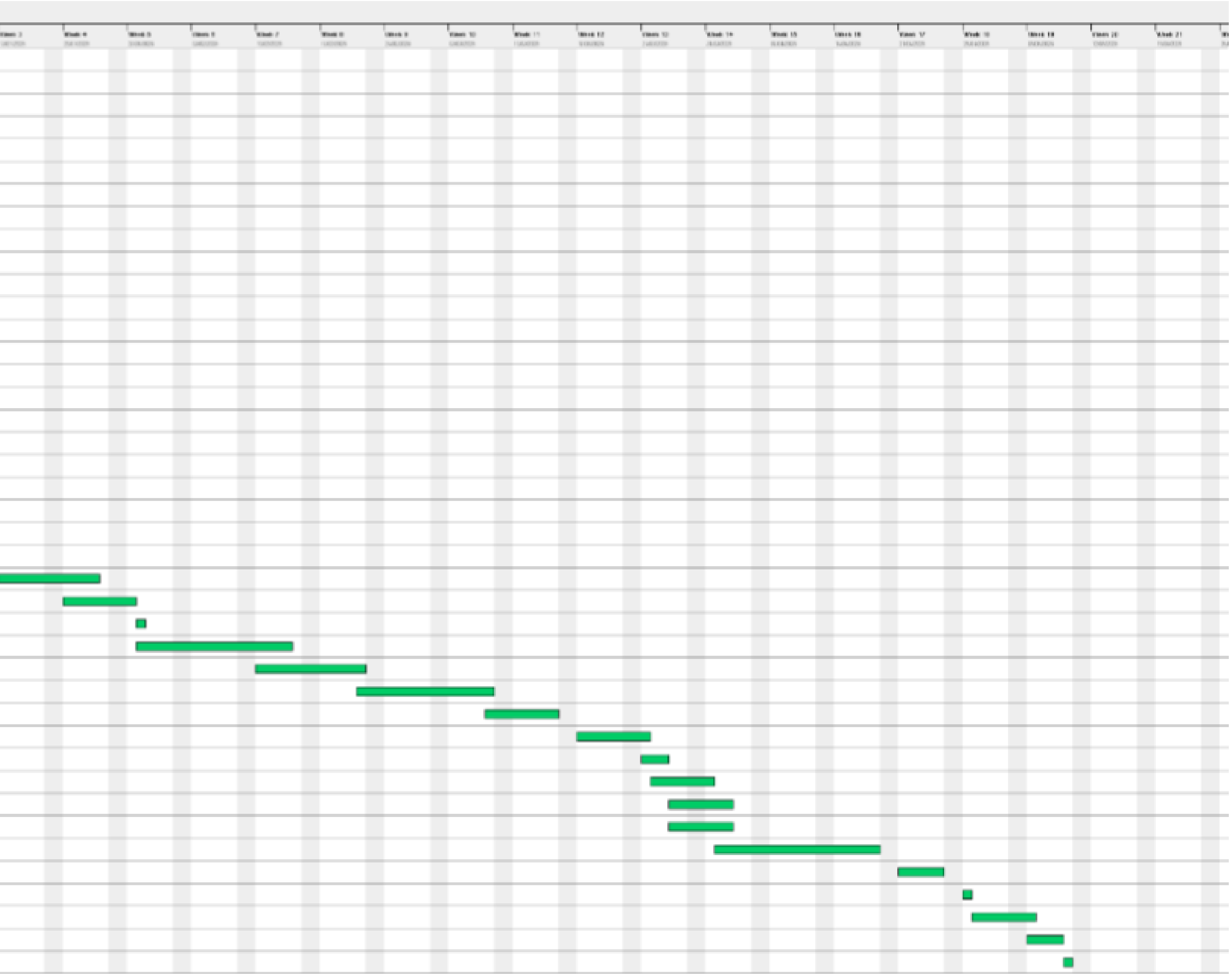
Wickes, (2025). *Wickes PSE Redwood Timber – 69 x 69 x 2400mm.* Available at: https://www.wickes.co.uk/Wickes-PSE-Redwood-Timber---69-x-69-x-2400mm/p/236388?gclsrc=aw.ds&&utm_source=google&utm_medium=cpc&utm_campaign=PMAX%20Shopping%20-%20Timber&gad_source=1&gbraid=0AAAAADs4IsaVajRvm2ZVOxxhhcDYm_tdL&gclid=CjwKCAjwwqfABhBcEiwAZJjC3gjnCGqaN9h9aG8KHXnVEB50dPZL6rH8tgUorKSvyaGduWcsrveBghoCGJ0QAvD_BwE (Accessed 25th April 2025)

Wzorek, M., Junga, R., Yilmaz, E., Niemiec, P., (2021). *Combustion behavior and mechanical properties of pellets derived from blends of animal manure and lignocellulosic biomass.* Available at: https://www.sciencedirect.com/science/article/abs/pii/S0301479721005491 (Accessed 27th April 2025)

# Appendices

## Appendix A – Gantt Chart





Appendix B – Task List (Milestone 2)

| | Owner | Progress | Deadline |
|---|---|---|---|
| **Exploration** | ALL | | |
| Group concept generation 635 | All | | |
| Dot Sticking Write up | All | | 05-Feb |
| Individual concept generation | All | | 05-Feb |
| PMI / evaluation | All | | 05-Feb |
| Phase 1 evaluation | CR | | 05-Feb |
| Researched concept | AS | | 05-Feb |
| PESTLE analysis | AR | | 05-Feb |
| Materials research | CS | | 05-Feb |
| 2 concepts each for forming and drying using criteria from 12th feb meeting and using dehydrator research | ALL | | 19-Feb |
| Evaluation | | | 19-Feb |
| Rating Matrix Evaluation for Drying | AS | | 26/02/2025 |
| Rating Matrix Evaluation for Forming | CR | | 26/02/2025 |
| DfX - Design for Manufacture and Design for Weatherproofing | | | 26-Feb |
| Add all concepts to rating matrix | CS | | 24-Feb |
| DfX - Design for Safety and Design for Usability | | | 26/02/2025 |
| Justification of concepts in concept rating table | CS | | 04/03/2025 |
| Client Meeting | All | | 27/02/2025 |
| Feedback -based concept analysis write up | | | 03/03/2025 |
| Prep for crit | All | | 03/03/2025 |
| UN STG's | | | |
| Final research into how solar dehydrators work | AS | | 31-Mar |
| Quick write about lessons learned from sketch models | All | | 31-Mar |
| Mechanical solar dehydrator research | AR | | 31-Mar |
| Developed design for pressing concepts | CR, CS | | 31-Mar |
| | | | |
| | | | |

# Appendix C – Minutes Tracking (Semester 2)

| | | | | | |
|---|---|---|---|---|---|
| 29/01/2025 | **Semester 2 - Meeting 1 - Week 2 - Concept Generation** | First meeting for the second, and final, semester working on this project. The group reflected on the first semester, and what went well and what didn't? The group did a 4-3-5 concept generation task for both methods of forming, and methods of drying. The group then discussed the objectives and deliverables for semester 2. | Tasks for each member were given out, the group is focussing on getting a lot of work done early. Tasks include a write up for Reflection on semester 1 , some specific concept research, a PESTEL analysis, and materials research. Additionally, each member is to carry out analysis and a write up on 2 concept sheets from the 4-3-5 exercise each. Then, each member is to draw up additional concepts that they had, different from the 4-3-5 concepts, perhaps using specific research or ideas that they had. | | 180 |
| 12/02/2025 | **Meeting 2 - Week 4** | We left sufficient time to have everyone draw up concepts from the 3-5-6, we ended up with 10 concepts for drying methods, and 8 methods for forming. As a group we did PMI for all 18 concepts. We then created brainstorm maps for both drying and forming, taking the best methods/overall ideas from the concepts. | Each group member will use the outcomes of the brainstorming sheets to create 1-2 concepts for each the drying and forming. These concepts will be narrowed down, and then presented to the client next week hopefully. | | 120 |
| 19/02/2025 | **Meeting 3 - Week 5** | We met up to compare, discuss, and analyse our developed concepts. Each member did between 1 and 2 detailed concepts for both a forming and a drying design. The concepts from these sections were then compared to each other in a weighting and rating matrix, where factors such as safety, efficiency, and cost were compared, resulting in a final score for each concept. We then scheduled meetings, and sent emails, to both our contact at Eat Sleep Ride CIC, and to our advisor. The marking schemes for upcoming deliverables were reviewed, and overall strategy for the project was revised. Progress was compared to our Gantt chart, confirming we were roughly on track. | Each member has been given a task to complete for next week, as to keep the word count for the overall project ticking over, and to spread the workload over the weeks rather than it being tail-heavy. For next week, 1 member will write up analysis on the weighting and aging matrix for drying, one person will do the same for forming, and 2 people will share the following 4 topics for 'design for (x)'; safety, usability, manufacture, and weatherproofing. | **Craig - Busy** | 150 |
| 26/02/2025 | **Meeting 4 - Week 6** | We discussed progress since the last week, and updated the teams with any new documents. We also finished the matrix from last week with 2 more concepts. The group prepared and organised for the upcoming meetings, both with our advisor, and with the client (tomorrow). Tables were made in advance to easily record the opinations and any other info from the client on the concepts. All deliverable dates were checked, and a full plan was made with deliverables for dates leading up to each hand-in. | By next week the client meeting will be done, and the group will do evaluation from the information gained from the meeting. This will be used as well as the matrix to inform the finalised the concepts. Prep will be done for the Tuesday meeting on the Monday, as well as a provisional meeting with the groups advisor | **Amir** | 120 |
| 19/03/2025 | **Client Meeting** | We met with the client to show our progress, and to get their feedback and thoughts on our concepts. We showed them a PowerPoint displaying around 5 concepts for both the forming and drying sections. The client gave very useful feedback on their pros and cons with each design, as well as adding useful information on aesthetics, feasibility, and manufacture requirements. | Physical modelling, detailed design, writing up details from meeting. | **Craig** | 60 |
| 31/03/2025 | **Workshop Session** | The team built some early sketch models/prototypes. These were done to inform the decision making process between the final concepts. These also informed form and function through physical models. | Reflection on learnings from concepts. Some further research on flaws that were brought up my modelling e.g. mechanisms (detailed design). | | 150 |
| 07/04/2025 | **Group Meeting** | Review of designs so far, selection of final designs, discuss design changes. Delegating tasks to group members - 2 people to work on sketches for the other 2 people to make CAD models from. 1 team working on the forming product, and the other team working on the drying product. | Make detailed design sketches, send them to group members, make CAD models for next week. | | 120 |
| 11/04/2025 | **Group Meeting** | Discussed the sketches, concepts, and CAD models that were made since the last meeting. Looked over detailed design as a group, decided on changes to make - e.g. refining clamp measurements, solar cell angle, clamp teeth style. A meeting was requested with our supervisor to discuss final plans, progress, and deliverables. An email was also sent to the client to request a final meeting to approve the final concepts. Deliverables were set out for the group for next week. | Confirm meetings, do CAD work - make specified changes, material selection, standard component suitability review and selection. | **Craig - Unknown** | 120 |
| 15/04/2025 | **Group Meeting** | Went over revised concepts. Looked at report structure - allocated tasks | Do individual sections of report for Monday (or if client wants a lot of changes, have report done for Friday to allow more time for implementation of client's requested changes. | | 80 |
| 16/04/2025 | **Client Meeting** | Met with Danielle to showcase our final designs and get feedback on any minor changes she wanted. Talked through the process of using both of the systems - gained feedback on what instruction they would need on Constuction and use of the devices. 4 new areas were identified to work on; a new design of integrated legs for the forming device, research into feasibility of burning some of the possible contaminants on site, instructions on what to do in multiple failure modes of briquette production, and guidance on storage of briquettes after production. | Complete to-do list that was made in the last group meeting, plus complete for the 4 new areas as well; a new design of integrated legs for the forming device, research into feasibility of burning some of the possible contaminants on site, instructions on what to do in multiple failure modes of briquette production, and guidance on storage of briquettes after production. Tasks were divided between each group member | | 60 |
| 22/04/2025 | **Group Meeting** | Looked at the report in more detail - assigned roles | Complete to-do list for the report | **Callum - Unknown, Craig - Unknown** | 30 |
| 25/04/2025 | **Group Meeting** | Started on FEA, material research, redesign of pressing mechanism, allocation of final tasks, discussion of progress, adding minutes to document, and general report formatting | Scheduled final group meeting (done on teams) for Sunday at 5pm, to review final report before submission. | | 120 |
| 27/04/2025 | **Final Group Meeting** | The group reviewed the full report, minor formatting changes were made, the report was submitted. Plans were made for meeting to complete the poster for the presentation (last part of this assignment). | Present the work of the project to the client at the event day on Friday 9th of May. | | 60 |

## Appendix D – Product Design Specification

### Updated PDS: (Items in **BOLD** have been added in this iteration)

1.0 Performance

- 1.1 Through daily use, the effectiveness of the product should remain the same, relying on durability to sustain its effectiveness.
- 1.2 The system must be able to effectively dry the manure and do so in a time-efficient manner.
- **1.3 Produced briquettes should be unform size and density (or as close to as possible)**

2.0 Materials

- 2.1 The materials must be durable
- 2.2 The material must be resistant to water 1
- 2.3 The material must be resistant to heat
- **2.4 Materials should be recycled or sourced locally where possible, relating to clients sustainability goals and will help with reducing costs**
- **2.5 Materials used for drying should have maximum thermal conductivity and moisture resistance**

3.0 Product Life Span

- 3.1 The product will have a life span of several years and must be able to process a large amount of manure
- **3.2 The product must be repairable if parts are damaged and need to be swapped etc**

4.0 Quantity

- **4.1 This product will be replicable by the client to fit their needs depending on volume production**
- 4.2 The design will have custom dimensions to suit the client's needs
- **4.3 The forming product must produce enough briquettes to fill 1 whole tray of the drying system.**
- **4.4 The drying system should be able to adapt to produce volume in accordance with the clients demand**

5.0 Documentation

- 5.1 The product should have detailed documentation to guide the user through the process
- **5.2 There should be instructions guiding the briquetting process**
- **5.3 There should be instructions guiding the drying process**
- 5.4 Instructions must be easy to understand for all staff/ volunteers
- **5.5 Instructions should be in both written and visual (pictured) formats, suitable for most possible users**

6.0 Legal

- 6.1 Machinery used must not pose unacceptable risks to people
- 6.2 Electrical components must adhere to legal standards

7.0 Safety

- 7.1 To adhere to environmental standards, the design must ensure horse manure is not stored near water
- 7.2 The user should wear gloves when handling horse manure/ using the briquetting system
- **7.3 Warning labels must be in place for any possible hot surfaces on any product**
- **7.4 Any hinges must lock in place to prevent collapsing in likely windy working conditions**

8.0 Testing

- 8.1 The briquette manufacturing should be fully tested, so it is easy to use by staff and volunteers
- 8.2 The drying system should be tested
- **8.3 Prototypes or sketch models should be made to test functionality before final designs are decided**

9.0 Environment

- 9.1 The designed system must be rain resistant
- 9.2 The designed system must be wind resistant
- 9.3 The designed system should be functional within the temperature range of the farm, roughly between -5 – 30 degrees Celsius
- **9.4 The process must not waste manure or excess material of any kind, as per STG 13: Climate Action**
- **9.5 Soil and water contamination must be avoided, as per STG 15: Life on Land**
- **9.6 The drying system must use renewable energy sources where possible, as per SDG 7: Affordable and clean energy**

10.0 Ergonomics

- 10.1 The system should be safe to handle – no splinters etc
- 10.2 The individual parts of the system should be of useable proportions (to be defined per part)
- **10.3 The required effort used to form the briquettes should be minimal (relating to client feedback on ease of use)**
- **10.4 The forming system must be able to be used by people with different anthropometrics**

11.0 Standard Specification

- 11.1 The designed system should utilise standard components so it can be fixed on site, and parts can be easily ordered in
- 11.2 The system should be constructed using common construction methods (Phillips head screws etc) so it can be adjusted easily if needed

**11.3 In any instructions, manufacturing up to the client's discretion should be allowed for where suitable (joining methods etc)**

12.0 Aesthetics

12.1 The designed system must take aesthetic inspiration from the location, reflecting similar buildings

12.2 The designed system must not sacrifice effectiveness for aesthetics, functionality is the focus.

**12.3 Neutral and natural colours and materials should be used**

13.0 Installation

13.1 Installation should be doable by the staff on site – no expert skills required

13.2 The system should be installed in a location where existing utilities can be easily accessible

**13.3 Assembly should be possible using basic power tools**

14.0. Life in Service

14.1 Product should be durable as to withstand rugged life on site.

14.2 Product should be able to be used rigorously, day after day as to meet quotas.

15.0 Performance

15.1 Through daily use, the effectiveness of the product should remain the same, relying on durability to sustain its effectiveness.

15.2 The system must be able to effectively dry the manure and do so in a time-efficient manner.

**15.3 The system must operate effectively in situations without external power**

**15.4 Briquettes should be easily transportable from the forming product to the drying product**

16.0 Product Cost

16.1 The total cost of the project should not exceed the budget of the 'innovation voucher' provided by the university.

16.2 The system should utilise existing parts that have been provided as to minimise cost and maximise budget on new parts.

**16.3 To reduce costs, the design should be suitable to be modified at the client's discretion for certain materials, mechanisms etc that would function the same as alternatives**

17.0 Shelf-life storage

17.1 This is not the type of product that would be sold at stores so shelf-life storage is not necessary, although it must be able to last a good number of years on the client's property before needing refurbed/replaced.

**17.2 The forming device must be able to be stored efficiently in a shed whilst not in use**

18.0 Quality reliability

18.1 The quality must be robust, so the client need not worry about it breaking when in use

18.2 The material choice must be suitable for outdoor windy and wet conditions that are prominent at the borders.

18.3 The quality must be reliable as continually repairing parts would be a waste of the client's valuable time.

18.4 Must be of high quality so it could withstand hits from machinery and horses.

**18.5 The products must be able to withstand impacts, both accidental and as part of functional day-to-day use**

19.0 Packing

19.1 Must be packed in a way that could be easily transported to the borders if needed.

19.2 Must adhere to environmental concerns in packaging materials as this is a factor the clients charity follows.

19.3 The packing must not be too heavy to keep it easily transportable.

20.0. Competition

20.1 This is not a major factor as this would not be a product that goes to market, although the customer could have someone else develop a product or system for them which could mean we would not get the work.

**20.2 The system must be competitive and have benefits compared to competitor products (e.g. be able to function without being connected to external power supply)**

21.0 Maintenance

21.1 The product or system must be easily maintainable by staff and volunteers on the farm as it is so far away, they must be able to keep it working themselves.

21.2 The fixings that are used must be standard components so the client would be able to find them easily.

21.3 Cleaning of any parts should be made simple.

**21.4 If any greasing should be necessary on mechanisms, it must be easy to reach and apply without a specialist**

22.0 Weight

22.1 The weight should be adequate to hold its own in the windy environment.

22.2 The weight should not be too much so it could be moved if needed.

22.3 If fastened to the shed, the weight must not be too large that it rips out of the wall and damages it.

**22.4 The forming system must be able to be carried, and set up from the shed to the desired location by staff, therefore it should not be constructed from heavyweight materials – use woods where suitable over metals.**

23.0 Market constraints

23.1 Some market constraints from our research could be any initial setup costs associated with the process of palletisation.

**23.2 The system must be scalable in small quantities to meet with volume demands by the client which may increase over time**

24.0 Politics

24.1 A politic issue can be when processing of the manure takes place, that the emissions from that are dealt with accordingly to not affect people in the area.

25.0 Customer

25.1 The customer is the organisation “Eat Sleep Ride CIC”

**25.2 Staff on location must be able to use both products with minimal training (not requiring specialists)**

26.0 Size

26.1 The product must fit in the required space provided by the client

**26.2 The briquettes from the forming system must be produced and transported to the drying device and fit correctly into place.**

27.0. Shipping

27.1 The product can be transported via vans/trucks/trailers; only road vehicles required

28.0 Company constraints

28.1 The company is limited by storage space in the university buildings/workshop

28.2 The company is limited by number of internal staff to assemble a large-scale product

**28.3 As the company does not currently have budget for this project, instructions should be made on how to build them, for when the company has funds in the near future**

29.0 Disposal

29.1 The product should be able to be dismantled, and any recyclable materials are to be recycled

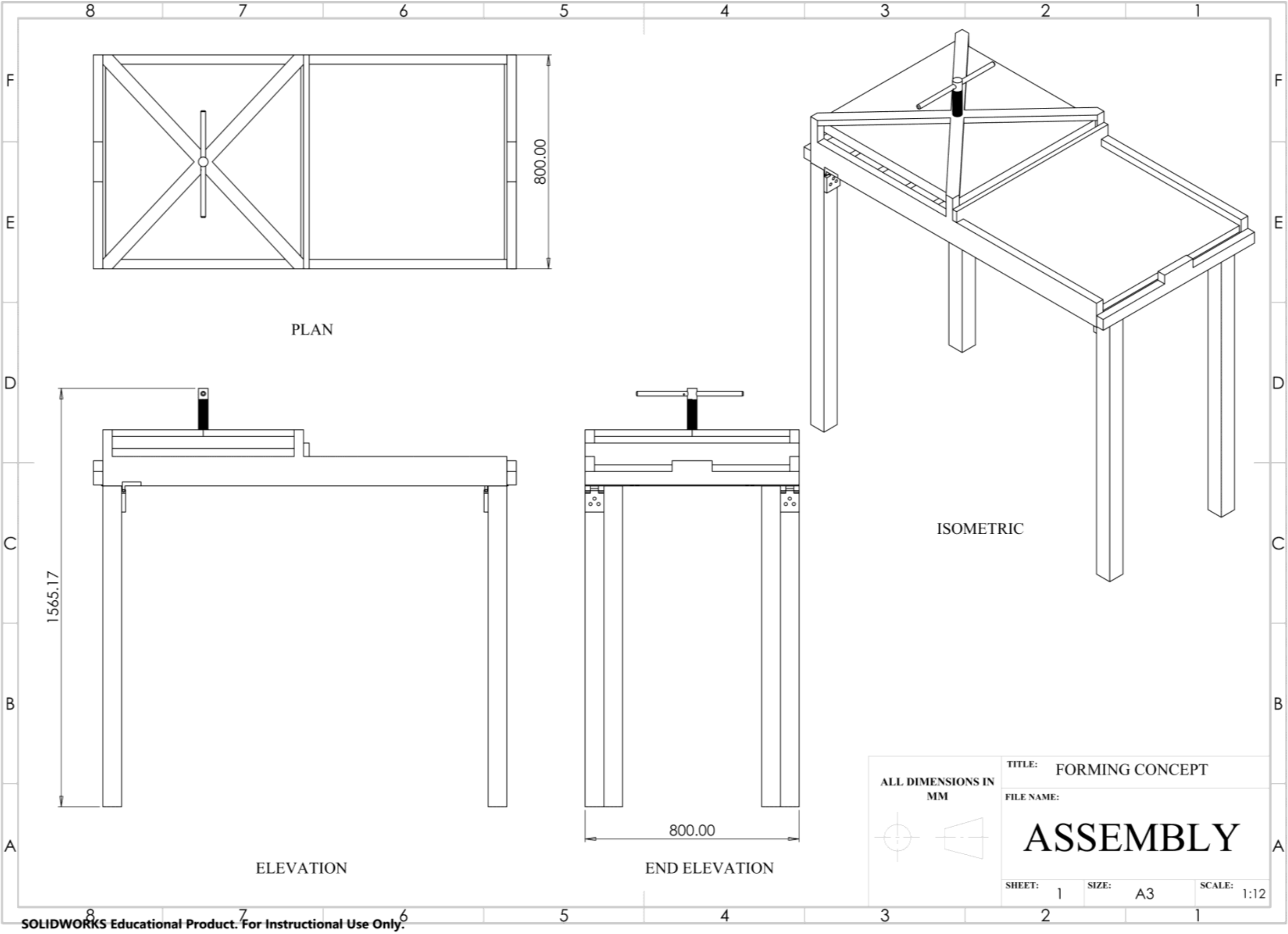
30.0 Manufacturing facility

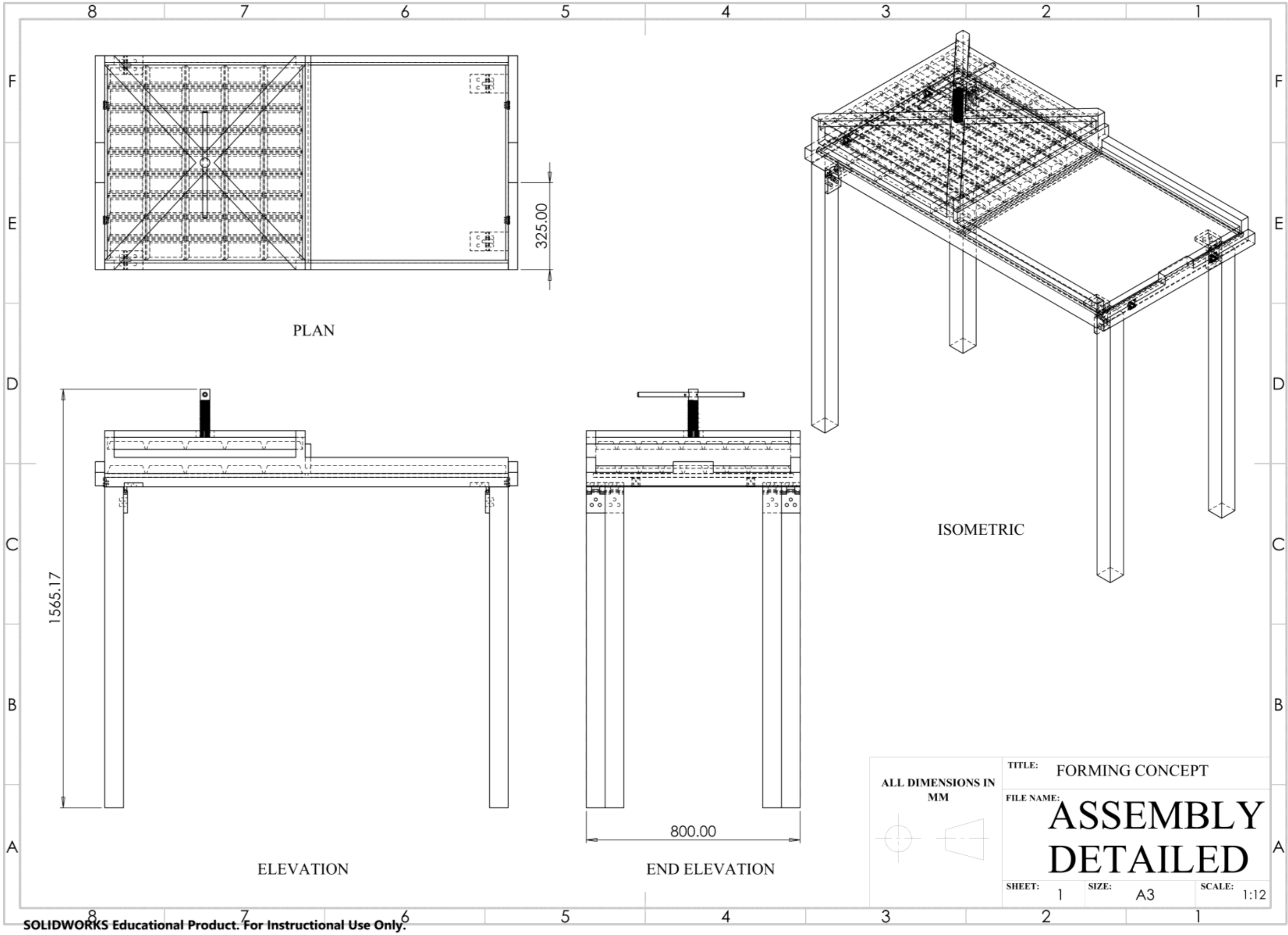
30.1 The manufacturing facility would be the DMEM workshop at the University of Strathclyde

30.2 The final assembly would be completed at the Eat Sleep Ride CIC farm

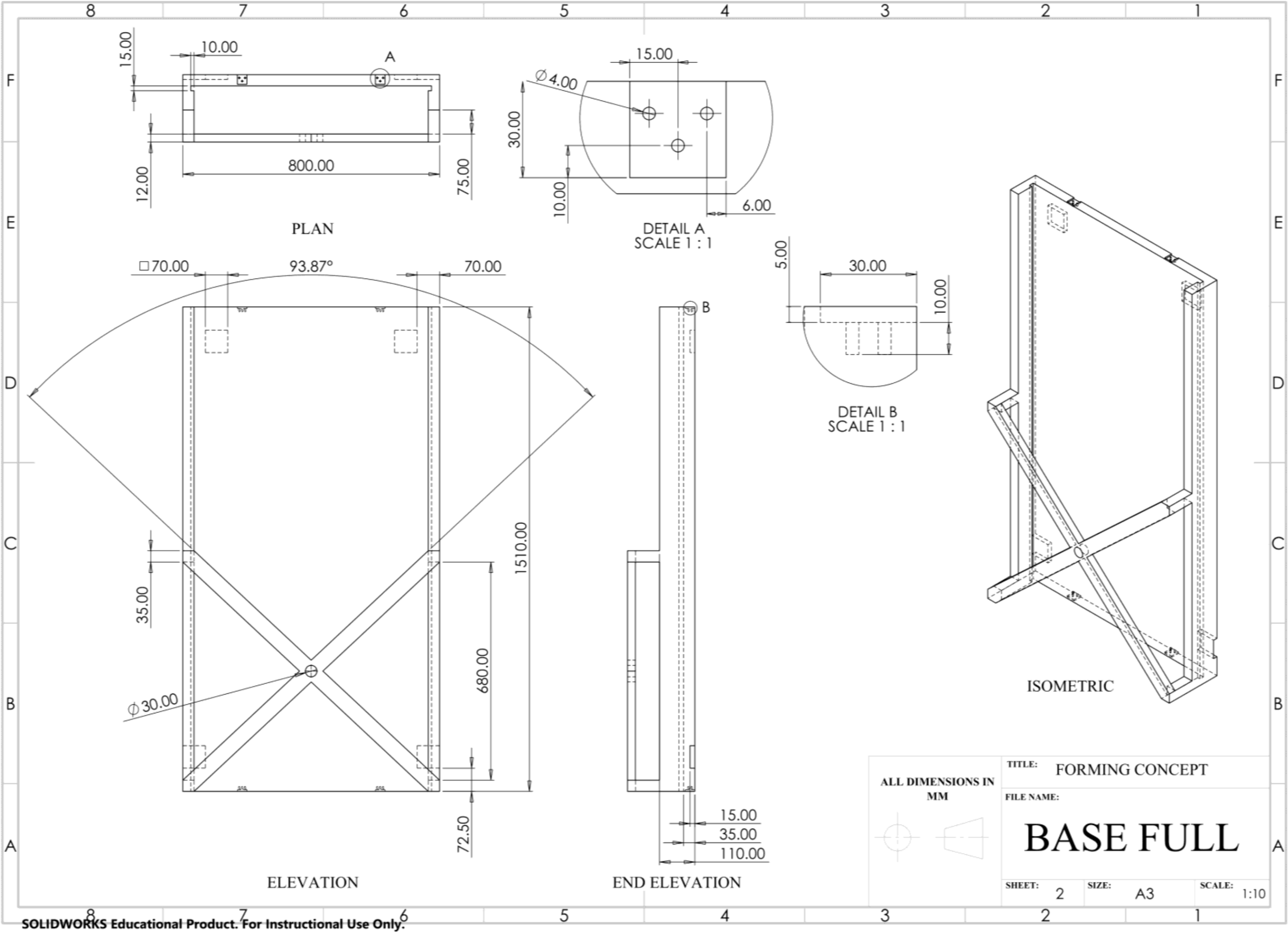
**30.3 Final Manufacturing would be done by staff of Eat Sleep Ride CIC or by a contractor that the client choses to hire**

## Appendix E – Forming System Drawings

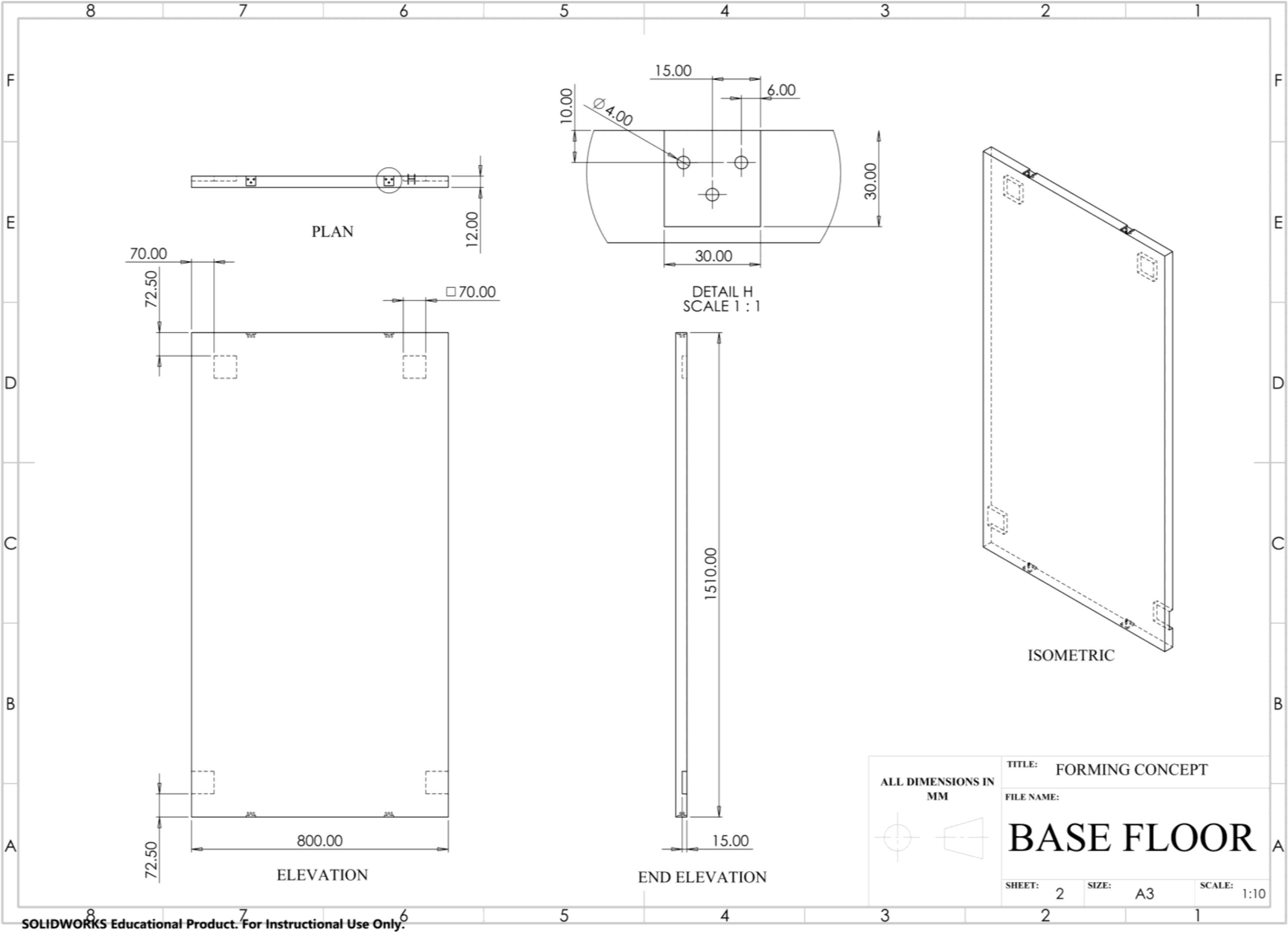




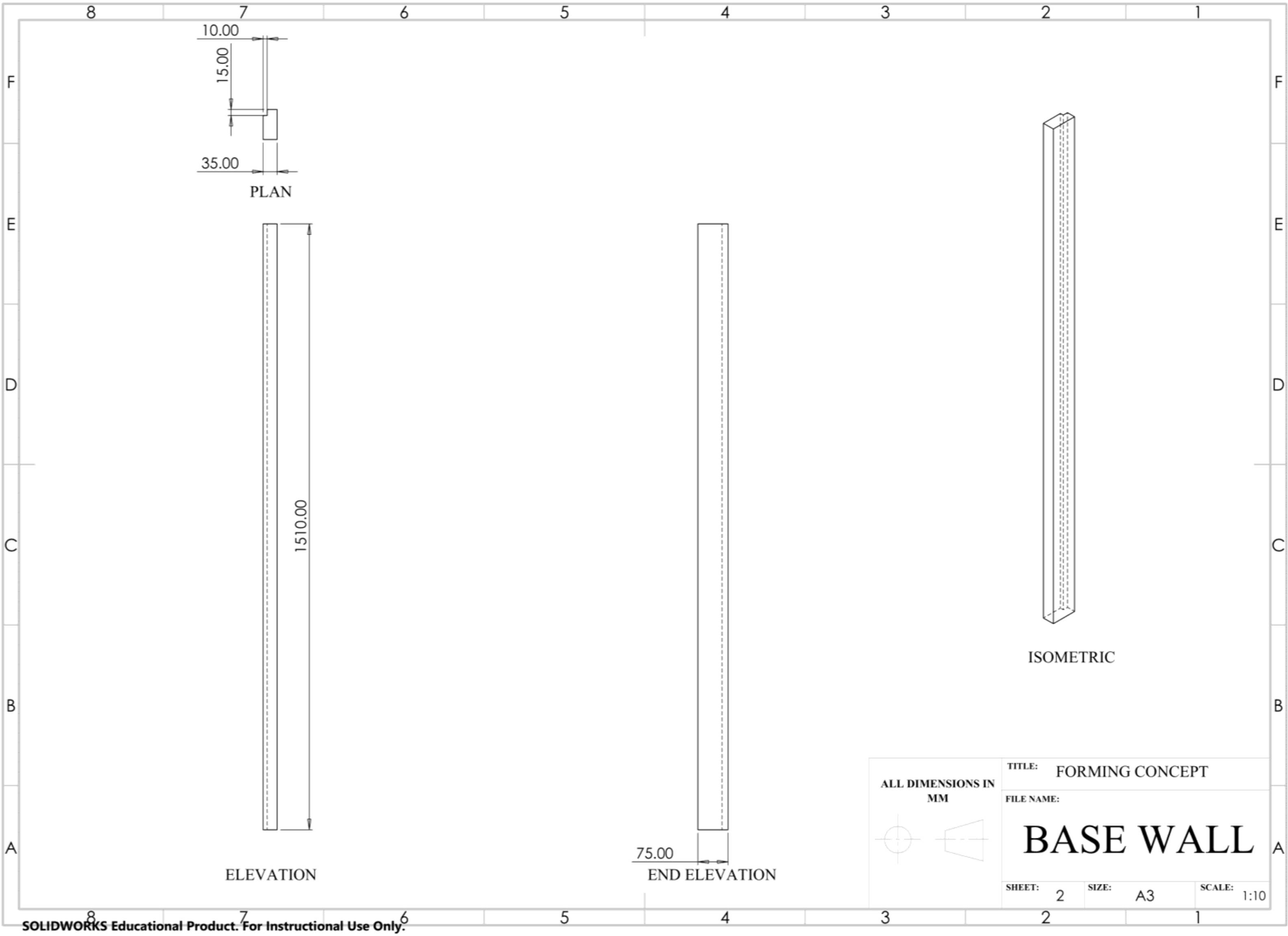
8
7
6
5
4
3
2
1
F
E
D
C
B
A
325.00
PLAN
1565.17
800.00
ISOMETRIC
ELEVATION
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME: ASSEMBLY DETAILED
SHEET: 1
SIZE: A3
SCALE: 1:12
SOLIDWORKS Educational Product. For Instructional Use Only.

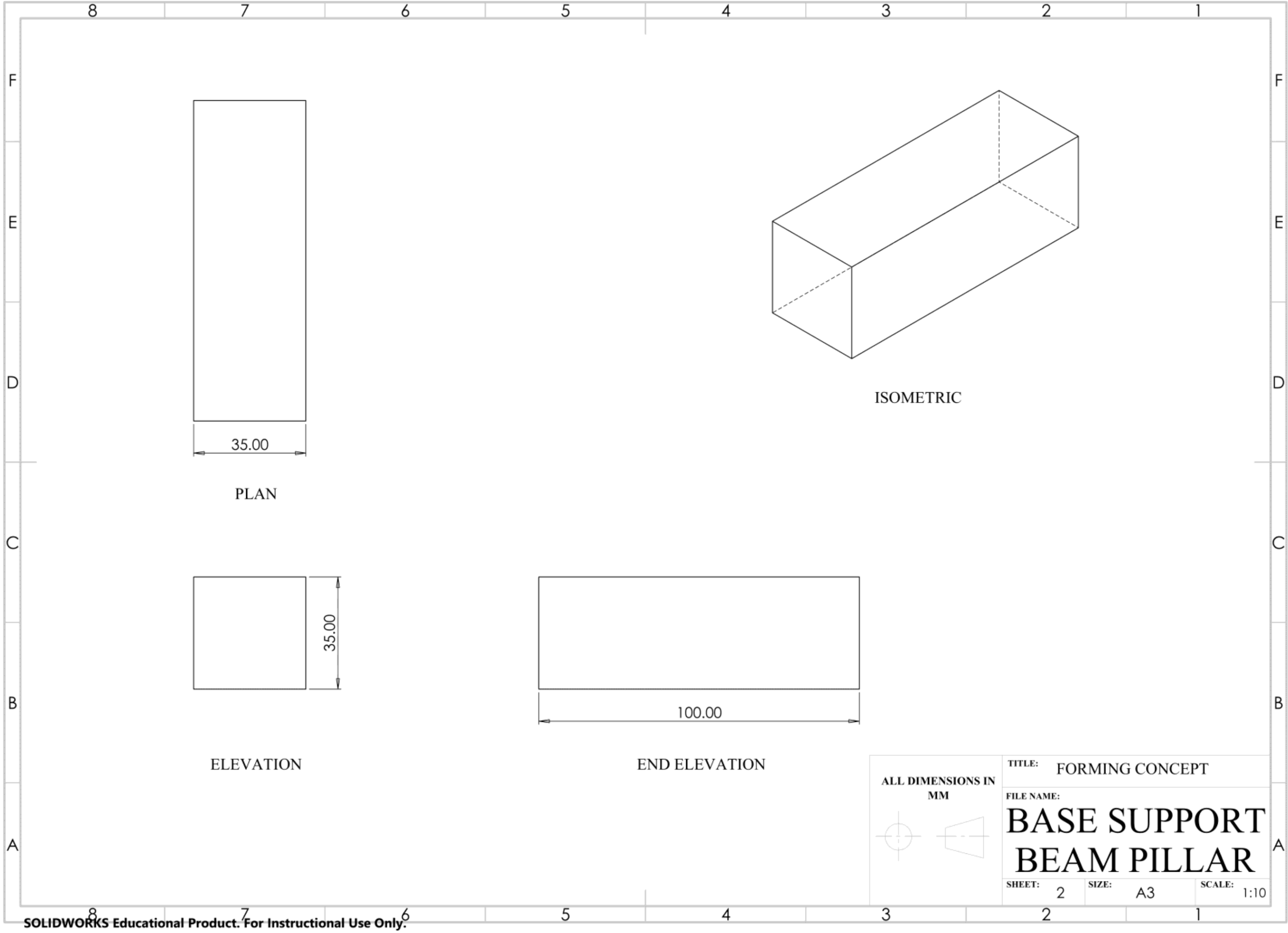


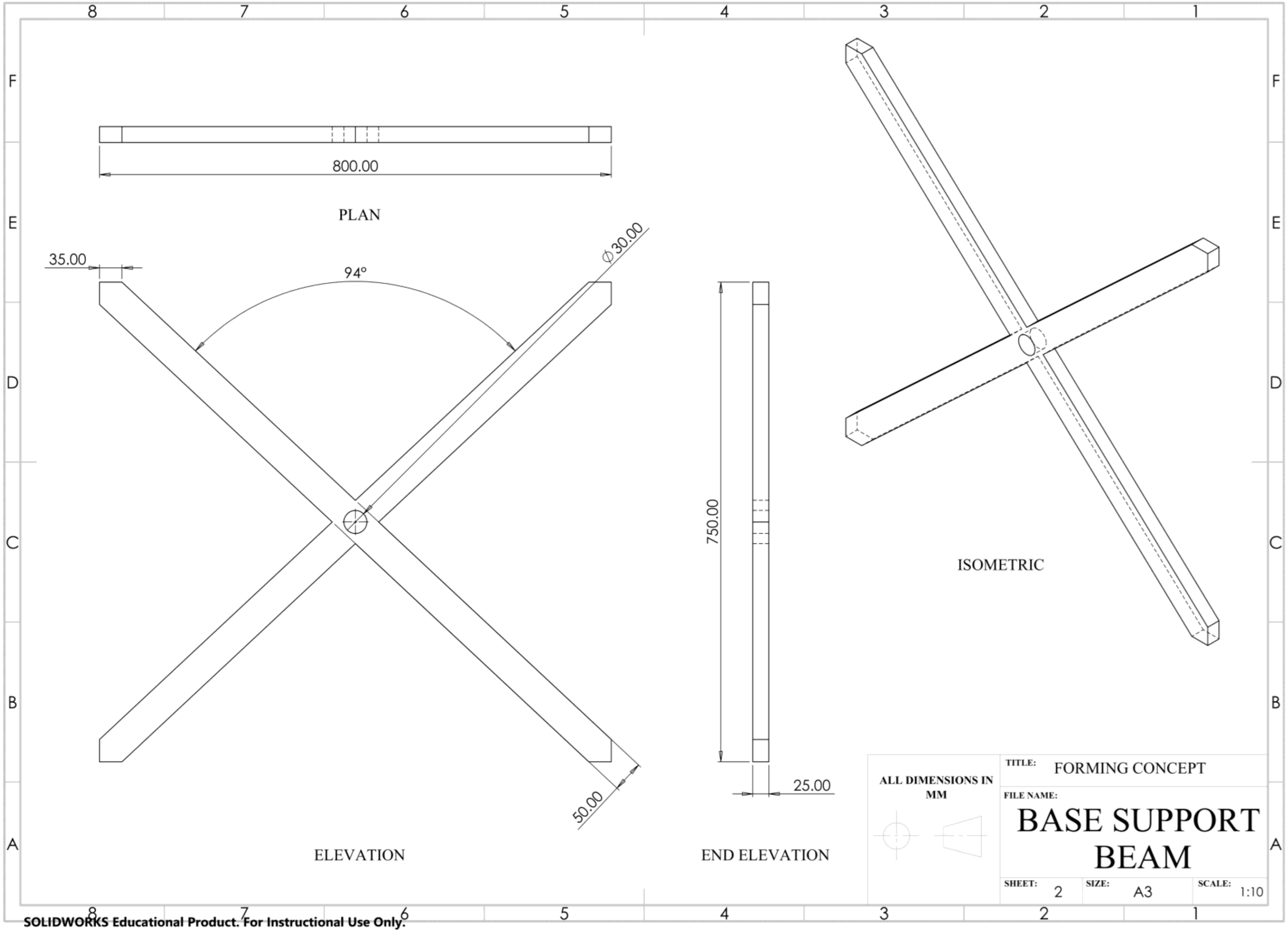
PLAN
15.00
10.00
A
800.00
12.00
75.00
Ø4.00
15.00
30.00
10.00
6.00
DETAIL A
SCALE 1 : 1
□70.00
93.87°
70.00
B
5.00
30.00
10.00
DETAIL B
SCALE 1 : 1
1510.00
35.00
680.00
Ø30.00
72.50
15.00
35.00
110.00
ELEVATION
END ELEVATION
ISOMETRIC
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
BASE FULL
SHEET: 2
SIZE: A3
SCALE: 1:10
SOLIDWORKS Educational Product. For Instructional Use Only.

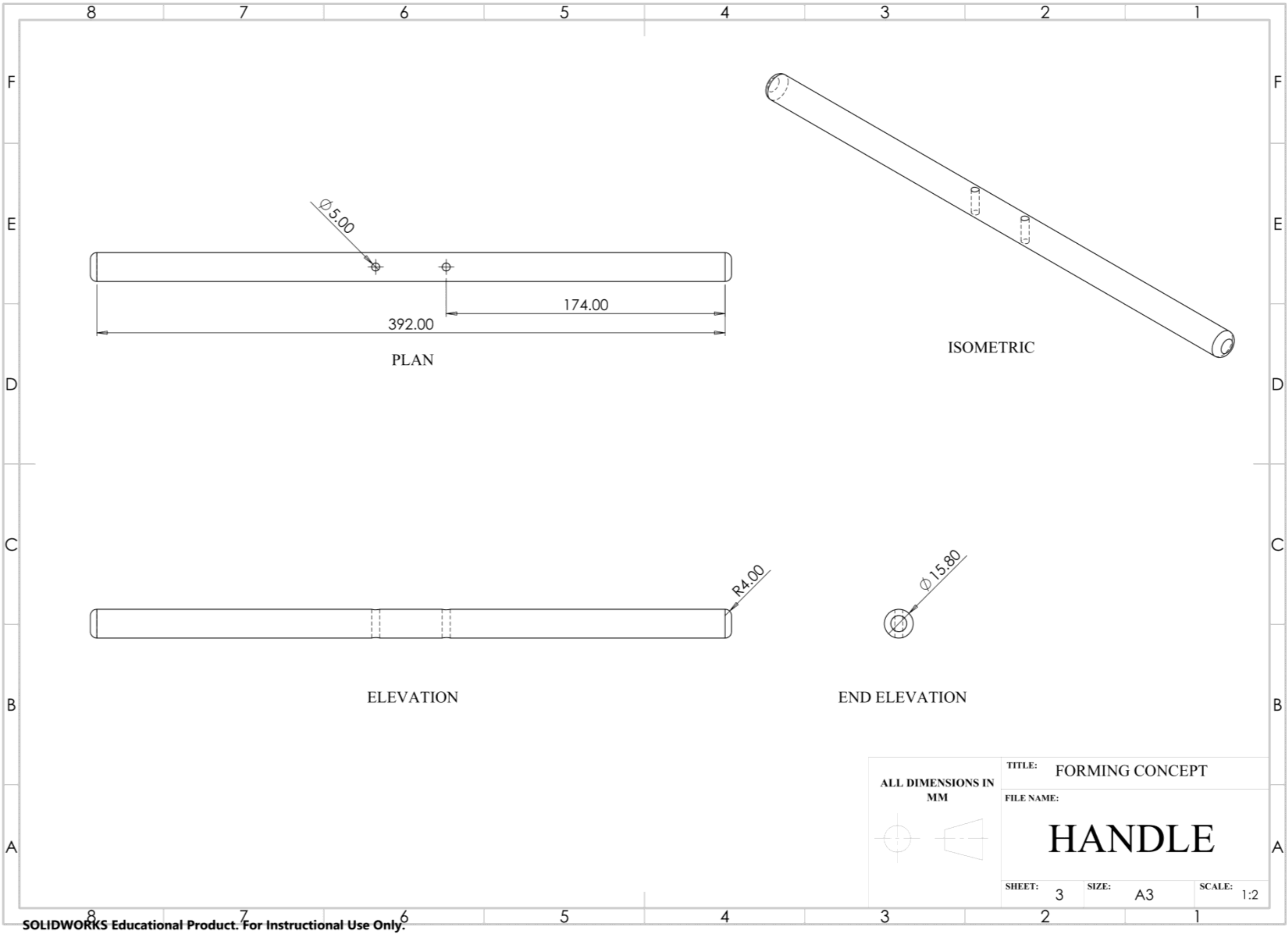


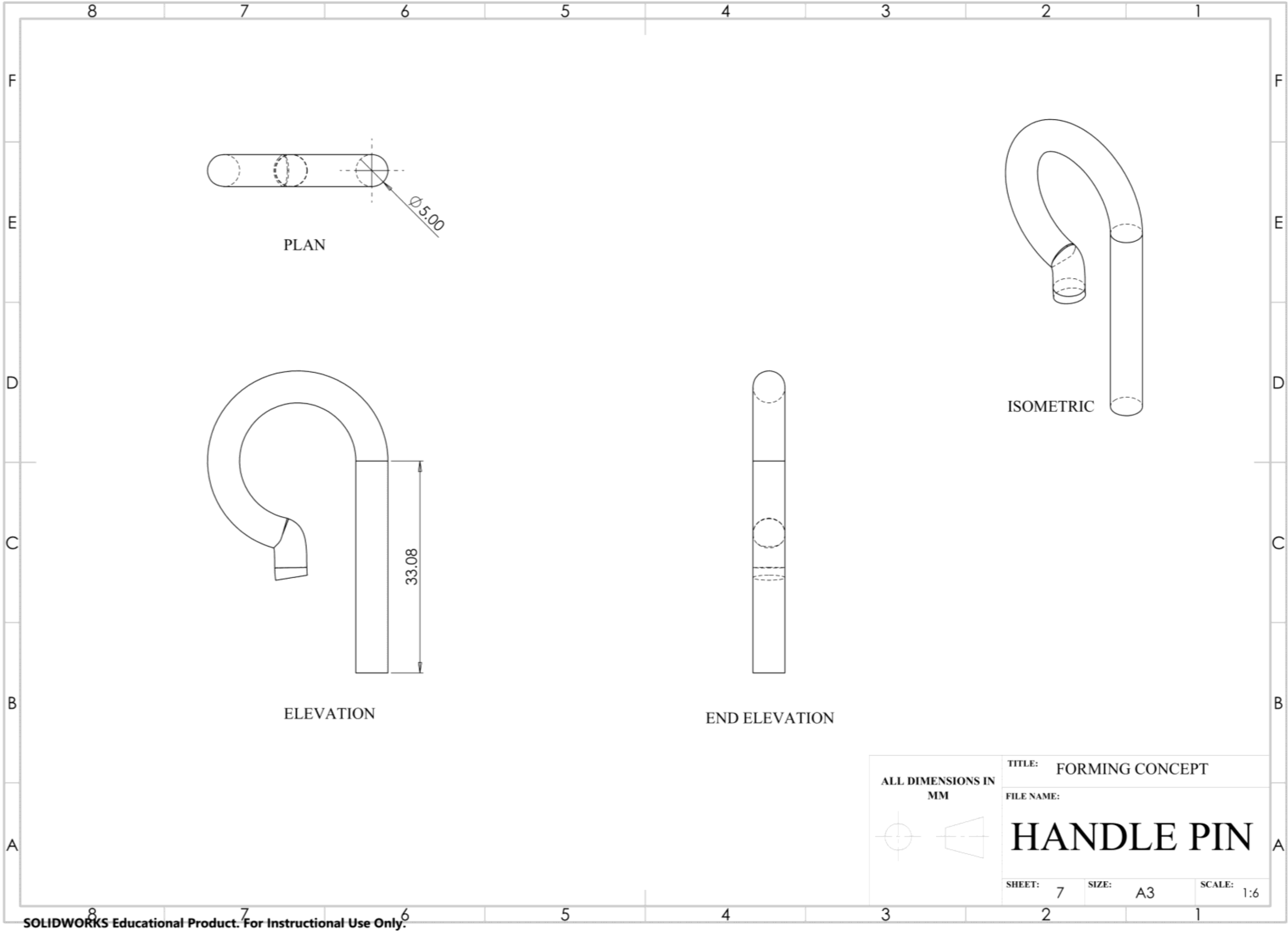
15.00
6.00
10.00
∅4.00
30.00
30.00
DETAIL H
SCALE 1 : 1
PLAN
12.00
70.00
72.50
□70.00
1510.00
800.00
72.50
15.00
ELEVATION
END ELEVATION
ISOMETRIC
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
BASE FLOOR
SHEET: 2
SIZE: A3
SCALE: 1:10
SOLIDWORKS Educational Product. For Instructional Use Only.

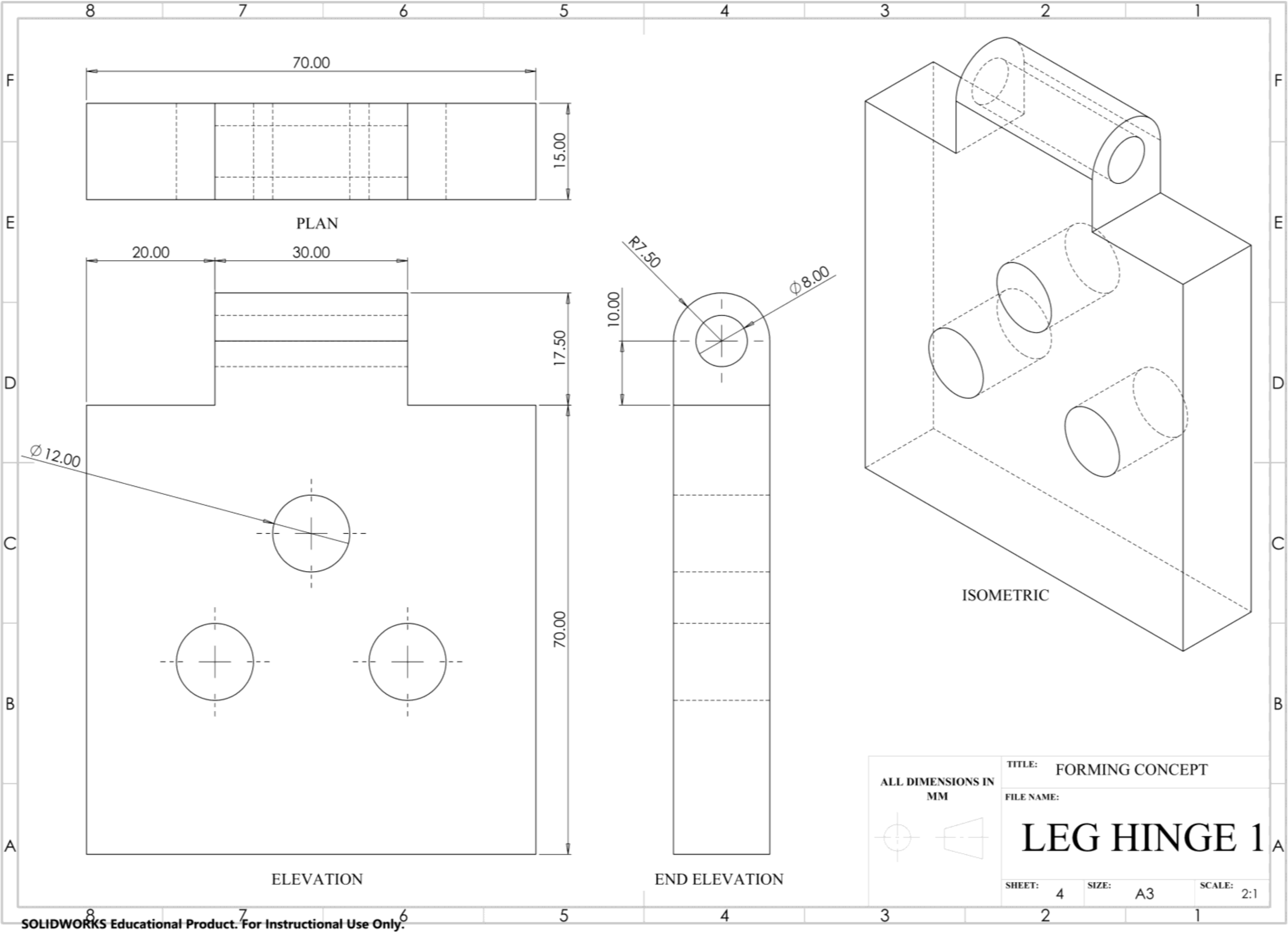

10.00
15.00
35.00
PLAN
1510.00
ELEVATION
75.00
END ELEVATION
ISOMETRIC
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
BASE WALL
SHEET: 2
SIZE: A3
SCALE: 1:10
SOLIDWORKS Educational Product. For Instructional Use Only.

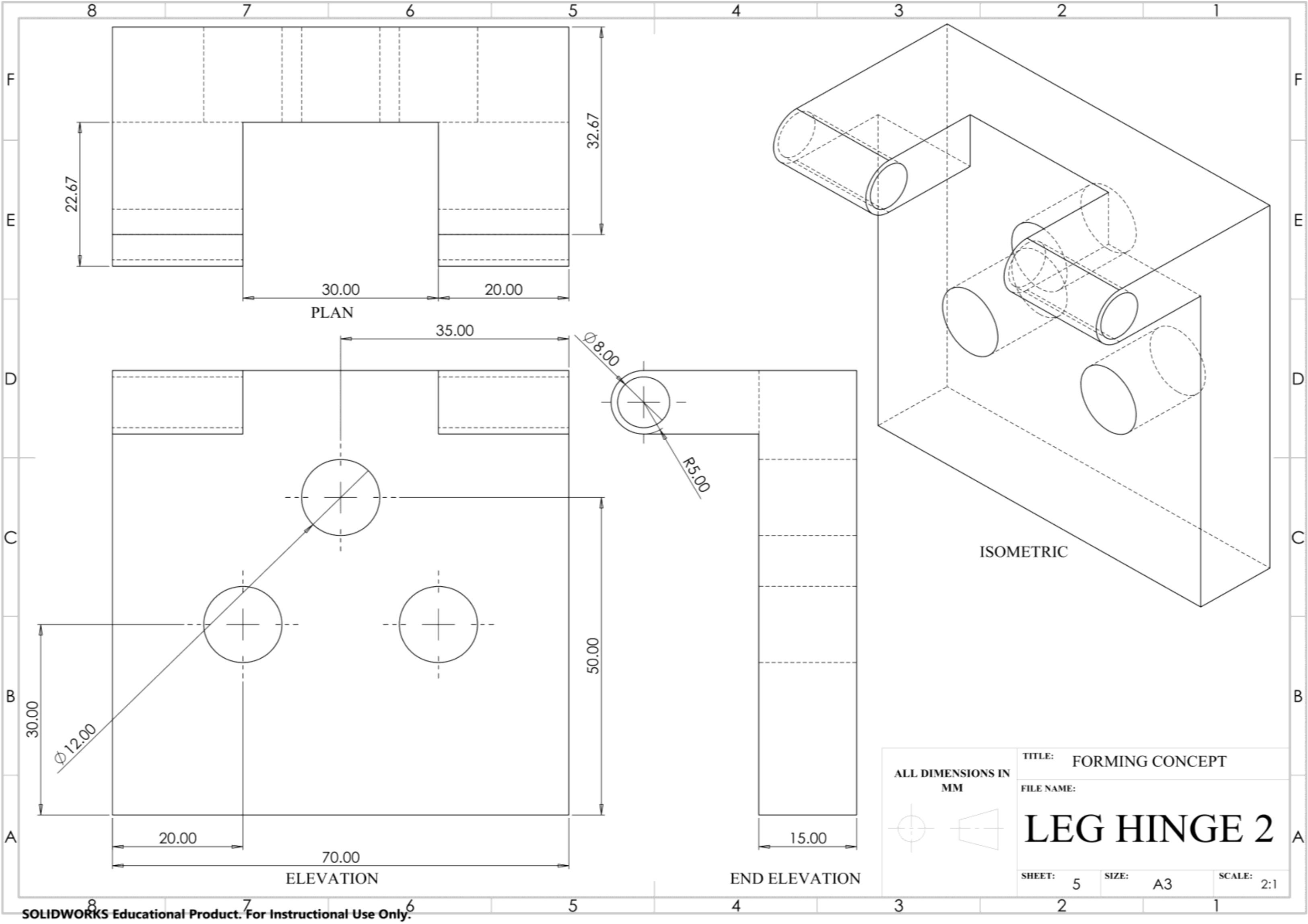

35.00
PLAN
ISOMETRIC
35.00
100.00
ELEVATION
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
BASE SUPPORT BEAM PILLAR
SHEET: 2
SIZE: A3
SCALE: 1:10
SOLIDWORKS Educational Product. For Instructional Use Only.


800.00
PLAN
35.00
94°
Ø30.00
750.00
ISOMETRIC
50.00
25.00
ELEVATION
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
BASE SUPPORT BEAM
SHEET: 2
SIZE: A3
SCALE: 1:10
SOLIDWORKS Educational Product. For Instructional Use Only.

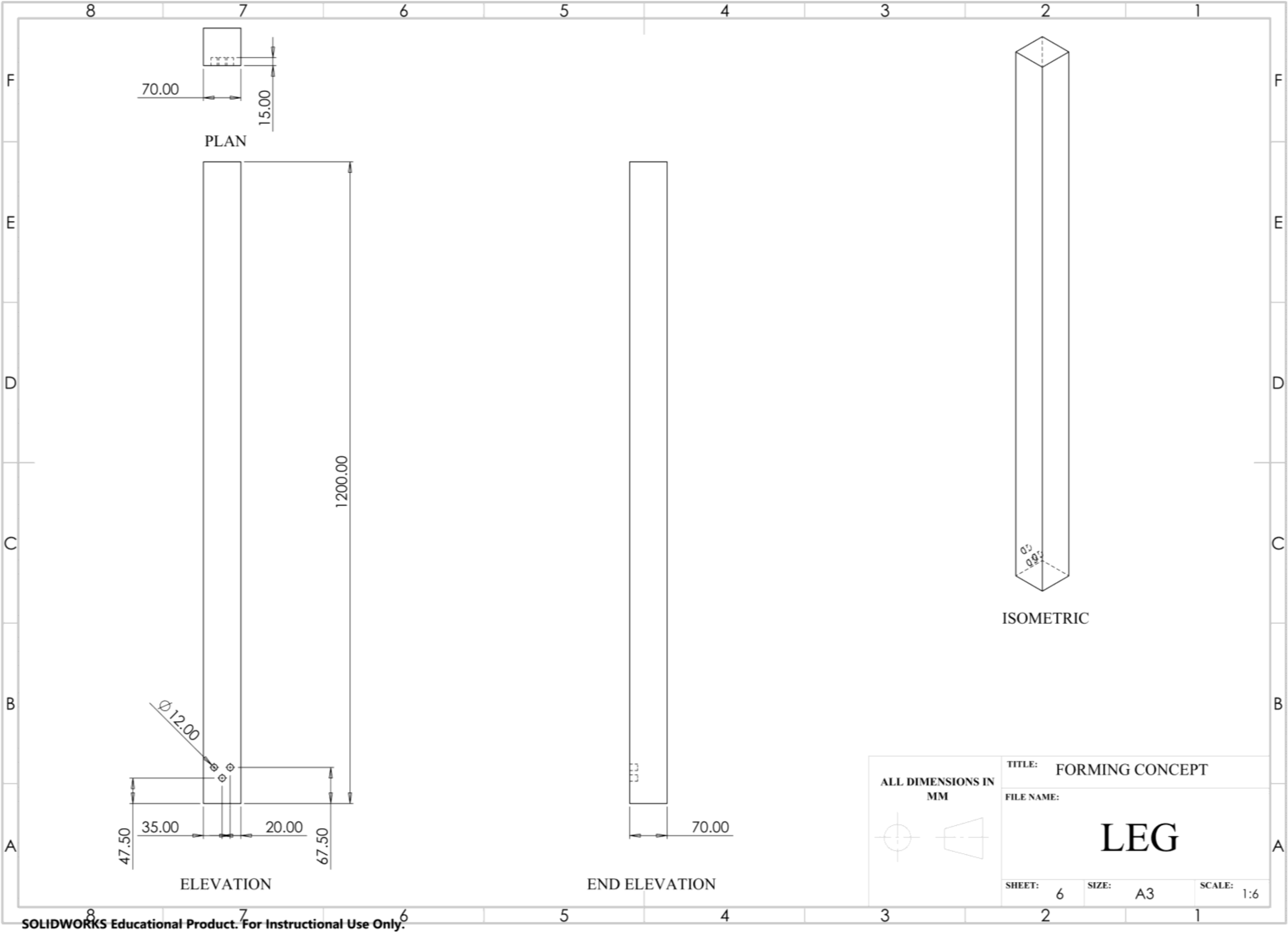

8
7
6
5
4
3
2
1
F
E
D
C
B
A
Ø5.00
174.00
392.00
PLAN
ISOMETRIC
R4.00
Ø15.80
ELEVATION
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
HANDLE
SHEET: 3
SIZE: A3
SCALE: 1:2
SOLIDWORKS Educational Product. For Instructional Use Only.

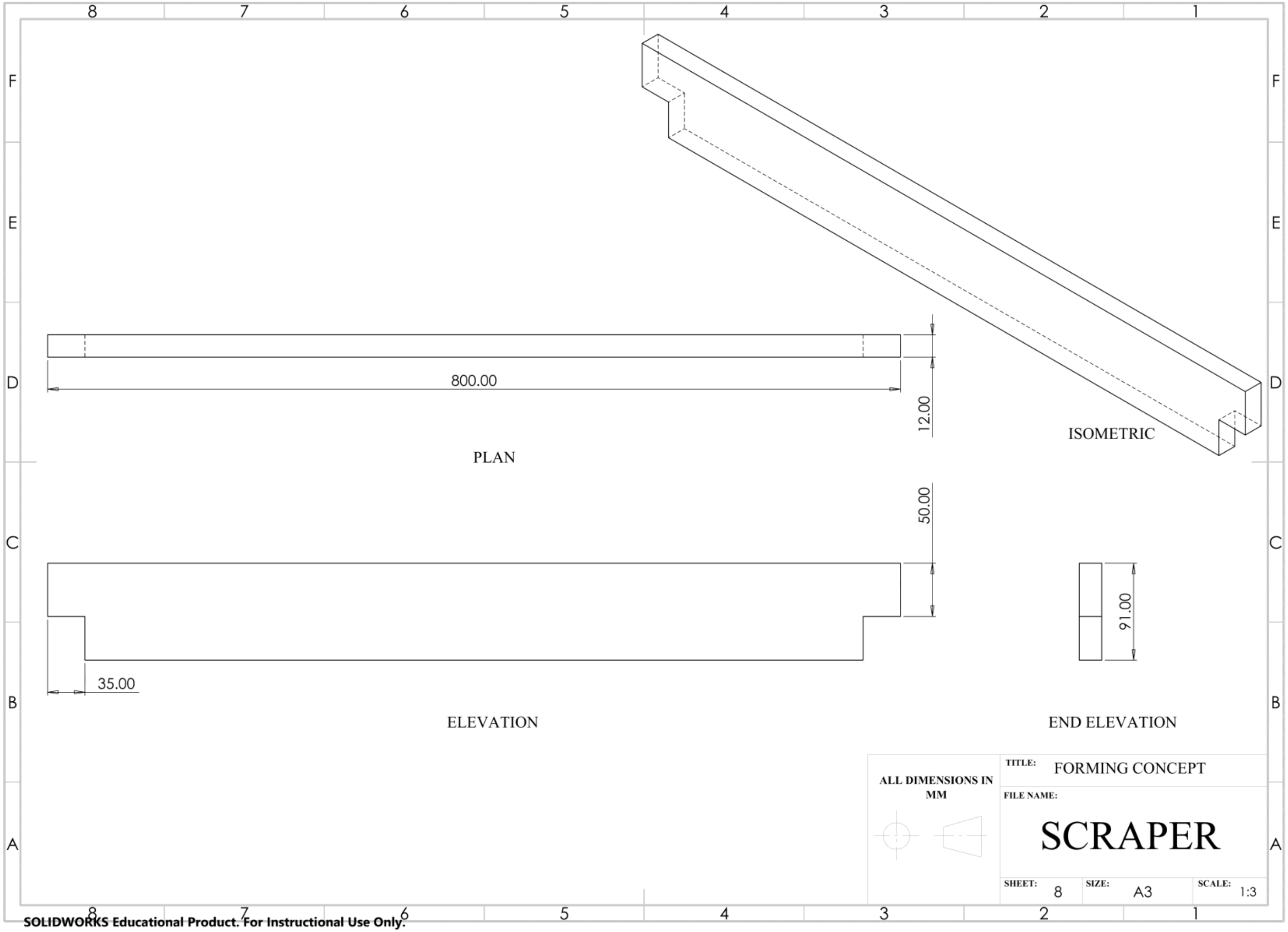

PLAN
Ø5.00
ELEVATION
33.08
END ELEVATION
ISOMETRIC
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
HANDLE PIN
SHEET: 7
SIZE: A3
SCALE: 1:6
SOLIDWORKS Educational Product. For Instructional Use Only.


70.00
15.00
PLAN
20.00
30.00
17.50
70.00
∅12.00
ELEVATION
R7.50
∅8.00
10.00
END ELEVATION
ISOMETRIC
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
LEG HINGE 1
SHEET: 4
SIZE: A3
SCALE: 2:1
SOLIDWORKS Educational Product. For Instructional Use Only.

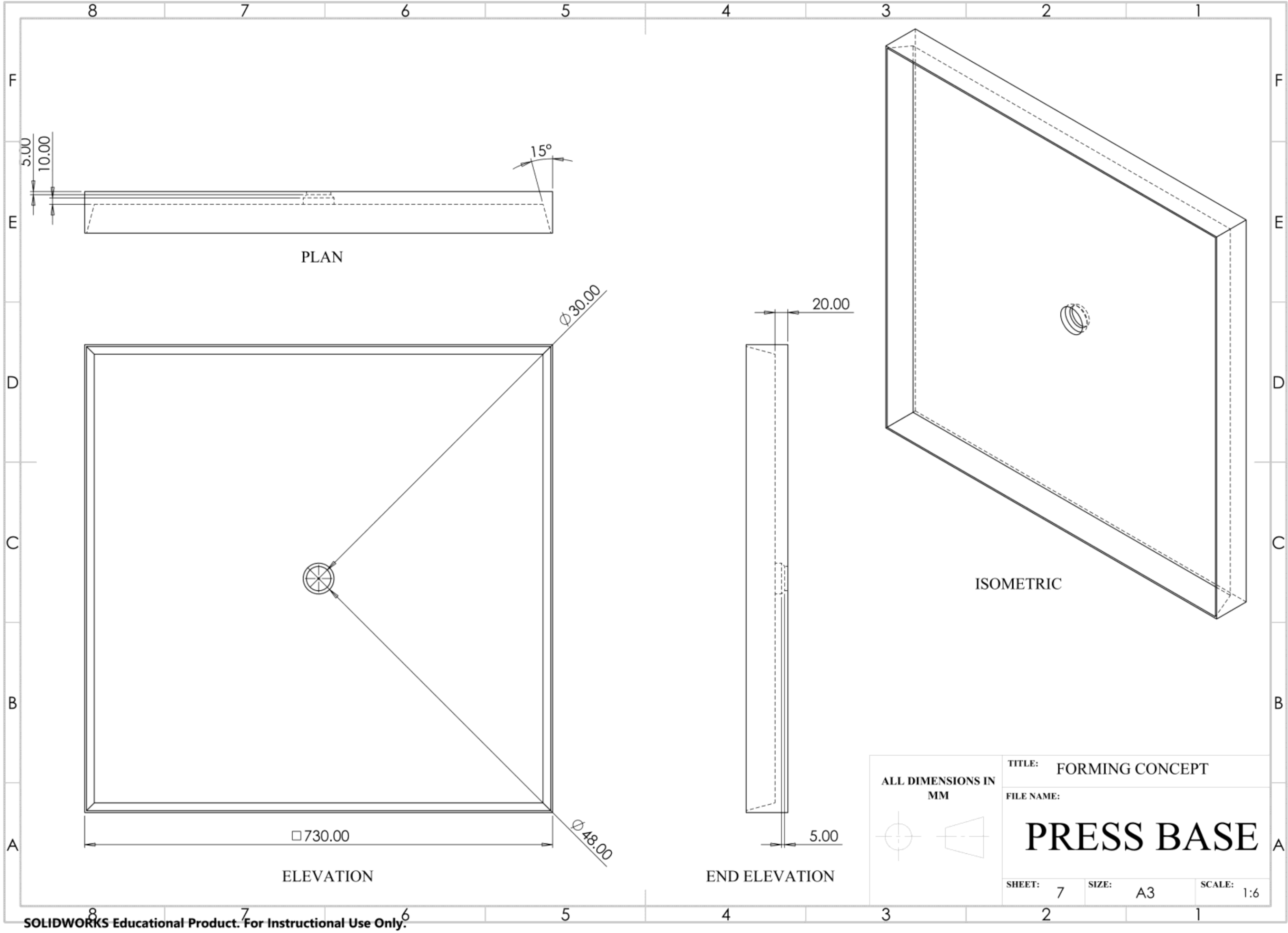


32.67
22.67
30.00
20.00
PLAN
35.00
Ø8.00
R5.00
50.00
30.00
Ø12.00
20.00
70.00
ELEVATION
15.00
END ELEVATION
ISOMETRIC
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
LEG HINGE 2
SHEET: 5
SIZE: A3
SCALE: 2:1
SOLIDWORKS Educational Product. For Instructional Use Only.

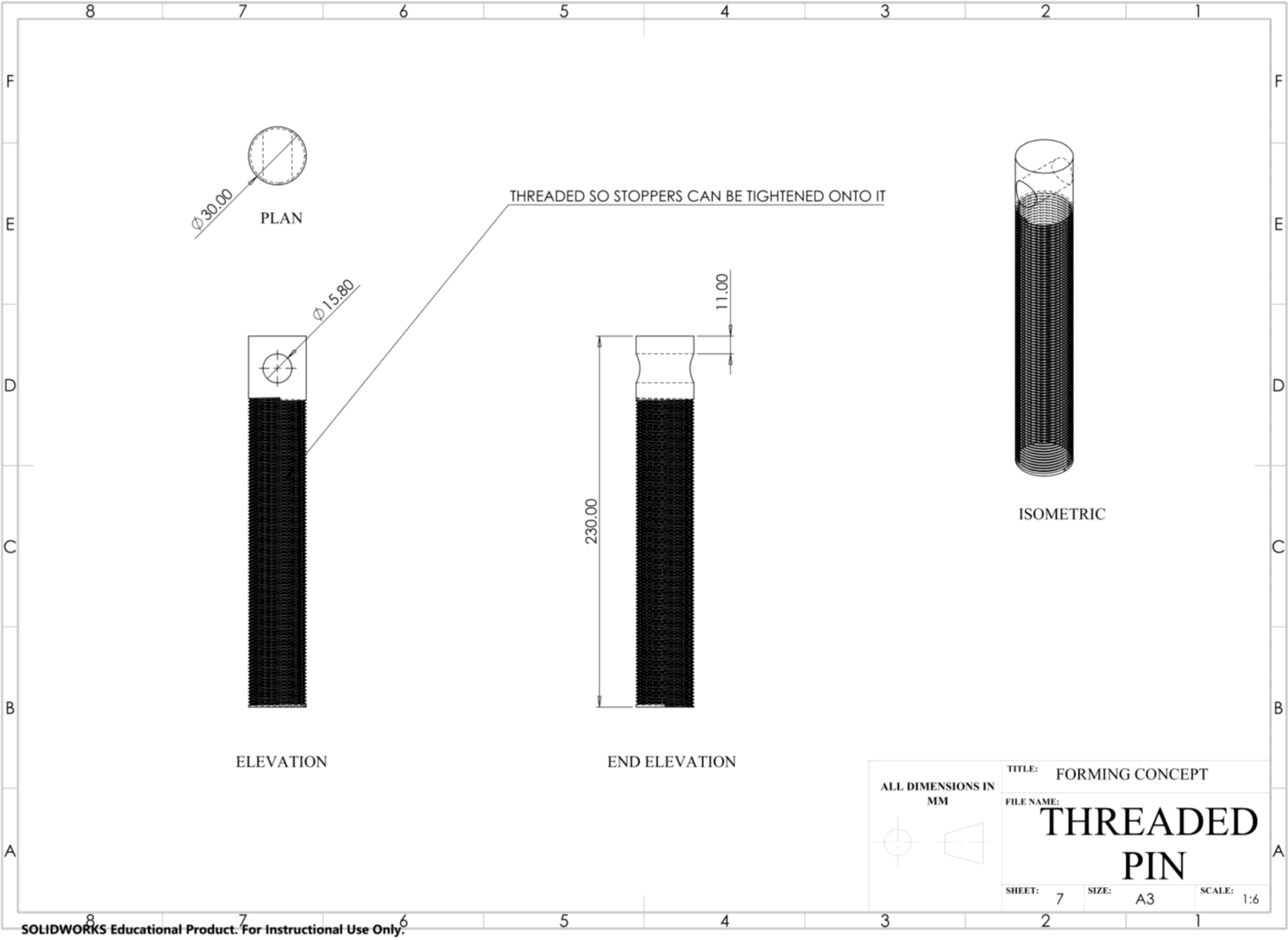

70.00
15.00
PLAN
1200.00
Ø12.00
35.00
20.00
47.50
67.50
ELEVATION
70.00
END ELEVATION
ISOMETRIC
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
LEG
SHEET: 6
SIZE: A3
SCALE: 1:6
SOLIDWORKS Educational Product. For Instructional Use Only.

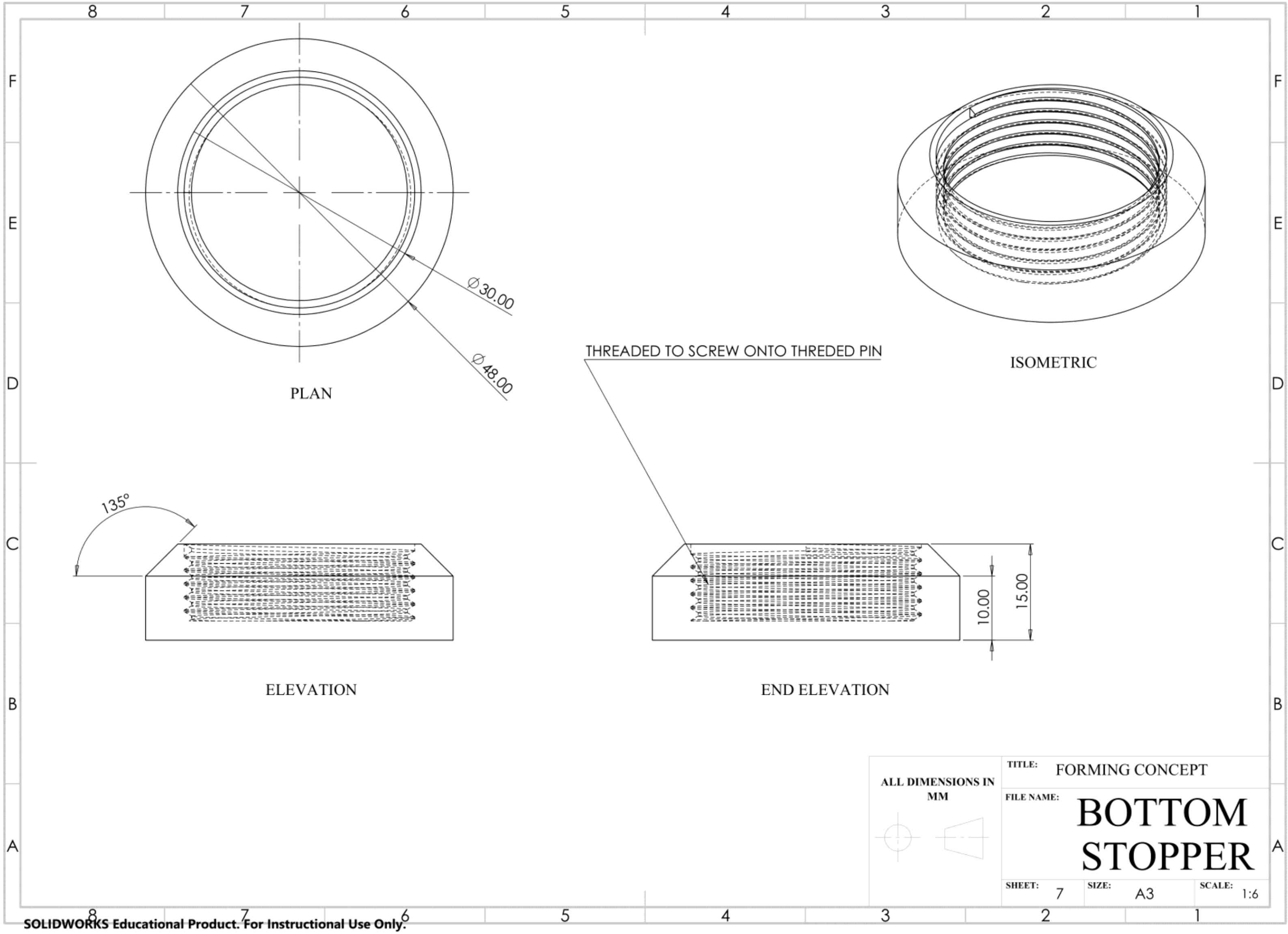


PLAN
800.00
12.00
ISOMETRIC
ELEVATION
50.00
35.00
END ELEVATION
91.00
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
SCRAPER
SHEET: 8
SIZE: A3
SCALE: 1:3
SOLIDWORKS Educational Product. For Instructional Use Only.

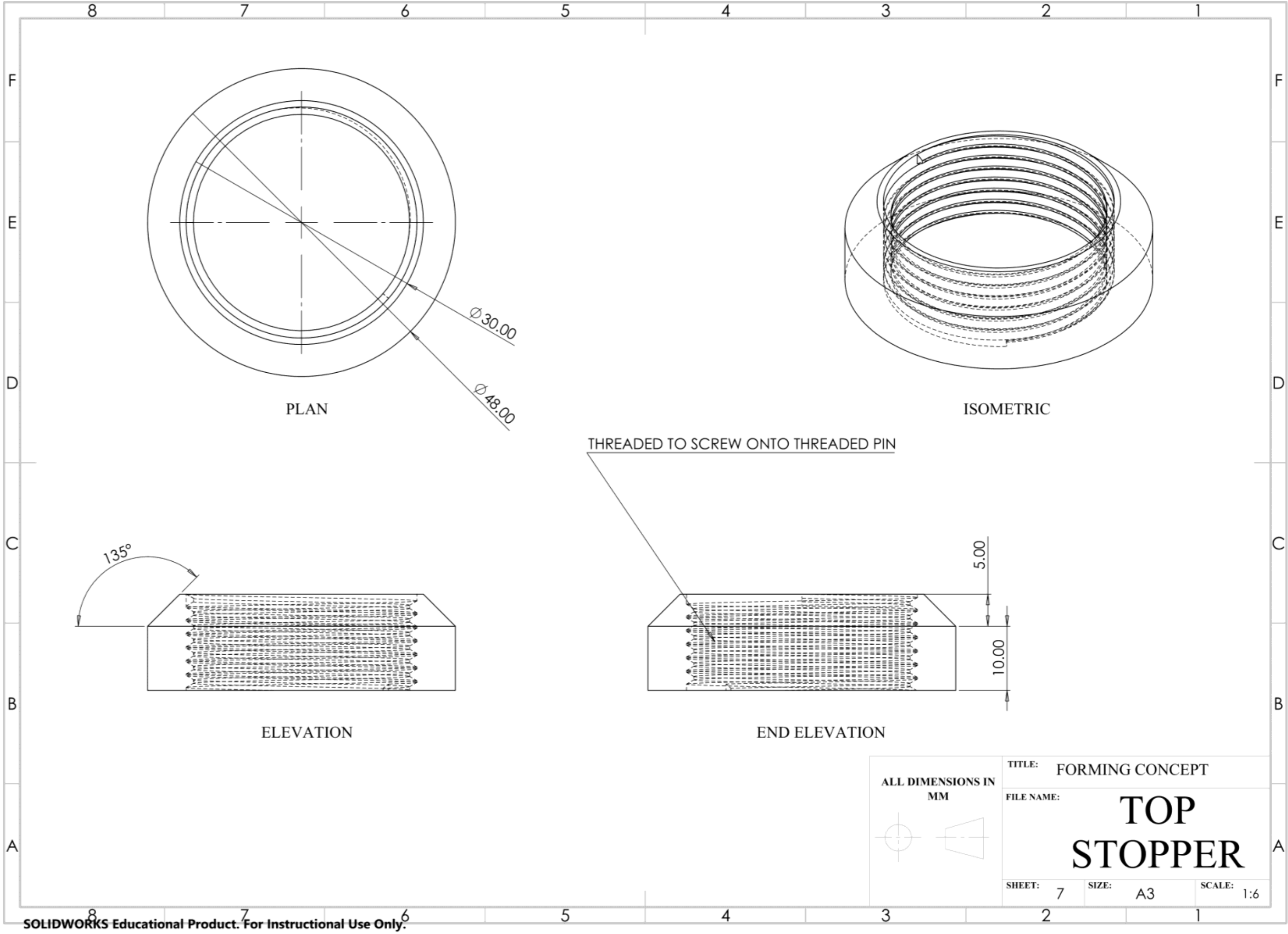


5.00
10.00
15°
PLAN
⌀30.00
20.00
ISOMETRIC
□730.00
⌀48.00
5.00
ELEVATION
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
PRESS BASE
SHEET: 7
SIZE: A3
SCALE: 1:6
SOLIDWORKS Educational Product. For Instructional Use Only.

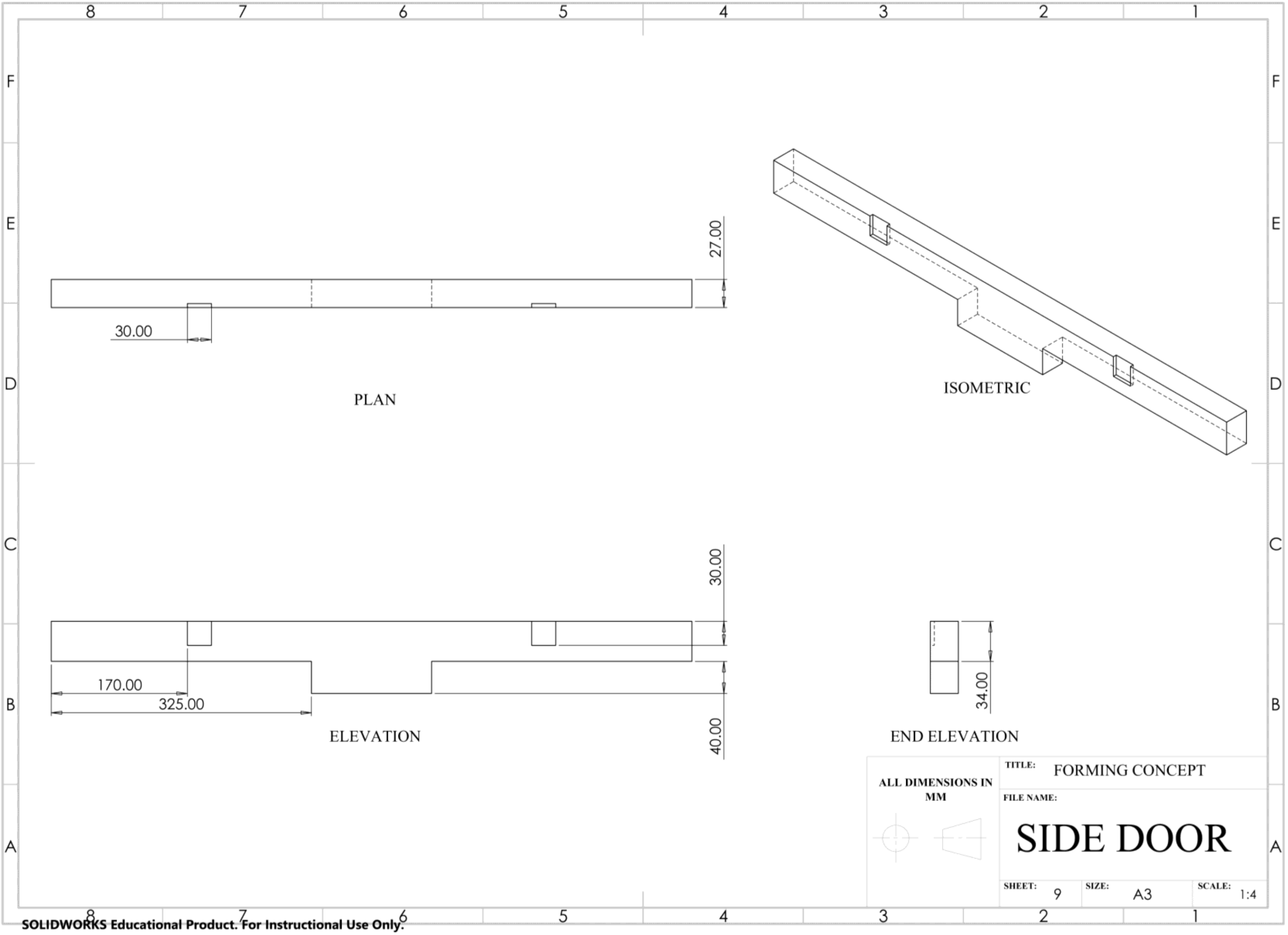

8
7
6
5
4
3
2
1
F
E
D
C
B
A
Ø30.00
PLAN
THREADED SO STOPPERS CAN BE TIGHTENED ONTO IT
Ø15.80
11.00
230.00
ISOMETRIC
ELEVATION
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME: THREADED PIN
SHEET: 7
SIZE: A3
SCALE: 1:6
SOLIDWORKS Educational Product. For Instructional Use Only.

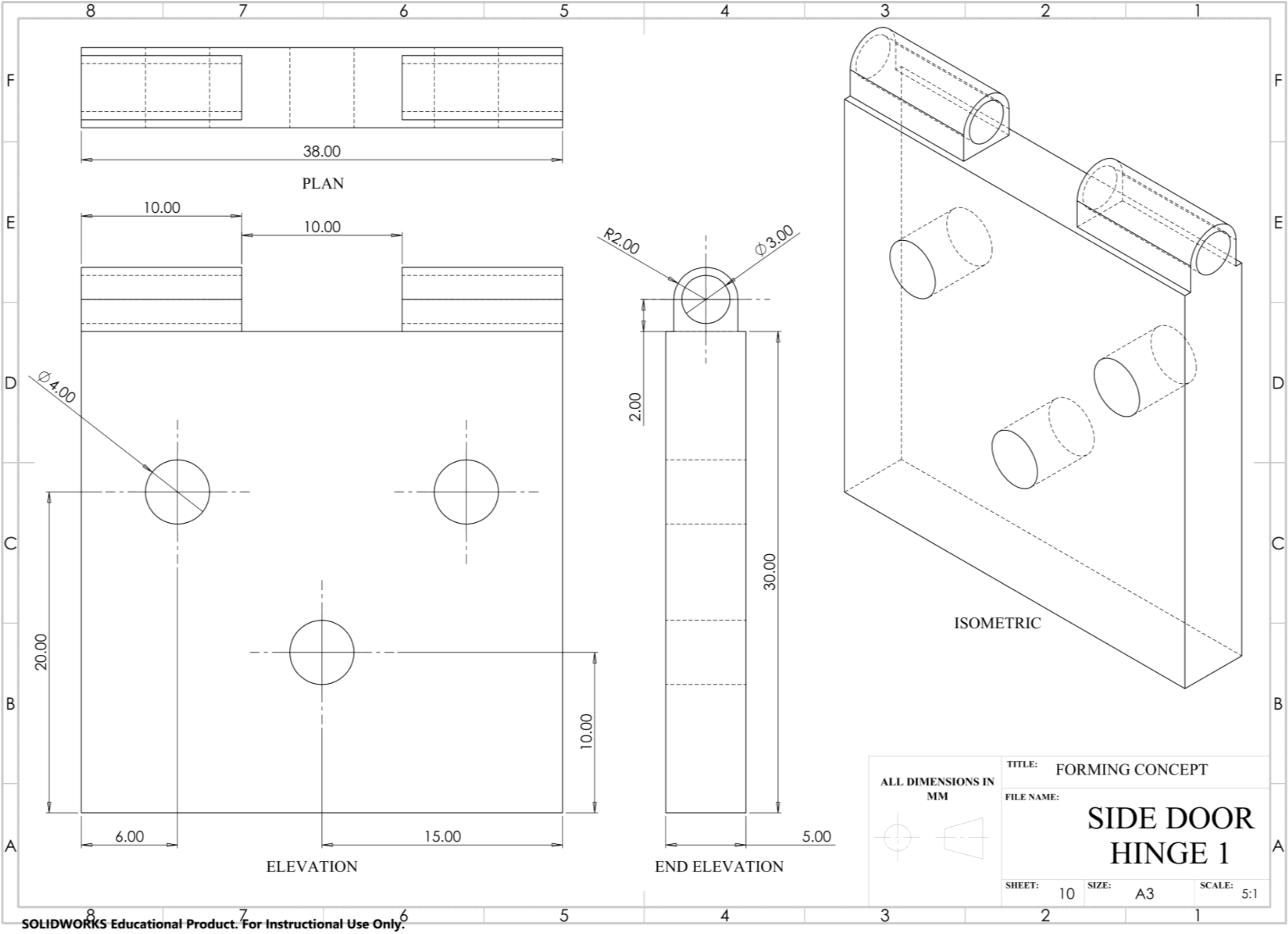


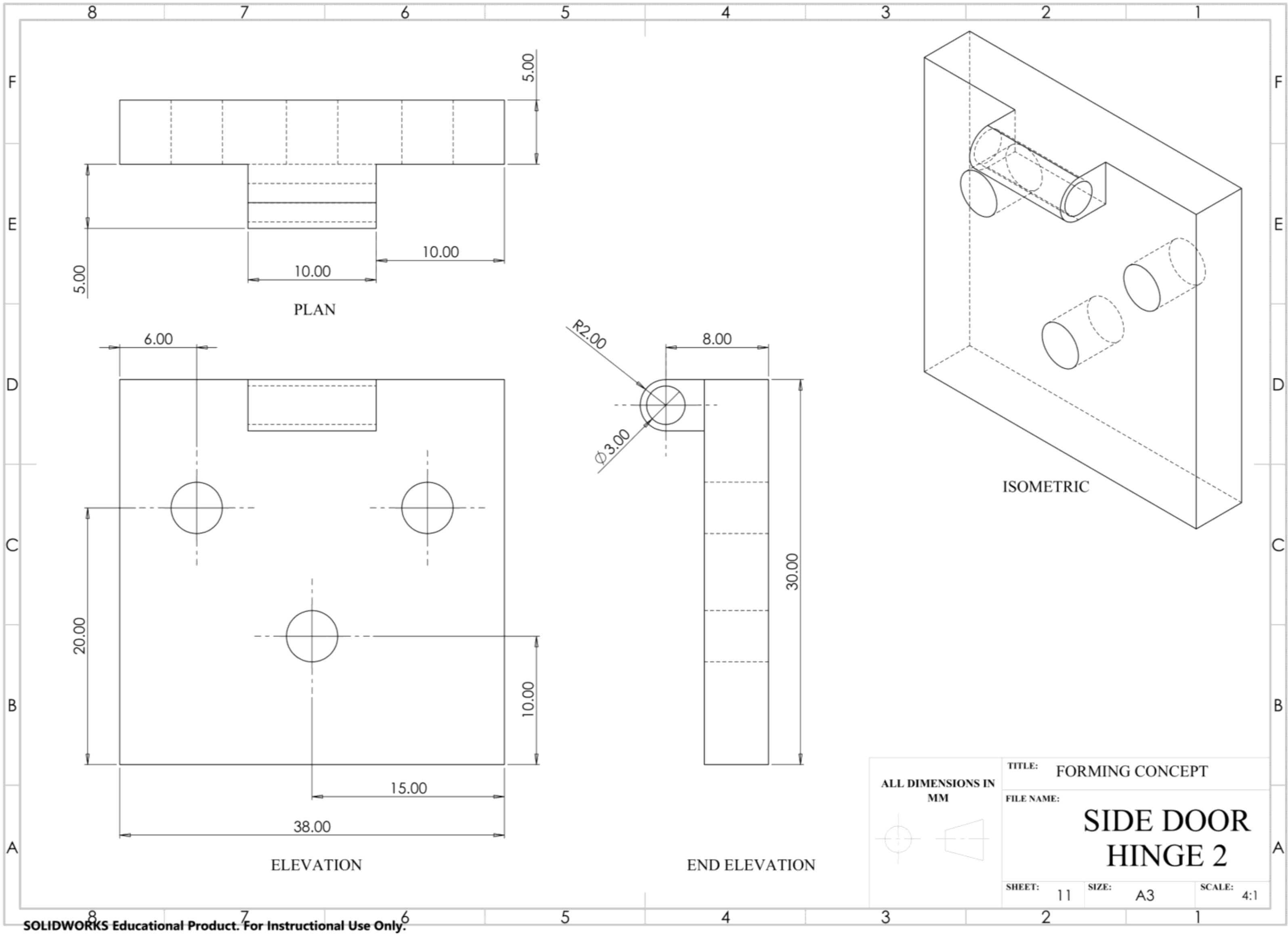
∅30.00
∅48.00
PLAN
THREADED TO SCREW ONTO THREDED PIN
ISOMETRIC
135°
ELEVATION
10.00
15.00
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME: BOTTOM STOPPER
SHEET: 7
SIZE: A3
SCALE: 1:6
SOLIDWORKS Educational Product. For Instructional Use Only.

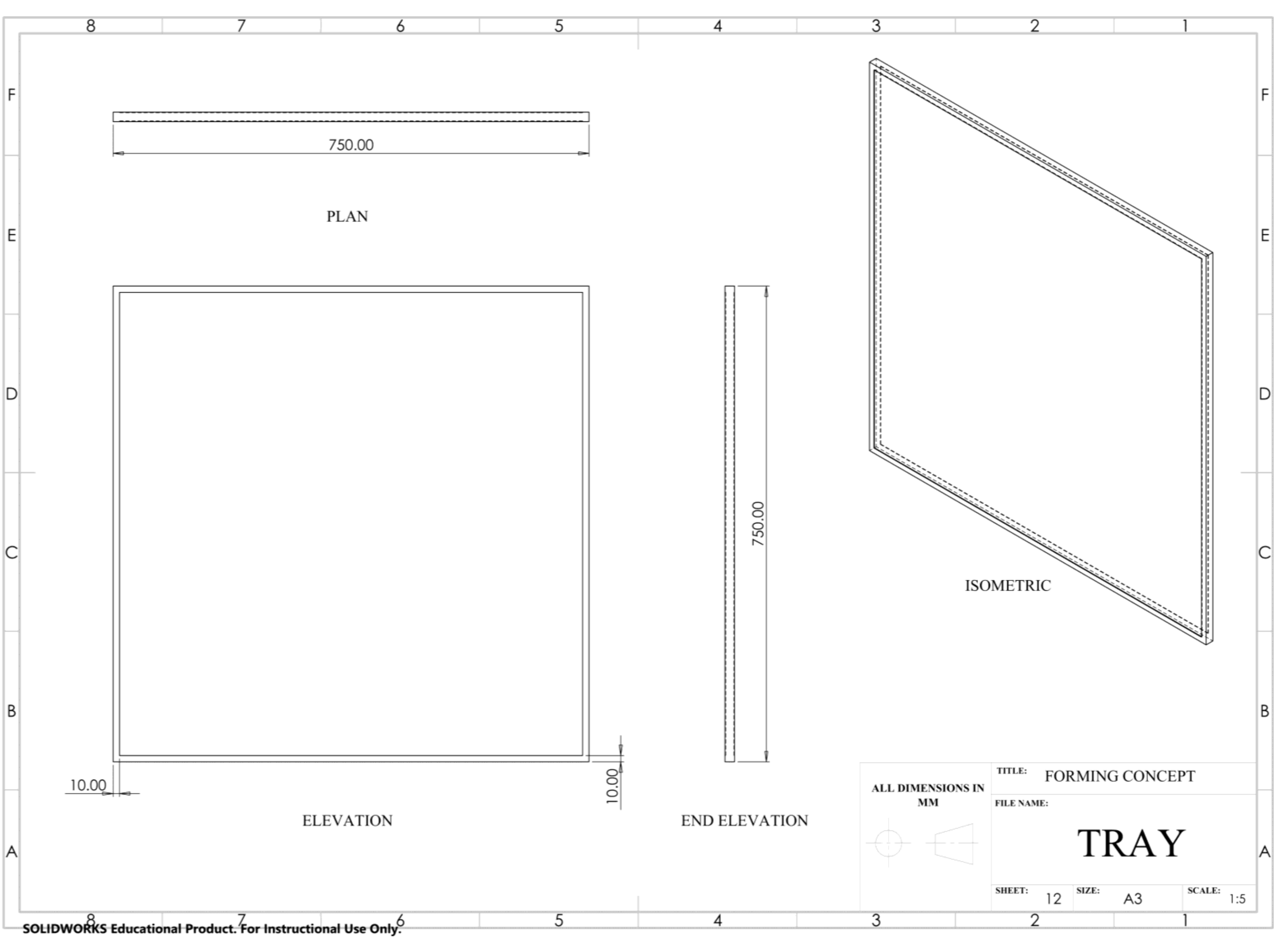


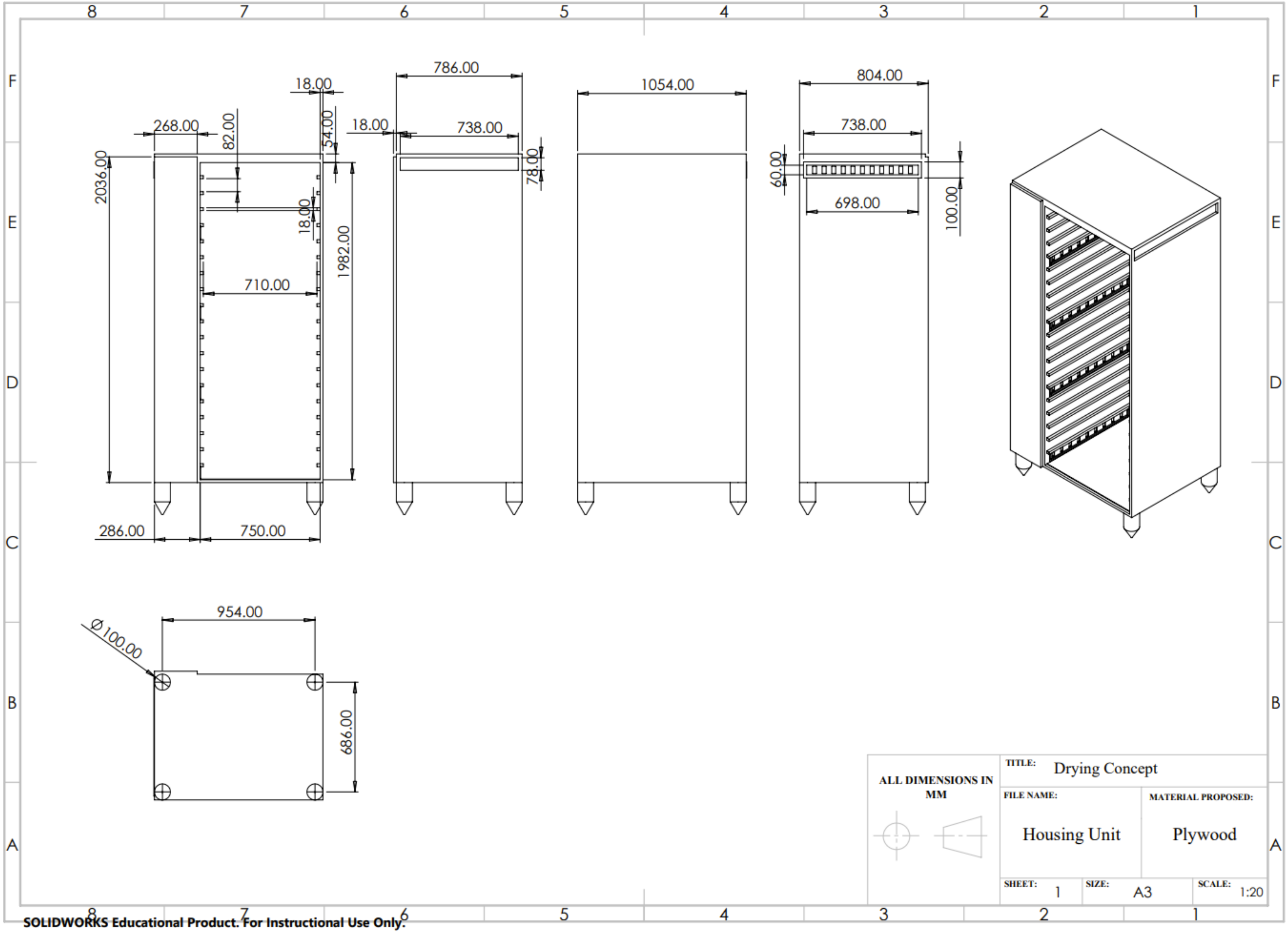
PLAN
∅30.00
∅48.00
ISOMETRIC
THREADED TO SCREW ONTO THREADED PIN
135°
ELEVATION
5.00
10.00
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME: TOP STOPPER
SHEET: 7
SIZE: A3
SCALE: 1:6
SOLIDWORKS Educational Product. For Instructional Use Only.


8
7
6
5
4
3
2
1
F
E
D
C
B
A
27.00
30.00
PLAN
ISOMETRIC
30.00
170.00
325.00
40.00
34.00
ELEVATION
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
SIDE DOOR
SHEET: 9
SIZE: A3
SCALE: 1:4
SOLIDWORKS Educational Product. For Instructional Use Only.

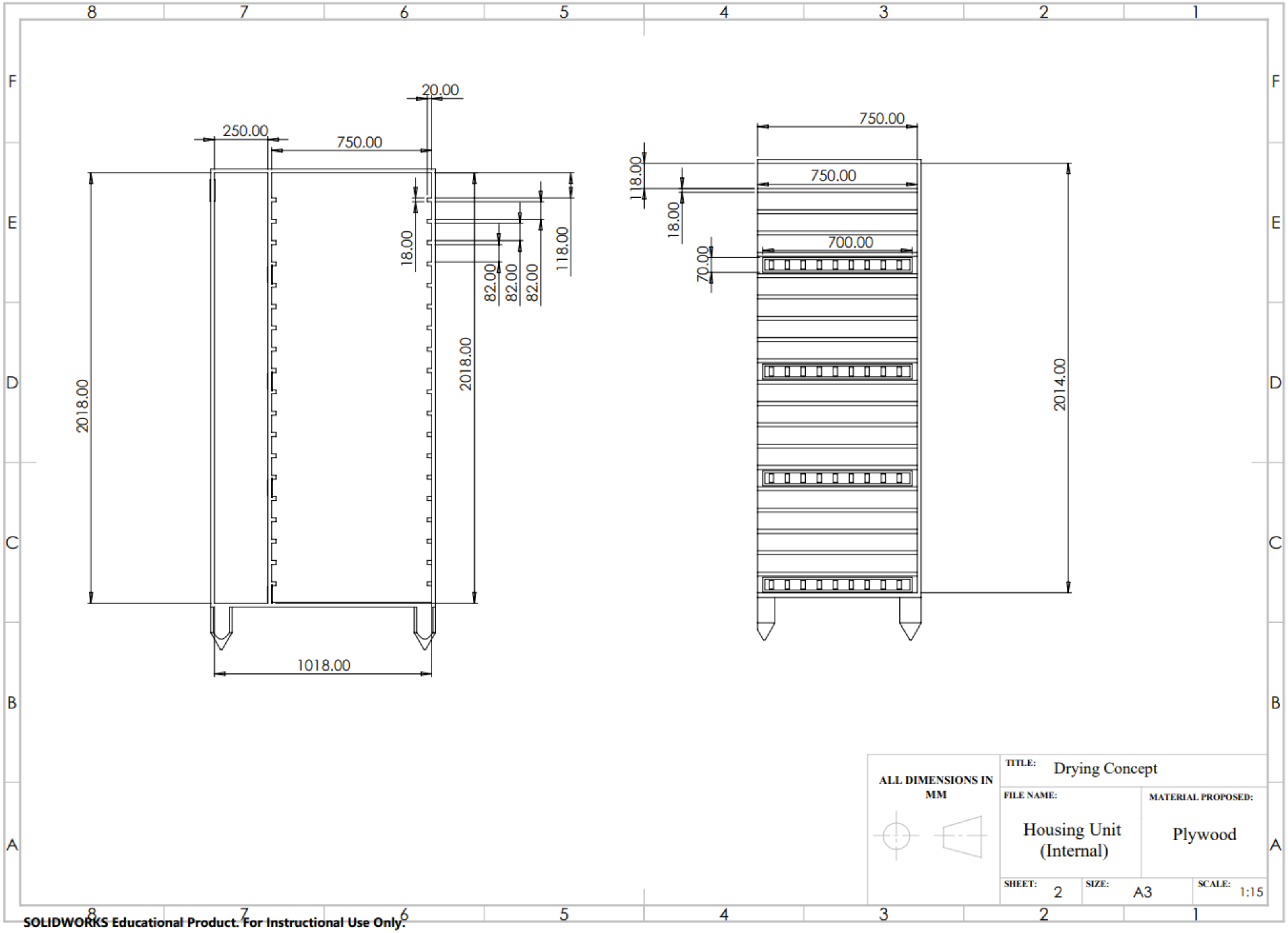

38.00
PLAN
10.00
10.00
R2.00
⌀3.00
⌀4.00
2.00
30.00
20.00
10.00
6.00
15.00
5.00
ELEVATION
END ELEVATION
ISOMETRIC
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME: SIDE DOOR HINGE 1
SHEET: 10
SIZE: A3
SCALE: 5:1
SOLIDWORKS Educational Product. For Instructional Use Only.

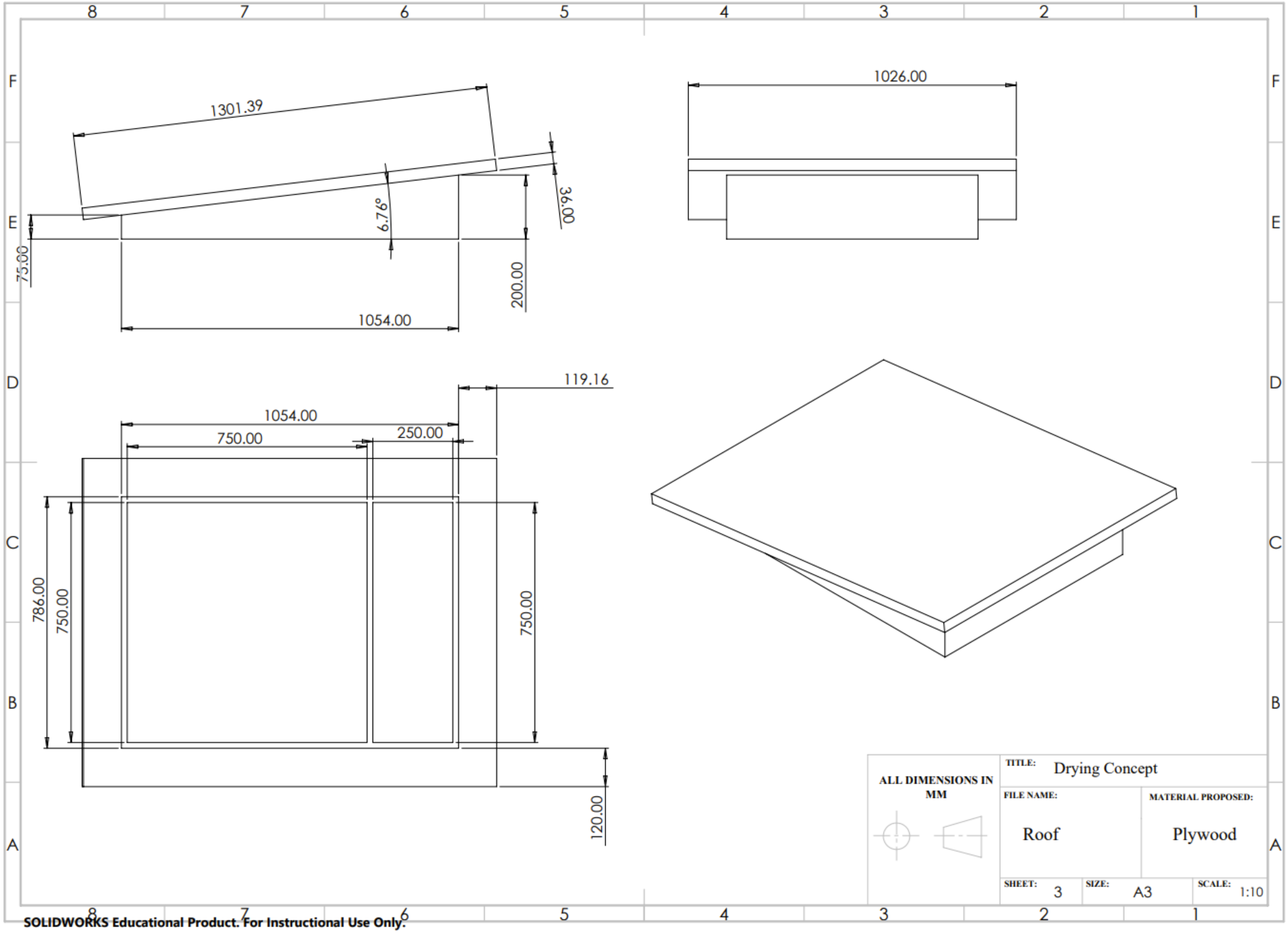

PLAN
5.00
5.00
10.00
10.00
ELEVATION
6.00
20.00
10.00
15.00
38.00
END ELEVATION
R2.00
⌀3.00
8.00
30.00
ISOMETRIC
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME: SIDE DOOR HINGE 2
SHEET: 11
SIZE: A3
SCALE: 4:1
SOLIDWORKS Educational Product. For Instructional Use Only.

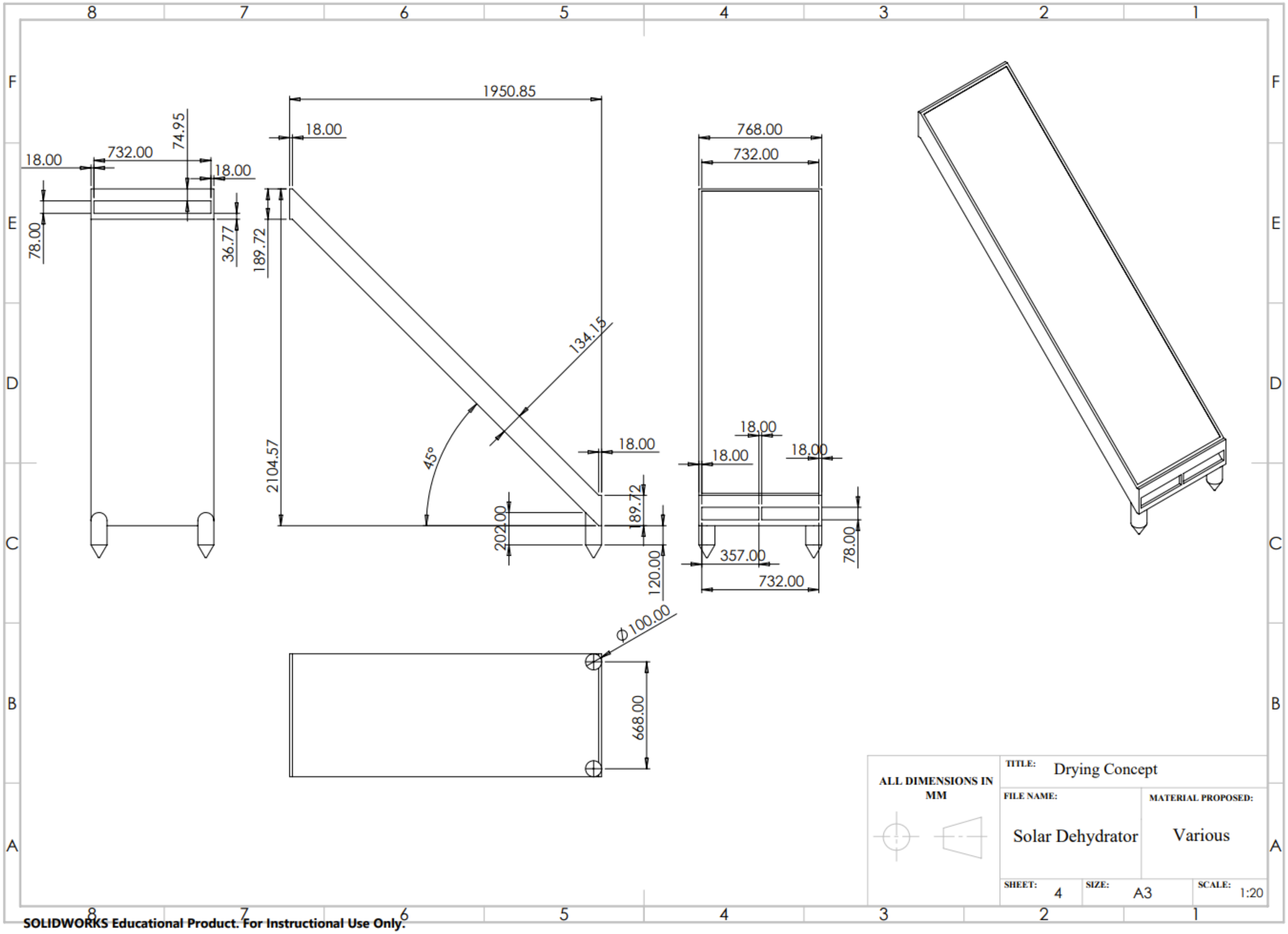

750.00
PLAN
750.00
ISOMETRIC
10.00
10.00
ELEVATION
END ELEVATION
ALL DIMENSIONS IN MM
TITLE: FORMING CONCEPT
FILE NAME:
TRAY
SHEET: 12
SIZE: A3
SCALE: 1:5
SOLIDWORKS Educational Product. For Instructional Use Only.

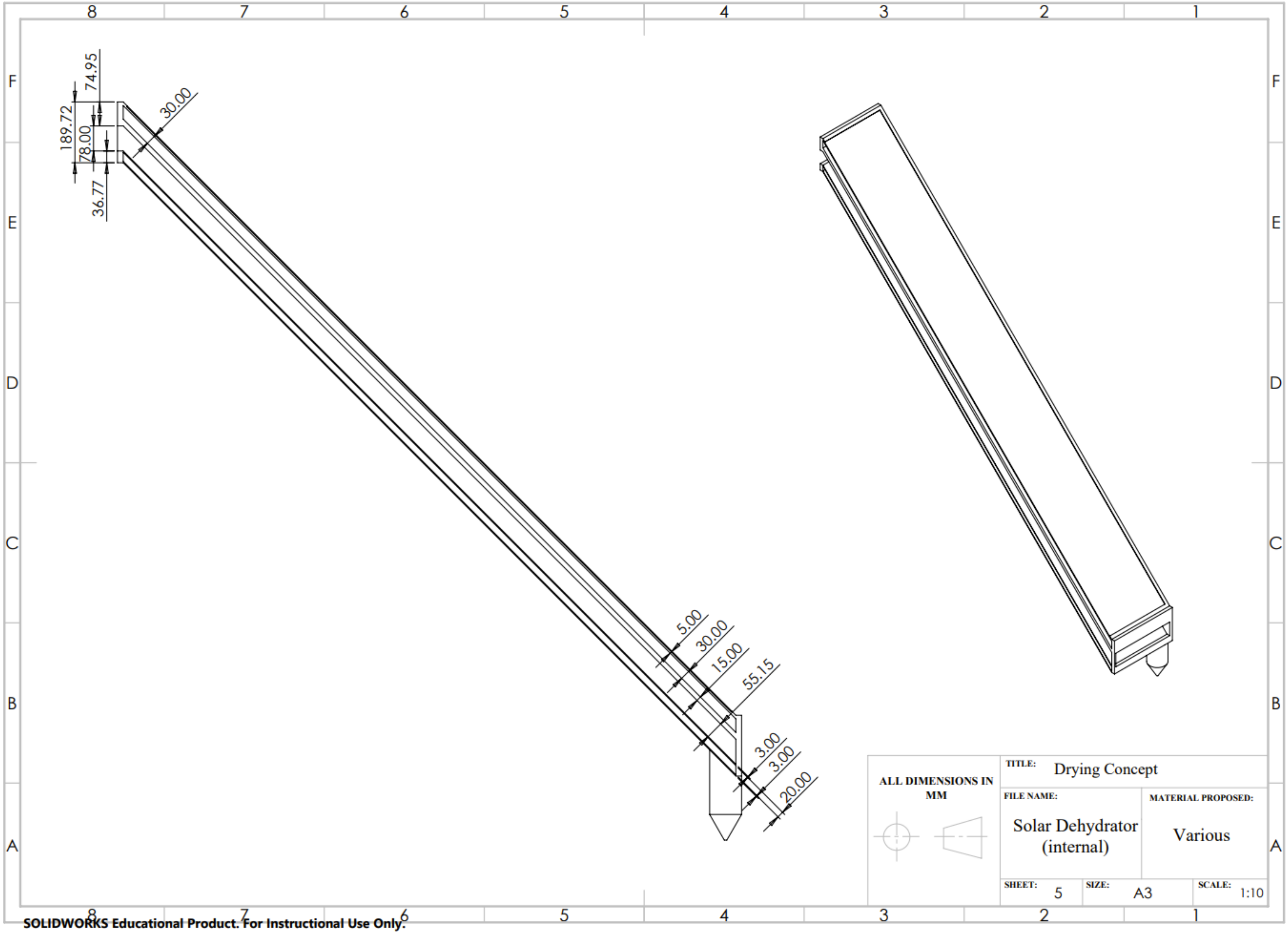


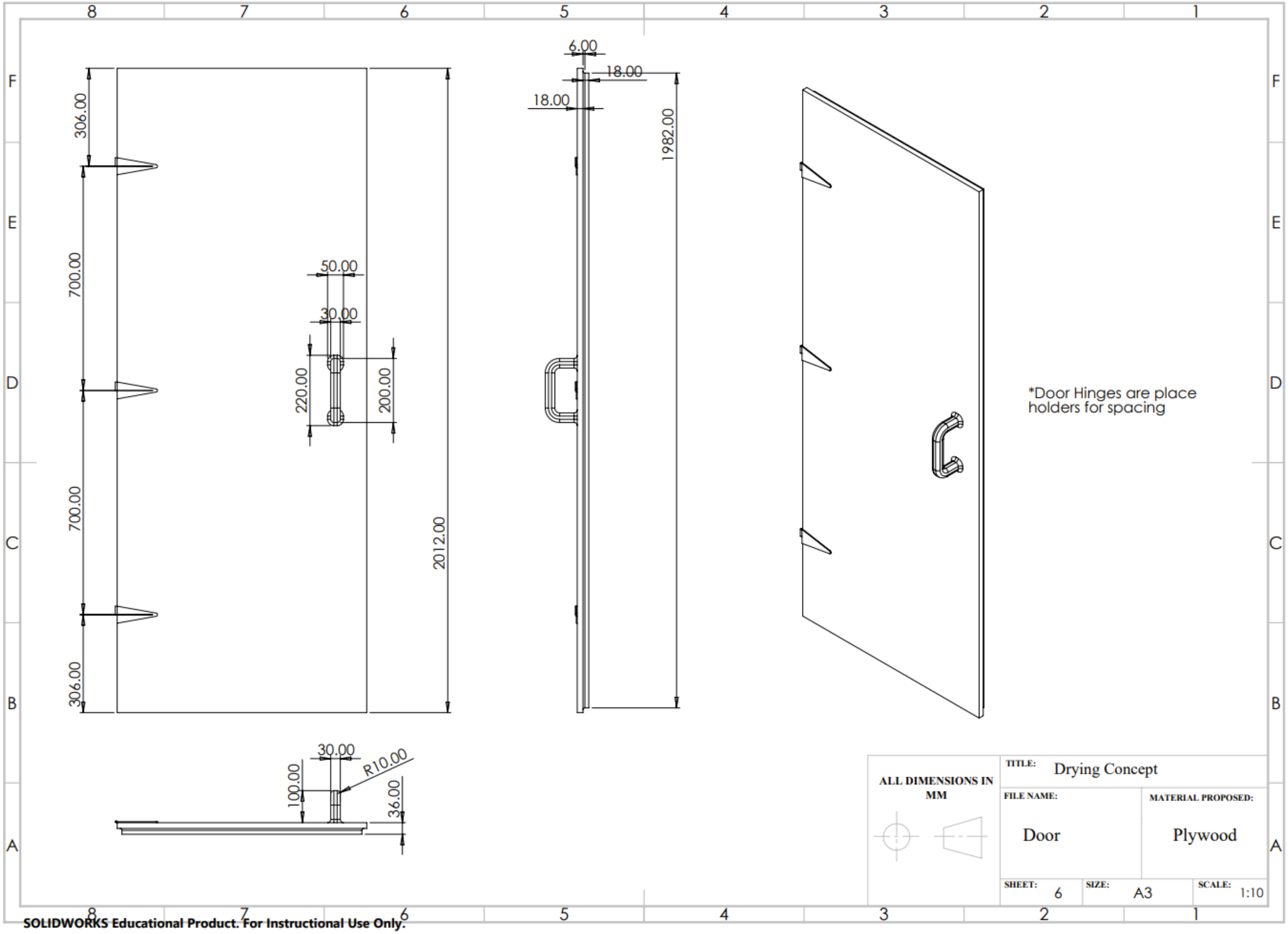
18.00
786.00
1054.00
804.00
268.00
82.00
54.00
18.00
738.00
738.00
2036.00
78.00
60.00
100.00
698.00
18.00
1982.00
710.00
286.00
750.00
954.00
Ø100.00
686.00
ALL DIMENSIONS IN MM
TITLE: Drying Concept
FILE NAME: Housing Unit
MATERIAL PROPOSED: Plywood
SHEET: 1
SIZE: A3
SCALE: 1:20
SOLIDWORKS Educational Product. For Instructional Use Only.


20.00
250.00
750.00
2018.00
18.00
82.00
82.00
82.00
118.00
2018.00
1018.00
750.00
118.00
750.00
18.00
700.00
70.00
2014.00
ALL DIMENSIONS IN MM
TITLE: Drying Concept
FILE NAME: Housing Unit (Internal)
MATERIAL PROPOSED: Plywood
SHEET: 2
SIZE: A3
SCALE: 1:15
SOLIDWORKS Educational Product. For Instructional Use Only.

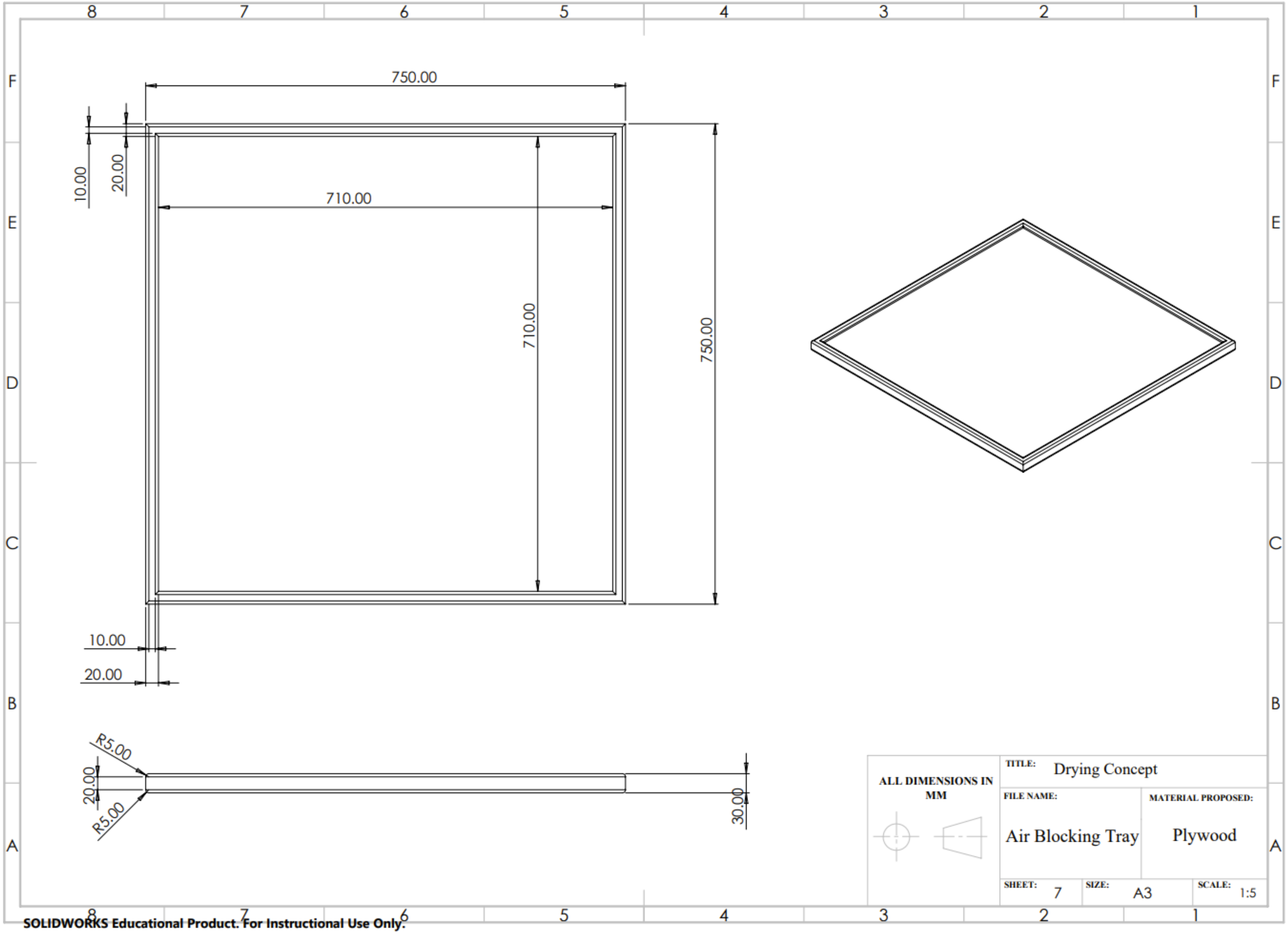

1301.39
6.76°
36.00
75.00
200.00
1054.00
1026.00
119.16
1054.00
750.00
250.00
786.00
750.00
750.00
120.00
ALL DIMENSIONS IN MM
TITLE: Drying Concept
FILE NAME: Roof
MATERIAL PROPOSED: Plywood
SHEET: 3
SIZE: A3
SCALE: 1:10
SOLIDWORKS Educational Product. For Instructional Use Only.


1950.85
18.00
732.00
74.95
768.00
78.00
36.77
189.72
134.15
2104.57
45°
202.00
120.00
357.00
Ø100.00
668.00
ALL DIMENSIONS IN MM
TITLE: Drying Concept
FILE NAME: Solar Dehydrator
MATERIAL PROPOSED: Various
SHEET: 4
SIZE: A3
SCALE: 1:20
SOLIDWORKS Educational Product. For Instructional Use Only.


74.95
189.72
78.00
36.77
30.00
5.00
30.00
15.00
55.15
3.00
3.00
20.00
ALL DIMENSIONS IN MM
TITLE: Drying Concept
FILE NAME: Solar Dehydrator (internal)
MATERIAL PROPOSED: Various
SHEET: 5
SIZE: A3
SCALE: 1:10
SOLIDWORKS Educational Product. For Instructional Use Only.



6.00
18.00
18.00
1982.00
306.00
700.00
700.00
306.00
50.00
30.00
220.00
200.00
2012.00
30.00
R10.00
100.00
36.00
*Door Hinges are place holders for spacing
ALL DIMENSIONS IN MM
TITLE: Drying Concept
FILE NAME: Door
MATERIAL PROPOSED: Plywood
SHEET: 6
SIZE: A3
SCALE: 1:10
SOLIDWORKS Educational Product. For Instructional Use Only.


750.00
10.00
20.00
710.00
710.00
750.00
10.00
20.00
R5.00
20.00
R5.00
30.00
ALL DIMENSIONS IN MM
TITLE: Drying Concept
FILE NAME: Air Blocking Tray
MATERIAL PROPOSED: Plywood
SHEET: 7
SIZE: A3
SCALE: 1:5
SOLIDWORKS Educational Product. For Instructional Use Only.