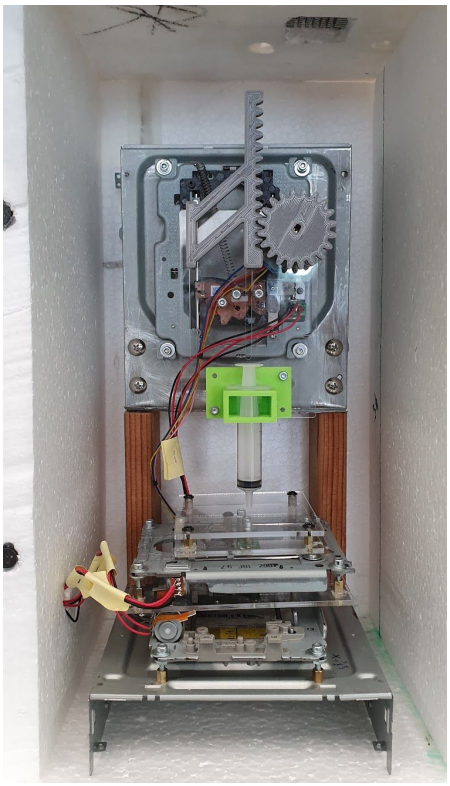
3D Food Extruder



Allen Michael Bautista Tan	P1831894
Lim Cheng Ee	P1820078
Vincent	P1824762

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Acknowledgement

We would like to thank the following people who have made this report possible.

Mr Roy Tan and Mr Shin Jen Teo, Lecturer, Singapore Polytechnic, for giving us the opportunity to write this report.

Focus Issue

As food wastage is becoming a more prevalent issues in our society. Starting from the government holding Year Towards Zero Waste campaign this year .Campaign is targeted at the food wastage in eateries and supermarket .Traditionally, bad looking food is usually thrown out but.we are going to be using it to creatie the filament of the 3D printer.This reduce food wastage and also increase the shelf life of the fruits.

Introduction

The way most people picked their fruits is by appearance.This lead to having a lot of ugly fruits wasted and this adds on to Singapore food wastage.With Technology however,there is a way to put the ugly fruits into good use.The ugly food will be dried into powder and rehydrated into paste .This will then be used for the filament of the 3D printer we are creating

Objective

The product aims to reduce the wastage of ugly fruits .This is to cope with food shortages

Scope

This product contains both hardware system and software system.The hardware is the 3D printer .The software system is for the user interface to control the 3D printer

Background

Food wastage has been a Global concern as we have limited supply and the population is going to increase .This might lead to not being able to meet the demand of food shortage.Preserving food is a way to deal with the demand of food shortage.Traditionally,this ugly fruits are thrown out regardless of whether is edible or not.This adds on to our waste.

Identified Problem

Food wastage is a big problem in Singapore.Food wasted 2017 was 809,800 tonnes.There is an increase of over 24,000 tonnes since 2015, according to statistics published on the NEA website.Food wastage in Singapore is expected to increase as population increases. Only 133,000 tonnes of food waste was recycled. The remaining food waste was disposed of at waste-to-energy plants for incineration.
In a news article published in 2018 by straits time,Mustafa Centre was found to be disposing of nearly 100kg of fruits and vegetables daily.This is because Mustafa Centre typically throws out produce that remains unsold after three days, Shin Min Daily News reported.
Food waste is a global problem.
Food waste ends up wasting water supply, food that is never eaten accounts for 25% of all freshwater consumption globally
Food waste is a massive market inefficiency
33-50% of all food produced globally is never eaten, and the value of this wasted food is worth over $1 trillion
Food waste is bad for the environment.
Resources that went into creating the uneaten food wasted and when food waste goes to landfill,, it decomposes without access to oxygen and creates methane, which is 23x more deadly than carbon dioxide.

800 million people go to bed hungry every night. That is 1 in 9 people on the planet who are starving or malnourished.Yet there is a large amount of food is waste.d

Alternative Solution

- Reduced-to-clear promotions for fruits and vegetables that are close to expiry or blemished are a common strategy adopted by these supermarkets.

  -A FairPrice spokesman told TNP that by doing so, it was able to save 675,000kg of fruits and vegetables across 145 stores islandwide last year.

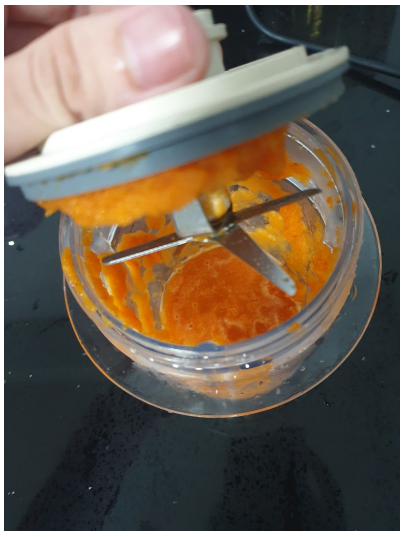
- As part of an initiative to recycle food waste, Giant hypermarkets at Tampines and Suntec have installed the Eco-Wiz, an on-site food waste treatment system that converts food waste to potable water

- Sheng Siong helped the anti-food waste effort by supporting the Food Unfiltered campaign.The campaign encouraged members of the public to embrace "ugly food" as a simple way to reduce food waste in Singapore and featured educational posters across Sheng Siong supermarkets.

- Smarter storage.The fridge will inform the user when food is going to expire

- App for expired food.This informs you of food that is going to expire soon,It helps with getting cheap deals. However this is only available in North America

Food Paste





Food paste:

Cut the carrot into slices, and dehydrate it using an oven. Then grind the dehydrated carrot to powdered form.(Warning! This process can be very noisy. Be considerate and refrain from doing this process at night). If the powder is not find enough, put the powder in a Ziploc bag, put the Ziploc bag on a strong flat surface, and finally use a solid(I used my fist) and smash it.

To rehydrate to make it into a paste for 3D Printing, add one portion of water and 3 portion of water. Then blend it. Pour the contents into a container. Take a clean syringe and filled the syringe with paste.

Building 3D Extruder

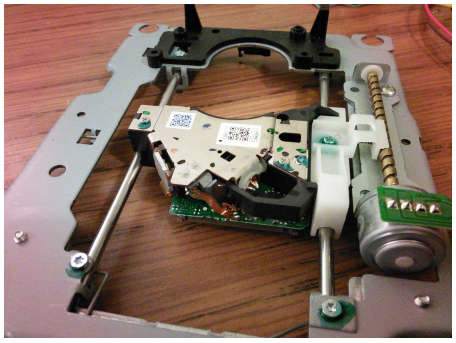
We built the 3D extruder using optical CD drives, following the steps provided by a youtube video: https://www.youtube.com/watch?v=3p8BP7B7Pmw, while adding our own modifications to it.

Materials needed -

Electrical:

- 2 Arduino UNO
- Wires
- 4 l298 (Dual-Full H-Bridge Drivers)
- 2 USB Heads
- 2 Phone charger Plug(5.2V,2.0A)

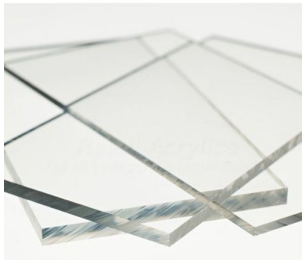
Mechanical:



[3] Computer CD drives (for x, y and z axis)

[2] Case of CD drives

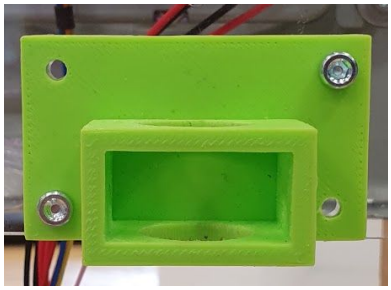
From left to right:
[25] Motherboard standoff screws
[sufficient] M3 nuts
[sufficient] M4 nuts
[4] M5 nuts
[sufficient] M3 washers
[sufficient] M4 washers
[sufficient] M3 socket screws
[sufficient] M3 motherboard screws
[4] M5 screws
[8] Wood screws



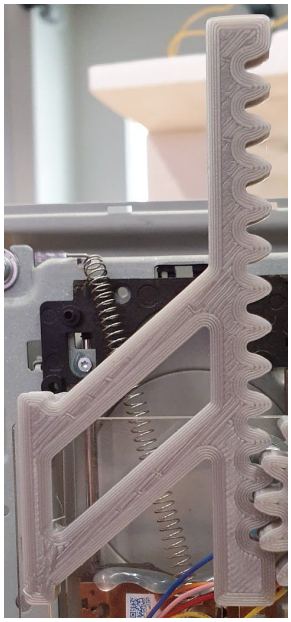
3mm thick acrylic

Wood

[2] L-shaped brackets



3D printed syringe holder



3D printed rack

3D printed pinion

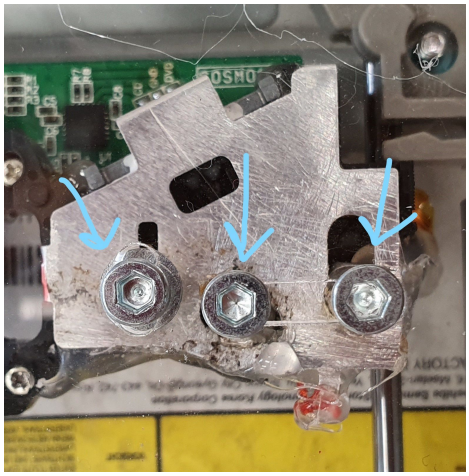
[1] stepper motor

The build will be split into 3 parts: **the bottom side with x and y axes**, **top side with z-axis and extruder head**, **and joining the bottom and top side together**.

Bottom side with x and y axes -

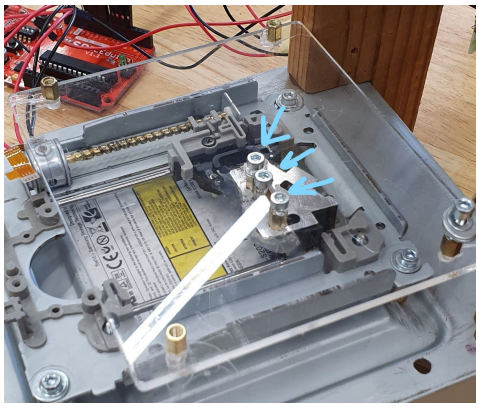
1. Drill 4 holes in one of the CD drive cases, we would mount the first CD drive on it to be the y-axis.
    1.1. Add 4 standoff screws and secure them using M4 nuts.

2. Drill 3 holes onto the part where the CDs used to get read by the laser in the first CD drive.



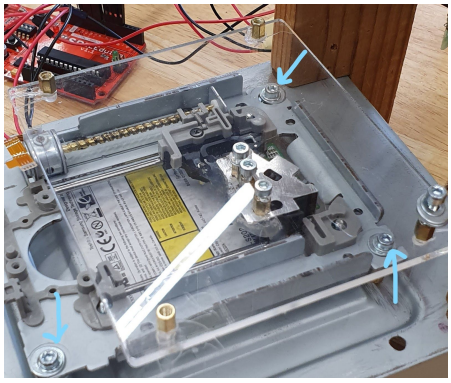
2.1. Add 3 standoff screws to it, secure using M4 nuts. (Hot glue if necessary)

2.2. Attach a piece of “specially designed” acrylic using M3 screws to the CD drive.

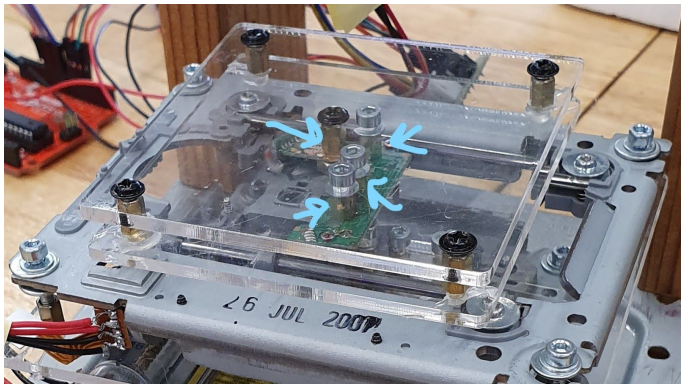


2.3. The specially designed acrylic has 4 holes near each corner, add 4 standoff screws to it.

3. Mount the finished CD drive to the CD drive case using M3 screws on the 4 standoff screws on the case. This will be the y-axis.

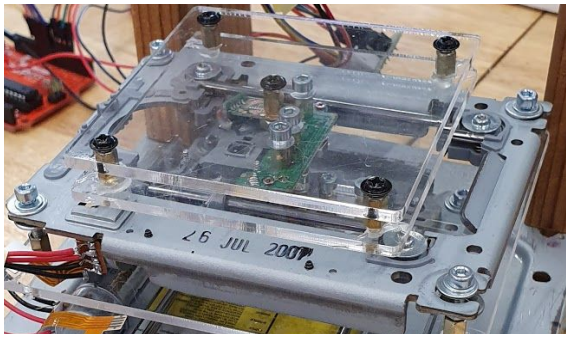


4. With a second CD drive, which will be used as the x-axis. Drill 4 holes onto the part where the CDs used to get read by the laser in the first CD drive.



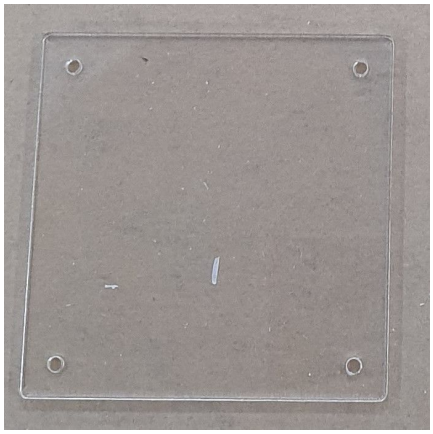
4.1. Add 4 standoff screws to it, secure using M4 nuts. (Hot glue if necessary)

4.2. Attach a piece of “specially designed” acrylic using M3 screws to the CD drive.



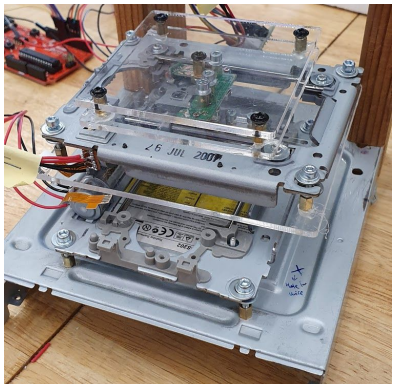
4.3. The specially designed acrylic has 4 holes near each corner, add 4 standoff screws to it.

5. Mount the extruding platform to the y-axis.



Extruding Platform

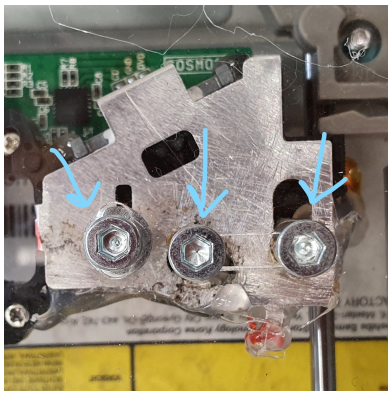
6. Once the x-axis is done, mount it to the y-axis, and the bottom side of the 3D extruder is now complete.



Top side with z-axis and extruder head -

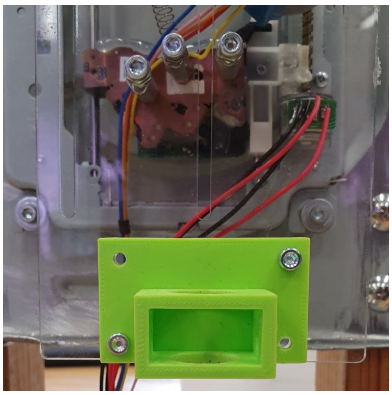
1. Drill 4 holes in the other CD drive case, we would mount the third CD drive on it, which will be the z-axis. (Same as before)
   1.1. Add 4 standoff screws and secure them using M4 nuts.

2. Drill 3 holes onto the part where the CDs used to get read by the laser in the CD drive. (Same as before)

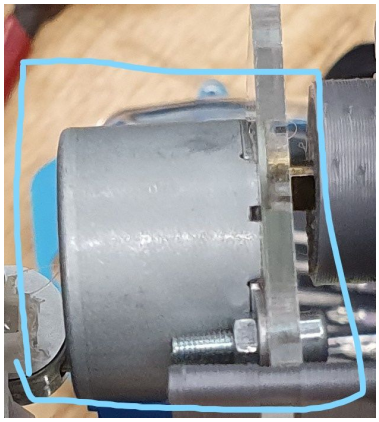


   2.1. Add 3 standoff screws, secure using M4 nuts. (Hot glue if necessary)

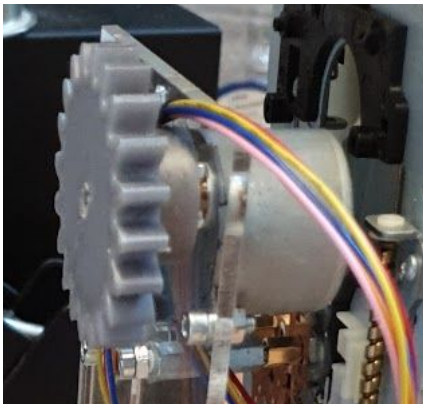
3. Attach the syringe holder to a “specially designed” acrylic with M3 screws and nuts.

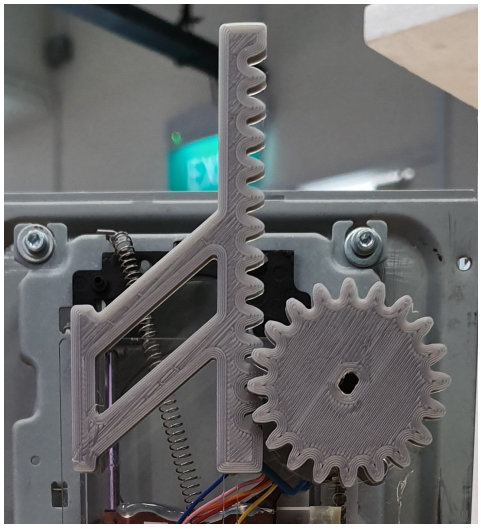
4. Attach the stepper motor to the “specially designed” acrylic, using M3 screws and nuts.



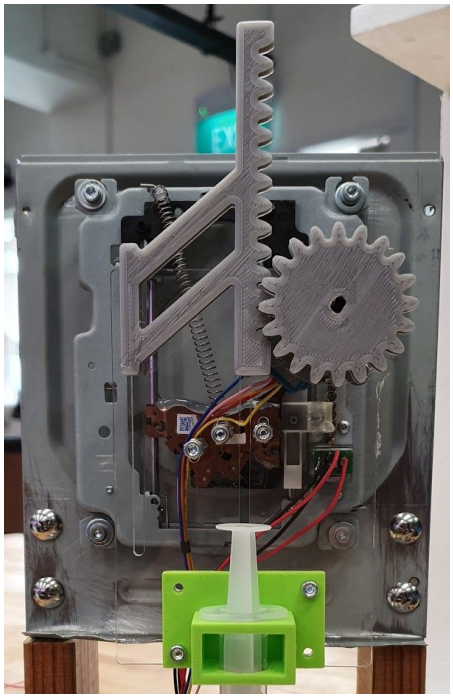
4.1. Attach the pinion to the stepper motor.



5. Slide in the rack to the “specially designed” acrylic, and align it as followed.



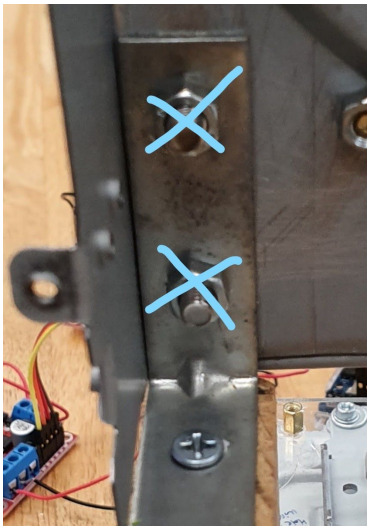
6. Attach the extruder head to the third CD drive using M3 screws. This will be the finished z-axis.
7. Attach the finished z-axis to the CD drive case using M3 screws. The top side of the 3D extruder is now complete.



Joining the bottom side and top side together -

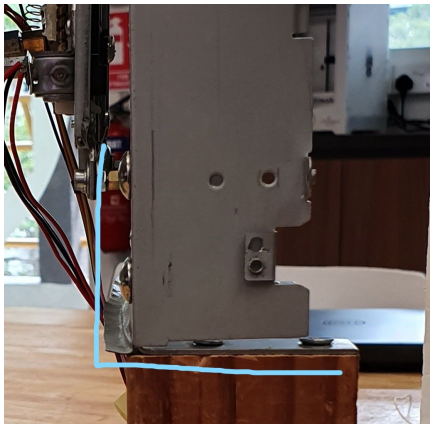
1. Drill 4 holes in the CD drive case of the bottom side. Diameter of the holes should be slightly larger than the diameter of wood screws used.

1.1. Drill 4 holes in the CD drive case of the top side. Diameter of the holes are for M5 screws to fit in.



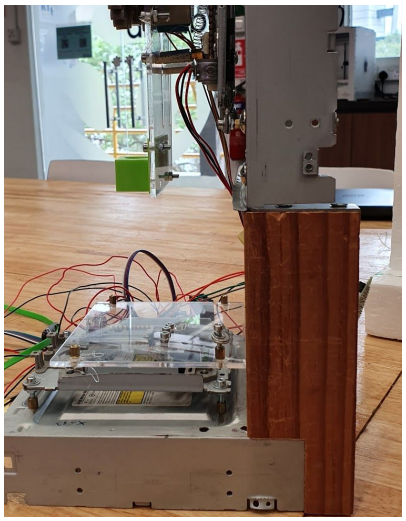
Do this for the other side as well

2. Attach 2 L-shape brackets to either ends of the top side of the 3D extruder, in the following way. Secure using M5 screw and nuts.



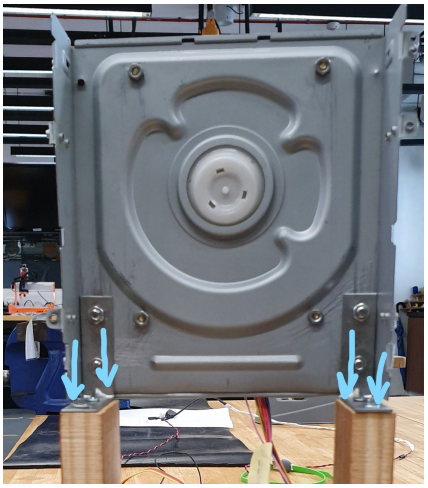
3. Using a wood that is cut into the shape below. (Done by aligning the wood to the CD drive case and marking the portion to be cut out) **[Repeat this step one more time]**

4. To join the bottom and top side together, put 2 pieces of wood prepared in step 3 in between the two sides.

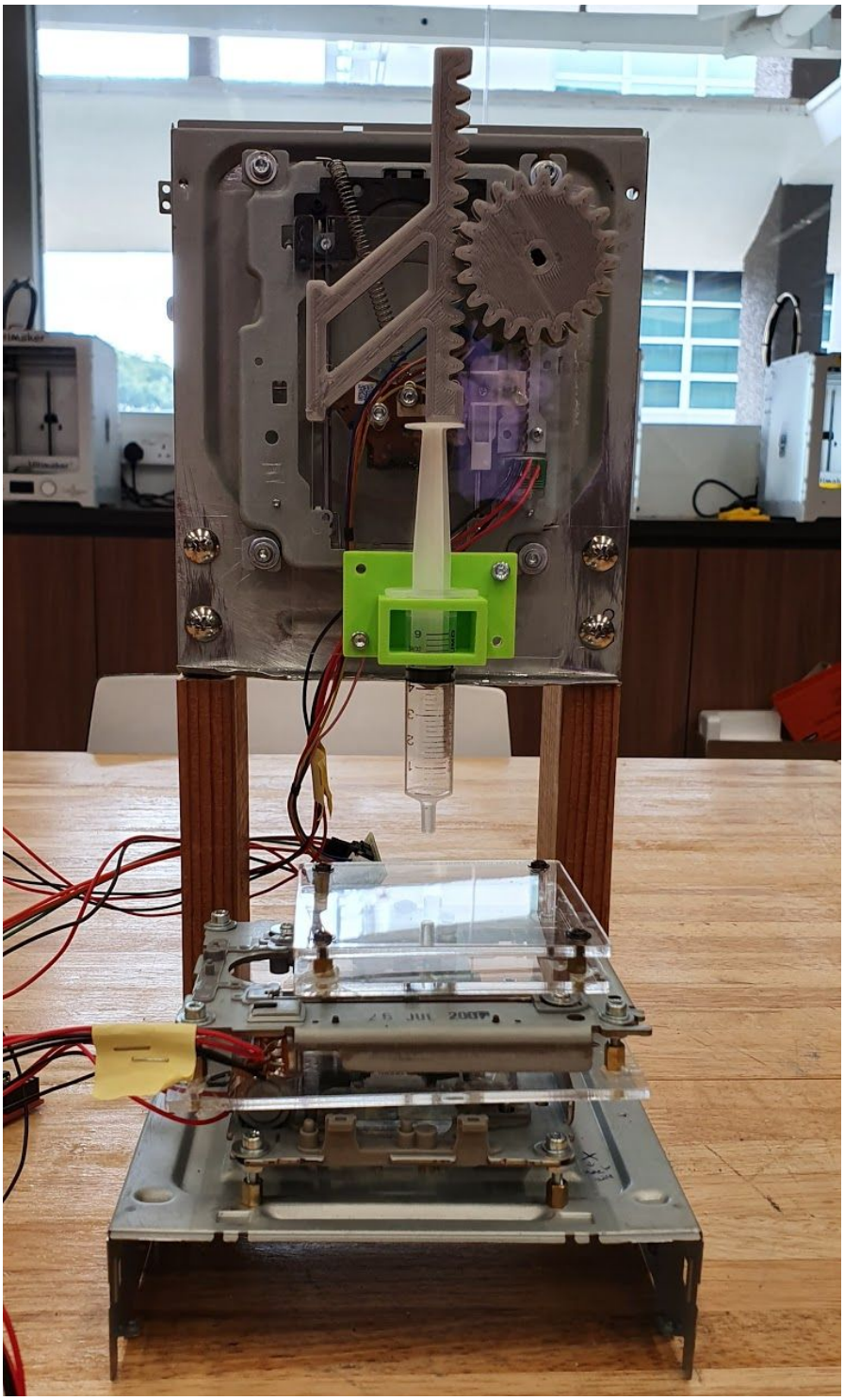


4.1. Drill 4 wood screws through the bottom side of the extruder with the holes already drilled in step 1 to the wood (2 screws at either ends).

4.2. Drill 4 wood screws through the L shape bracket of the top side of the extruder to the wood (2 screws at either ends).



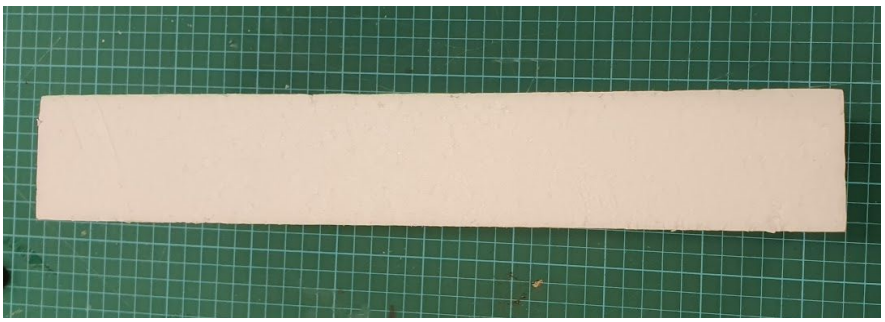
Finished 3D Extruder



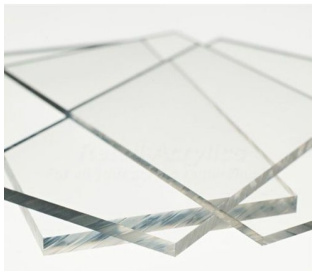
Building Peltier Box

As previously mentioned, for our extruded food to be solid, we would need to freeze it. So we built a peltier cooler box to freeze our food paste to a solid block.

Materials needed -

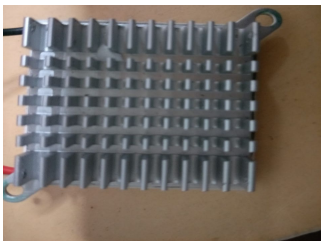


50mm thick styrofoam

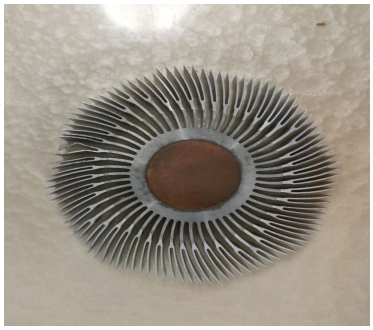


3mm thick acrylic

[8] Magnets

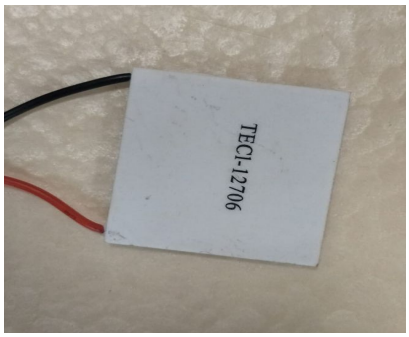


1 Small heatsink



1 Big heat sink

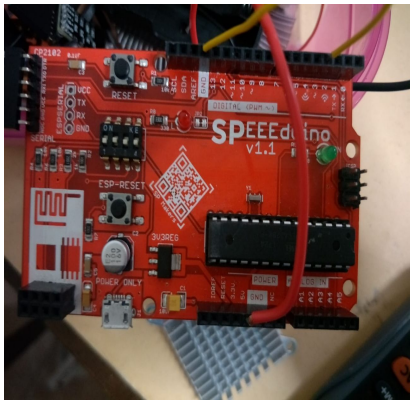
1 CPU fan



1 Peltier

4 AA batteries

1 Battery holder

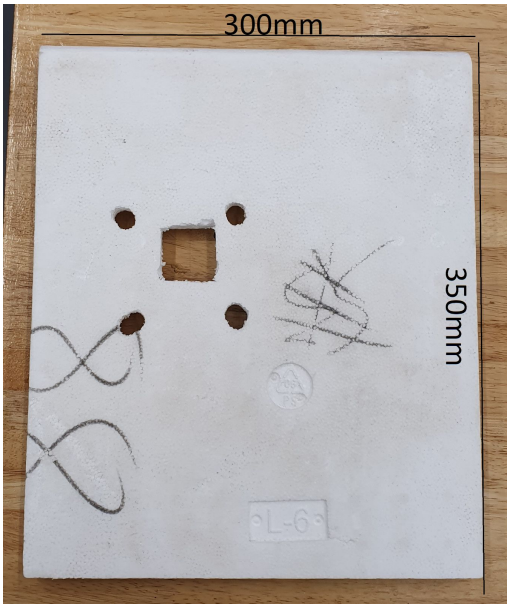


1 SPEEEduino

Making the box -

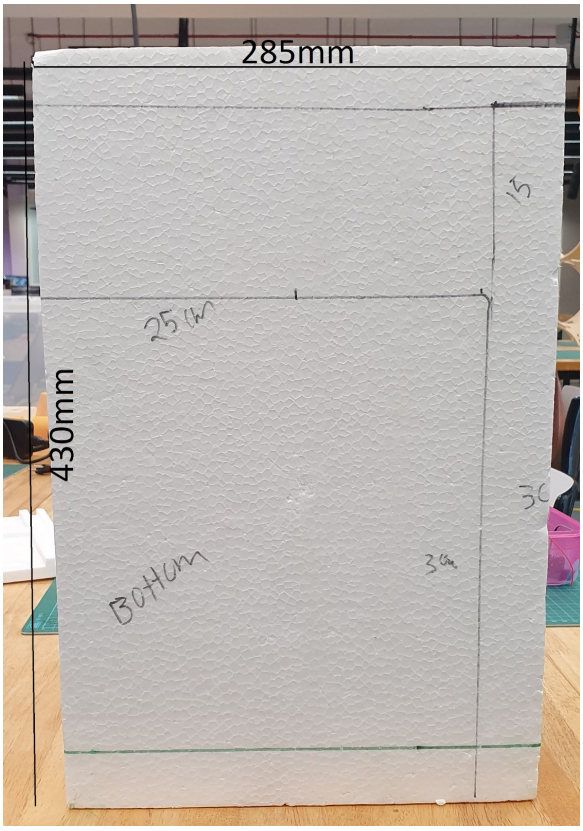
1. We require 6 pieces of styrofoam for this build (1 Bottom, 1 Top, 2 Sides, 1 Back, 1 “Door”). Cut the styrofoam to the following dimensions using a hot wire styrofoam cutter.
    1.1. Dimensions for the bottom: 300mm by 250mm by 50mm

1.2. Dimensions for the top: 300mm by 350mm by 21mm

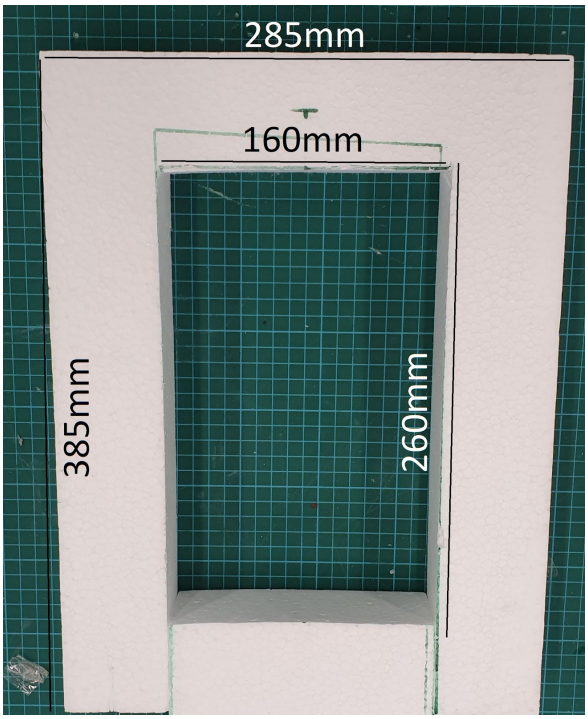


1.3. Dimensions for the 2 sides: 200mm by 380mm by 50mm

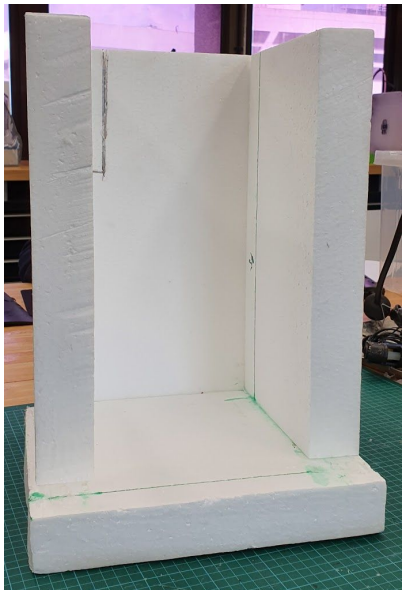
1.4. Dimensions for the back: 285mm by 430mm by 50mm



1.5. Dimensions for the “door”: 285mm by 385mm by 50mm with a slot of 260mm by 160mm by 50mm cut out in the centre

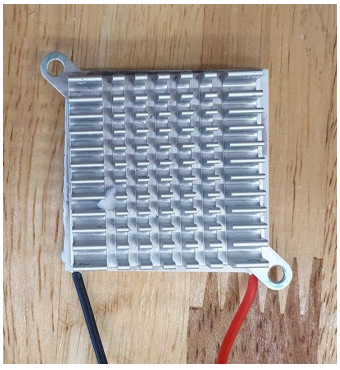


2. Assemble the pieces as followed. Attach them together with low heat hot glue gun.



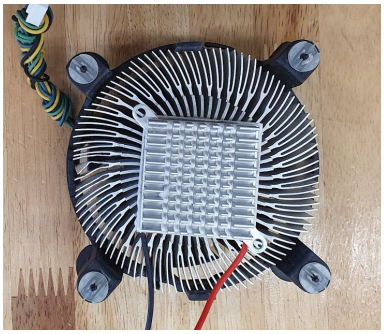
3. For our electronics,
   3.1. Attach the large heatsink to the fan

   3.2. Attach the peltier to the small heatsink using thermal paste.



Peltier is underneath the heatsink

3.3. Attach pieces from 3.1 and 3.2 together using thermal paste.

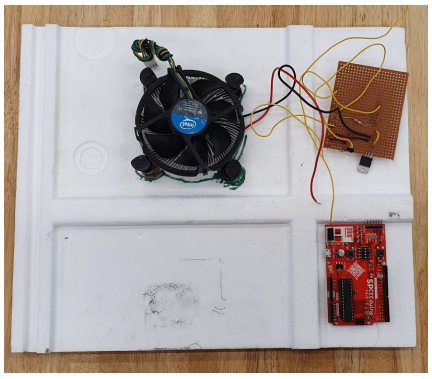


3.4. Solder on the transistor on to the strip board to drive the peltier with and arduino

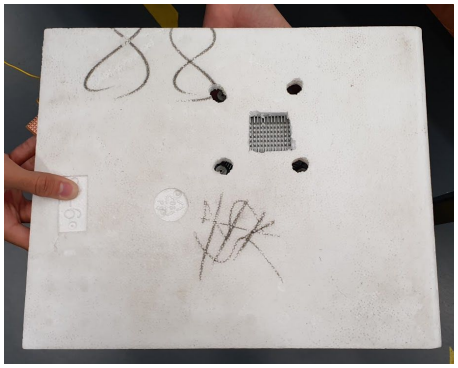
3.5. Run the code for the arduino

4. Trace out the fully assembled electronics on the top styrofoam. Then using a sharp penknife, cut out the traced parts, so that we can attach the electronics onto the styrofoam low heat hot glue gun.

Note: ONLY the small heatsink need to protrude out of the underside of the top styrofoam, the rest of the electronics should not be seen from the underside.

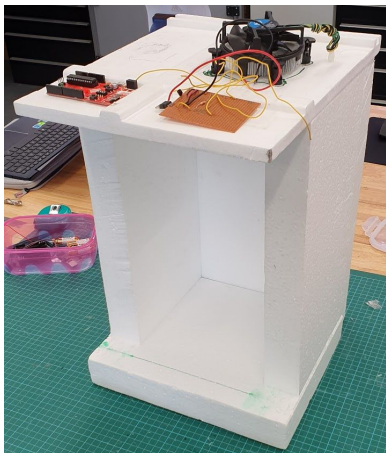


View from topside

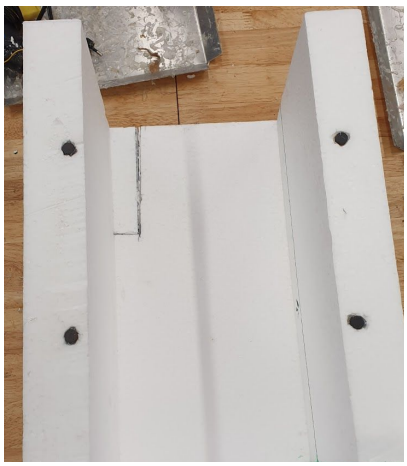


View from underside

5. Attach the assembled top piece of styrofoam on top of the box using low heat hot glue gun.

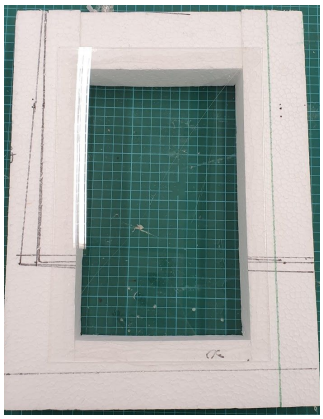


6. Make 4 holes on the 2 side pieces of styrofoam (2 holes on 1 side), then hot glue 1 magnet to each hole.

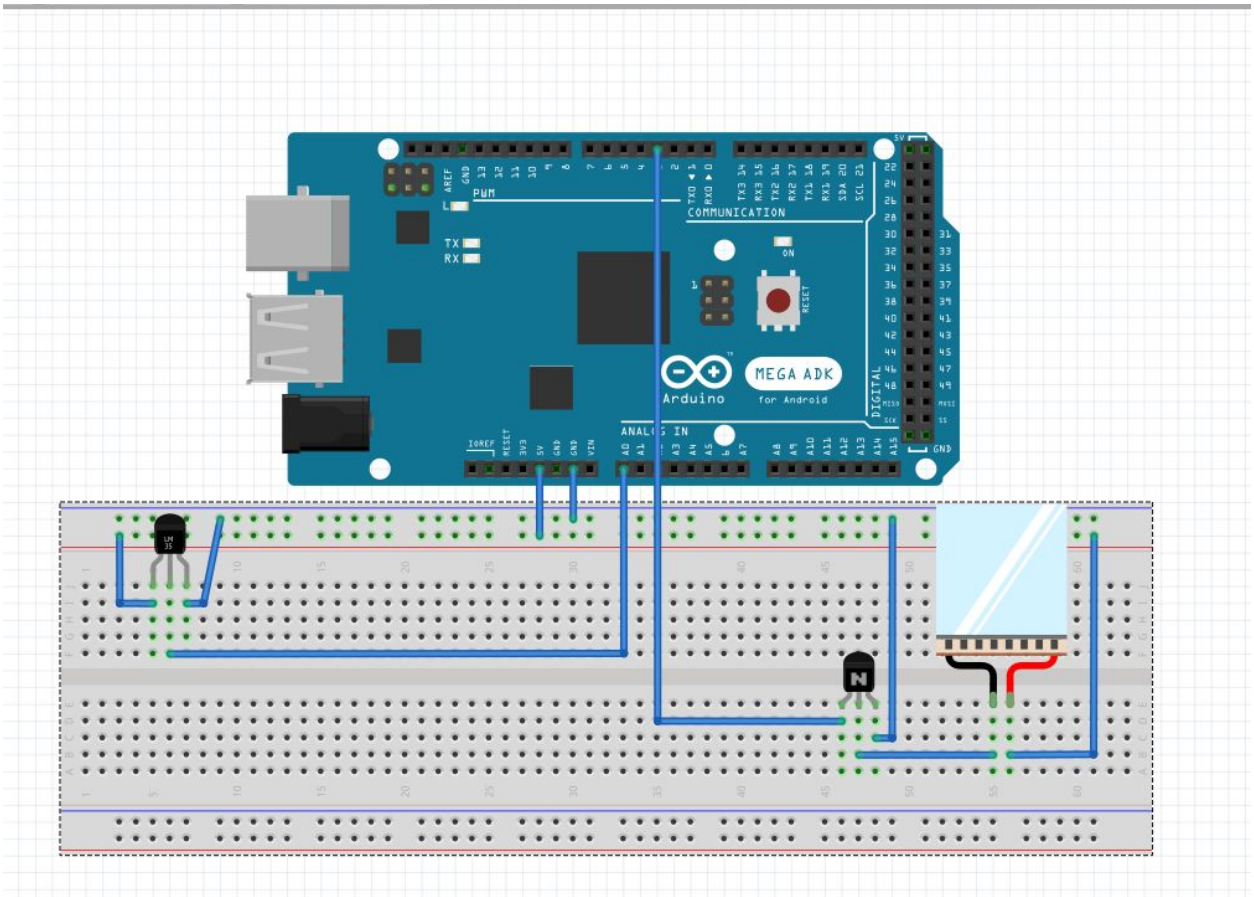


6.1. For the door, make 4 holes (2 holes on either side) that mirrors the 4 holes on the 2 side piece styrofoam, then hot glue 1 magnet to each hole.

7. Attach a piece of acrylic with the dimensions of 200mm by 300mm to the slot of the “door” using low heat hot glue gun.



Schematic



dCode for Arduino

```
const int lm35_pin = A5;
int peltier = 3;/* LM35 O/P pin */

void setup() {
  Serial.begin(9600);
    // generate 25kHz PWM pulse rate on Pin 3
   pinMode(pwmPin, OUTPUT);   // OCR2B sets duty cycle
   // Set up Fast PWM on Pin 3
   TCCR2A = 0x23;     // COM2B1, WGM21, WGM20
   // Set prescaler
   TCCR2B = 0x0A;   // WGM21, Prescaler = /8
   // Set TOP and initialize duty cycle to zero(0)
   OCR2A = 79;    // TOP DO NOT CHANGE, SETS PWM PULSE RATE
```

```
   OCR2B = 0;    // duty cycle for Pin 3 (0-79) generates 1 500nS pulse even when 0 :
   digitalWrite(2, HIGH);   // Starts reading
   Serial.begin(9600);
}

void loop() {
  int temp_adc_val;
  float temp_val;
  temp_adc_val = analogRead(lm35_pin);  /* Read Temperature */
  temp_val = (temp_adc_val * 4.88); /* Convert adc value to equivalent voltage */
  temp_val = (temp_val/10); /* LM35 gives output of 10mv/°C */
  Serial.print("Temperature = ");
  Serial.print(temp_val);
  Serial.print(" Degree Celsius\n");
  delay(1000);


analogWrite(peltier, 155); // Look first on how much voltage your peltier unit can handle 255 =
5V

}
```

Finished Peltier Box

Source Code

Source Code

I will be sharing 2 ways of doing the Coding for our printing machine.

1st (Using existing 3D Printer Source code)

Youtube link: https://www.youtube.com/watch?v=m1n_CQJiO8A&t=286s

Just have to change the head to an extruder rather than the 3d print head.

2nd(Hard Code)

In this project I will be using this method, because in the video there are many things that we have to get it specifically. This method uses 2 Arduino, “Core” and “Slave”.

Core

```
/*
200 stepsPerRevolution = 5cm
*/
// Include the Arduino Stepper Library
#include <Stepper.h>

// Number of steps per output rotation
const int stepsPerRevolution = 50;

// set pin mode
  // X Direction
          int s_Pin1 = 8;
          int s_Pin2 = 9;
          int s_Pin3 = 10;
          int s_Pin4 = 11;

  // Y Direction
          int s_Pin5 = 7;
          int s_Pin6 = 6;
          int s_Pin7 = 5;
          int s_Pin8 = 4;

// set time and speed
  int period_x = 500;
  int Speed_x = 60;

  int period_y = 500;
  int Speed_y = 60;

//set communication
```

```
  int transmit_z = 12;
  int transmit_exd = 13;

//set parameters of object
  int length_x = 1;
  int length_y = 3;
  int length_z = 3;

//set print status
  int length_current_x;
  int length_current_y;
  int length_current_z;

//sync period_z with Slave UNO
int period_z = 1000;

//Set command to start
char command = 0;

// Create Instance of Stepper library
  Stepper myStepper_x(stepsPerRevolution, s_Pin1, s_Pin2, s_Pin3, s_Pin4);  //X_Direction
  Stepper myStepper_y(stepsPerRevolution, s_Pin5, s_Pin6, s_Pin7, s_Pin8);  //Y_Direction

void setup()
{
  // set the speed at 60 rpm:
            myStepper_x.setSpeed(Speed_x);
            myStepper_y.setSpeed(Speed_y);
  // command Slave Uno
            pinMode(transmit_z,OUTPUT);
            pinMode(transmit_exd,OUTPUT);
  // initialize the serial port:
            Serial.begin(9600);
}

void loop()
{
  if (Serial.available() > 0)
  {
            command = Serial.read();
            if (command == 'p')
            {
            Serial.println("Printing...");



for(length_current_z= 1; length_current_z<= length_z; length_current_z ++)
     {
```

```
          //tell Slave UNO to move z axis
          digitalWrite(transmit_z,HIGH);
          //allow Slave UNO to register
          delay(period_z);
          //tell Slave UNO to stop moving z axis after moving the desired z axis
          digitalWrite(transmit_z,LOW);
          Serial.println("no z");
          //stop everything other than z axis moving for z axis duration and 0.5 sec allowance
          delay(period_z + 500);

         for(length_current_y= 1; length_current_y<= length_y; length_current_y ++)
          {
            digitalWrite(transmit_exd,HIGH);          //extrude paste
            myStepper_y.step(stepsPerRevolution);          //-stepsPerRevolution for reverse direction
            delay(period_y);

            for(length_current_x= 1; length_current_x<= length_x; length_current_x ++)
              {
              myStepper_x.step(stepsPerRevolution);        //-stepsPerRevolution for reverse direction
              delay(period_x);
              digitalWrite(transmit_exd,LOW);        //Do not extrude paste
              myStepper_x.step(-stepsPerRevolution);       //-stepsPerRevolution for reverse direction
              delay(period_x);
              }
           }
         //move back printing position for y axis
         myStepper_y.step(-stepsPerRevolution*3);
         delay(period_y);
    }
         }
         else
         {
         Serial.println("Invaild");
         }
  }
}
```

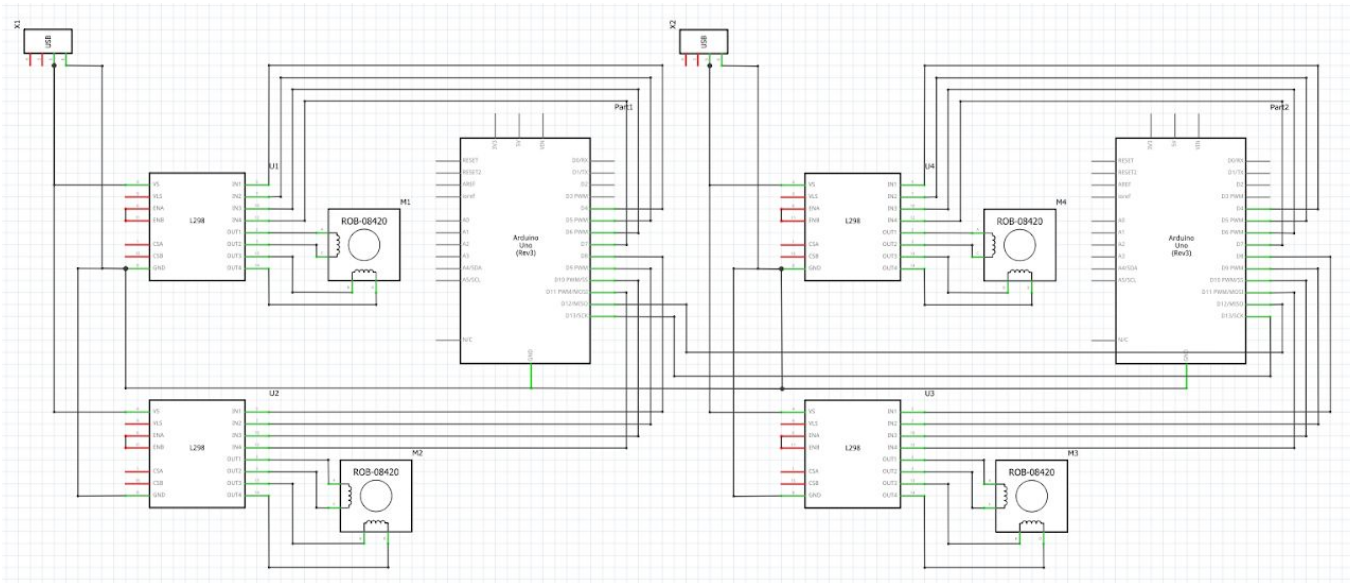
Slave

```
// Include the Arduino Stepper Library
#include <Stepper.h>

// Number of steps per output rotation
  const int stepsPerRevolution = 50;

// set pin mode
  int s_Pin1 = 8;             // Z Direction
  int s_Pin2 = 9;
```

```
  int s_Pin3 = 10;
  int s_Pin4 = 11;

  int s_Pin5 = 4;             // Extruder Direction
  int s_Pin6 = 6;
  int s_Pin7 = 5;
  int s_Pin8 = 7;

// set time and speed
  int period_z = 1000;
  int Speed_z = 60;

  int Speed_exd = 60;

//set communication
  const int reciever_z = 12;
  const int reciever_exd = 13;

  int reciever_z_state = 0;
  int reciever_exd_state = 0;

// Create Instance of Stepper library
  Stepper myStepper_z(stepsPerRevolution, s_Pin1, s_Pin2, s_Pin3, s_Pin4);  //Z_Direction
  Stepper myStepper_exd(stepsPerRevolution, s_Pin5, s_Pin6, s_Pin7, s_Pin8); //Extruder_Direction

void setup()
{
  // set the speed at 60 rpm:
          myStepper_z.setSpeed(Speed_z);
          myStepper_exd.setSpeed(Speed_exd); // initialize the serial port:
          pinMode(reciever_z,INPUT);
          pinMode(reciever_exd,INPUT);
          Serial.begin(9600);
}

void loop()
{
  digitalWrite(reciever_z_state,LOW);
  reciever_z_state = digitalRead(reciever_z);

  reciever_exd_state = digitalRead(reciever_exd);

  if(reciever_z_state == HIGH)
  {
          Serial.println("Received Z...");
          myStepper_z.step(-stepsPerRevolution);
          delay(period_z);                    //layer Height
  }
```

```
  else
  {
          if(reciever_exd_state == HIGH)
          {
          Serial.println("Extruding...");
          myStepper_exd.step(-stepsPerRevolution/5);
          delay(10);
          }
  }
}
```

Schematic



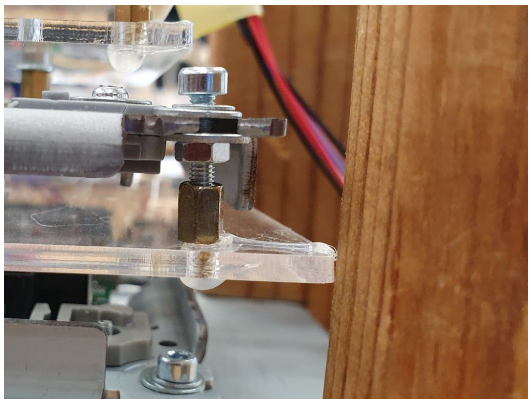
I am using 2 of USB male(5.3V, 2.0 A).
Take 2 USB charging cables, cut and separate the black and red wires. This will be used as power supply(red being the positive(VCC) and black being the negative(GND)).
All the enable buttons of the H-bridge are always enabled

Problems Faced

Alignment

One of the main problems faced is trying to align the different axes flat on their respective planes.

Solution: Use the following M3 screw setup: (m3 screw -> m3 washer -> m4 washer -> m3 washer -> m3 nut).

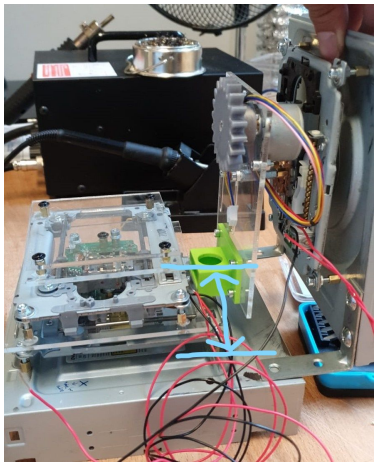



This is so that when we mount the different components onto the standoff screws, we have the liberty of adjusting the height of each corner, we can do this by adjusting the height of the M3 nut.

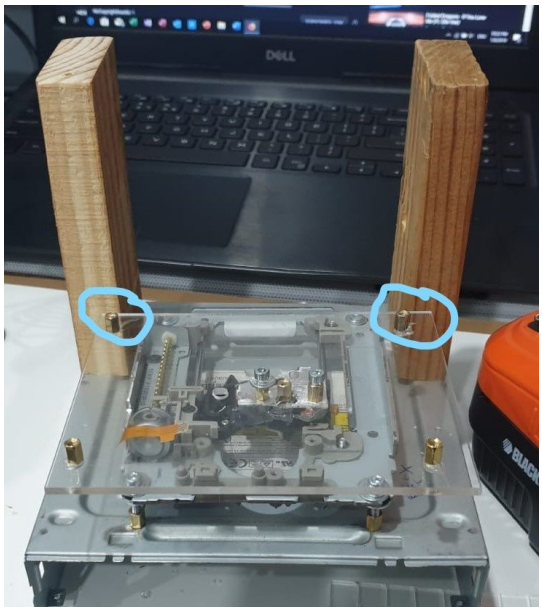
Alternative solution used: We also made use of washers and nuts to help offset the height to get our desired level of balance.

Joining the bottom and top side together

After making the x and y axes, the bottom side of the extruder is too high up (as shown in the picture below). Thus, we cannot mount the top side directly on the platform of the bottom side.



Solution: Elevate the top side using wood
However, by using any piece of wood, we run into a second problem, which is the y-axis while moving away will collide into the wood. (shown below)



Proposed solutions:

1. Rotate the wood backwards.

2. Cut slots in the existing wood support structure, add cylindrical rods to reinforce resulting wood structure

Chosen Solution: 1
Rationale: Solution 1 is easier to execute, and it is more aesthetically pleasing, and it wouldn't run the risk of the wood support structure failing.
Additional changes: Design changes to "specially designed" acrylics

- Symmetry
- Rounded corners

Acrylic pieces

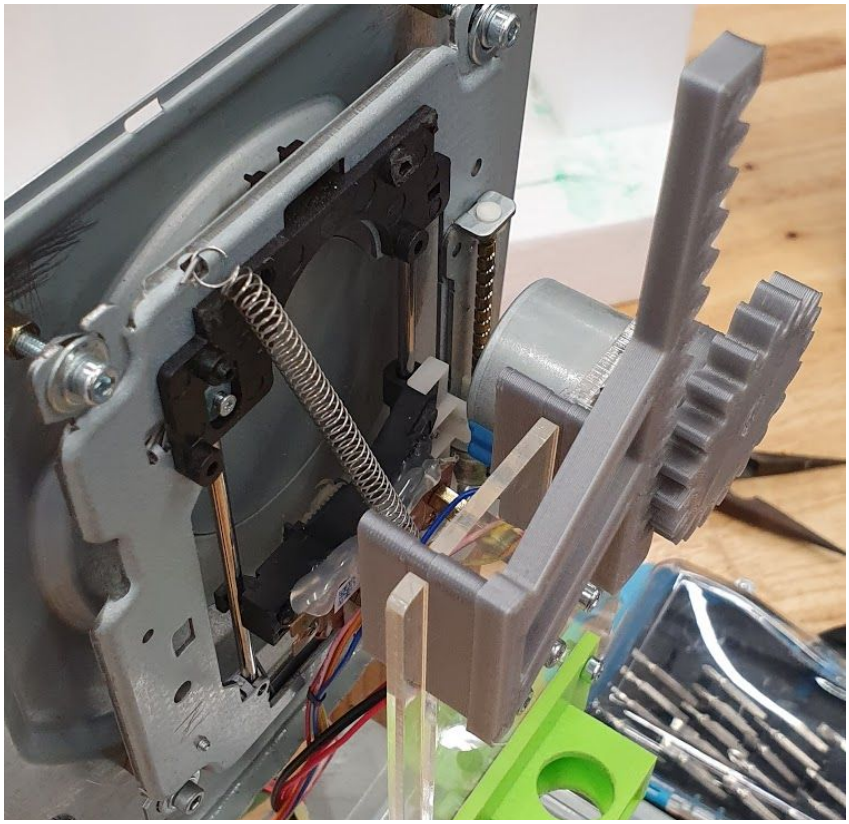
The problem is when we mount our “specially designed” pieces onto the standoff screws, there may be some misalignment and we need to realign it. With our old designs, which is just holes for the screws to go in, we would then need to enlarge the holes by filing it with needle files. However, this is inefficient, and we might risk breaking the acrylic.


Solution: Instead of making just holes, we made them into slots, so that there is sufficient room for alignment if there is a need for it.


Z axis load:

Given the weight of the additional feature, when we mount onto the Z axis, we realised that there is too much load, causing the stepper motor to stall. There are many ways to solve the problem. We can change to a stronger stepper motor, increase the power supply or find somehow to lighten the load. Changing of stepper motor will need some heavy funding, we opt it out. Since we are using phone charging USB plug as our power supply, it is risky to alter the internal circuitry. Buying a new power supply with 5-12V with 2- 4 A would require funding.

Solution: So we choose to lighten the load. In order to lighten the load, we can either reduce the weight(reduce the downward force) or increase the upward force. We cannot find any ways to reduce the downward force, so we choose to increase the upward force(force opposing gravity). We attach a tension spring given to us by our lecturer connecting the top of the extruder and the z-axis plate.



2D Drawings

The following 2D drawings shows the dimensions of the acrylic pieces and 3D printed parts used .