Gabe’s Chocolate Factory

By Gabriel Falcao, Jordan Coquoz, and George Vandorpe

Problem Statement

Purpose -

- The engineering team is designing a chocolate 3D printer for “Be Sweet” bakery.
- Primary goal is to print out chocolate letters for designs.
- The printer will be able to manually change the Z-axis for baked goods.

Scope -

- This project will have all its planning and details displayed on our website for future rebuilds.
- The total length of time this engineering team will have to create a functional prototype is 16 weeks.

Customer Requirements

- Printer must be able to print chocolate lettering for cakes. 30%
- Lettering should be easy to input and have a variety of fonts. 20%
- Must be easy to sanitize. 30%
- Should handle one print job without being reloaded. 10%
- Font must be appropriate for cakes. 10%

All data collected from client

Customer Requirements Met

- Prints in chocolate
- Has a variety of decoration applications
- Easy to sanitize
- Adequate chocolate volume and build area
- Low cost

Engineering Specifications

- Two axis bed to avoid inertial loads from the head -15
- Motors that can apply .525 lb of linear force -15
- Extruder head between 80 and 90 degrees celsius -20
- Feed rate of 4000 mm/min -5
- 24 volt power supply -10
- 4 ohm heating element -10
- Accuracy of .5 mm in at least one axis -25

Competition

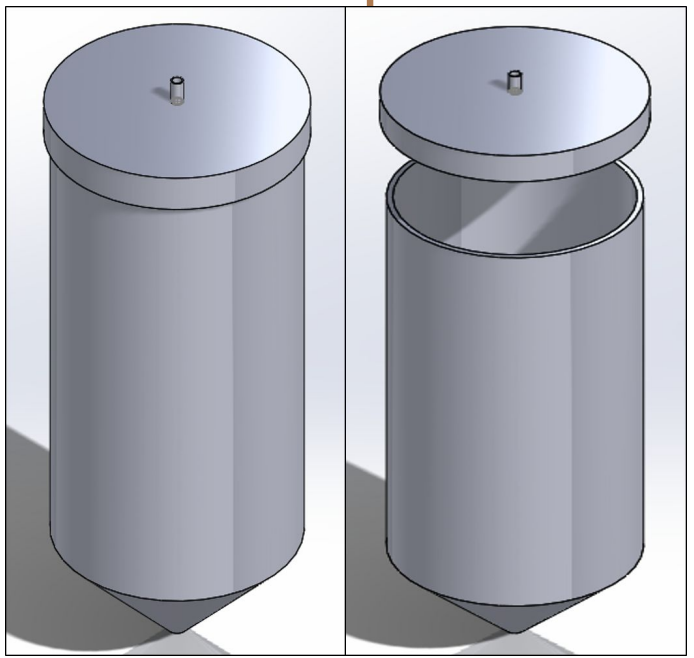
Cost: $2000

Functionally can print chocolate in 3D

Concept Generation - Head - Concept 1

The compressed air extruder would operate by having another system of compressed air being inserted into the extruder head.

The pressure form the compressed air would create flow.



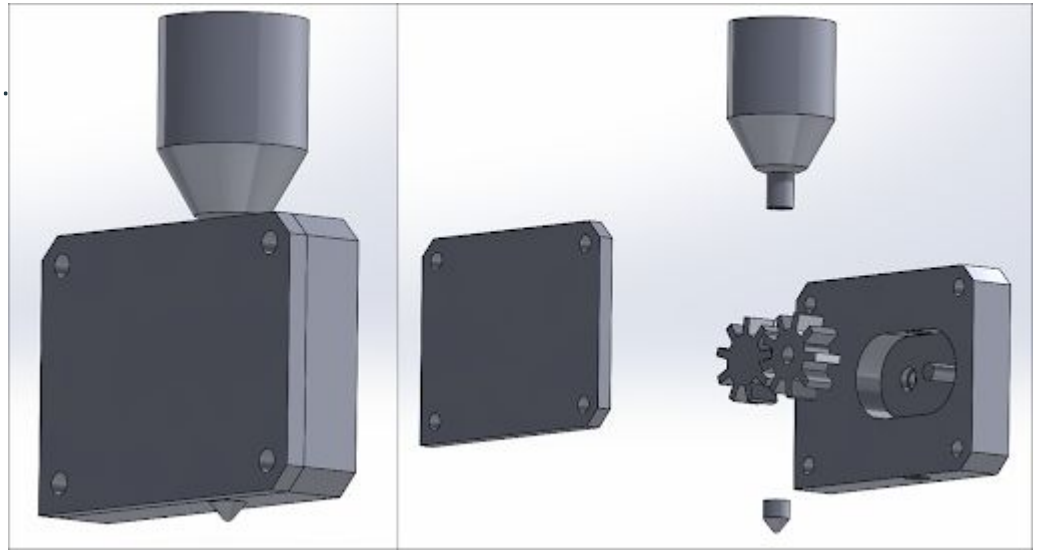
Concept Generation - Head - Concept 2

The gear extruder head would act like a pump.

There would be a motor that creates the

Motion of the two gears and pushes the

Chocolate through the head.



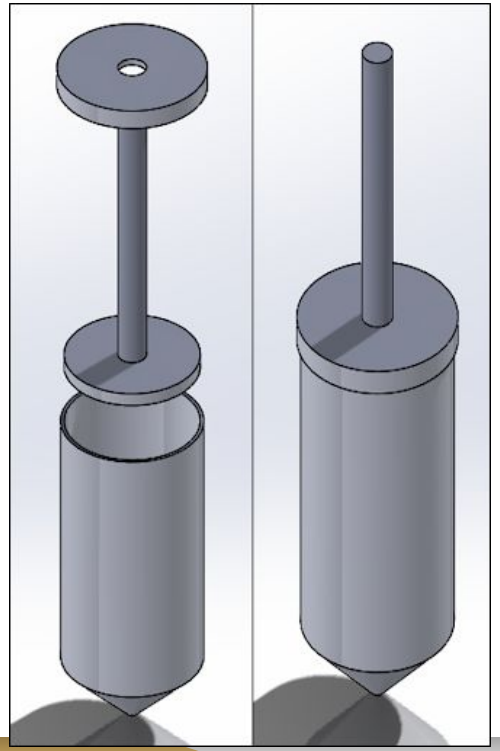
Concept Generation - Head - Final

The plunger concept for the head is a design where the chocolate would be

Extruded by adding pressure to a syringe. The compressed chocolate would

Escape through the hole at the bottom of the syringe and the rate at which

It leaves would be controlled by the pressure.



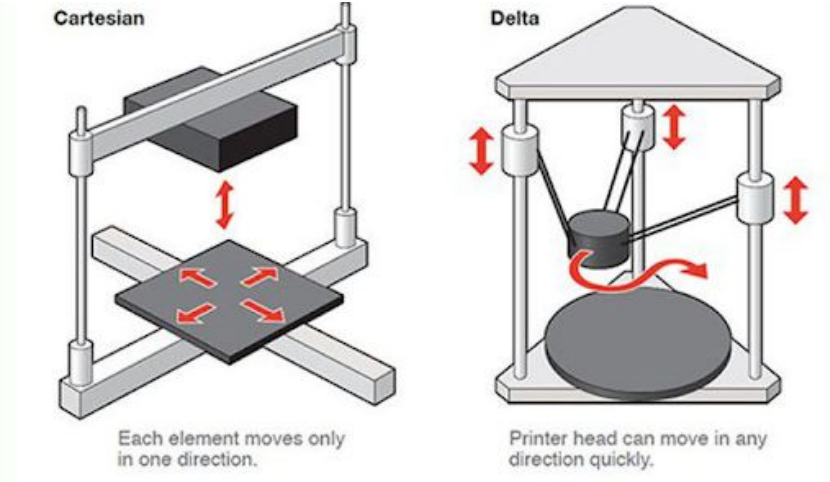
Concept Evaluation - Head & Chocolate

Extruder Heads	Weight	Gear Extruder	Plunger Extruder	Compressed Air
Cleanliness	0.5	0	1	0
Ease of Use	0.2	1	0	-1
Cost	0.2	-1	0	1
Novelty/Aesthethics	0.1	0	0	1
Total		0	0.5	0.1

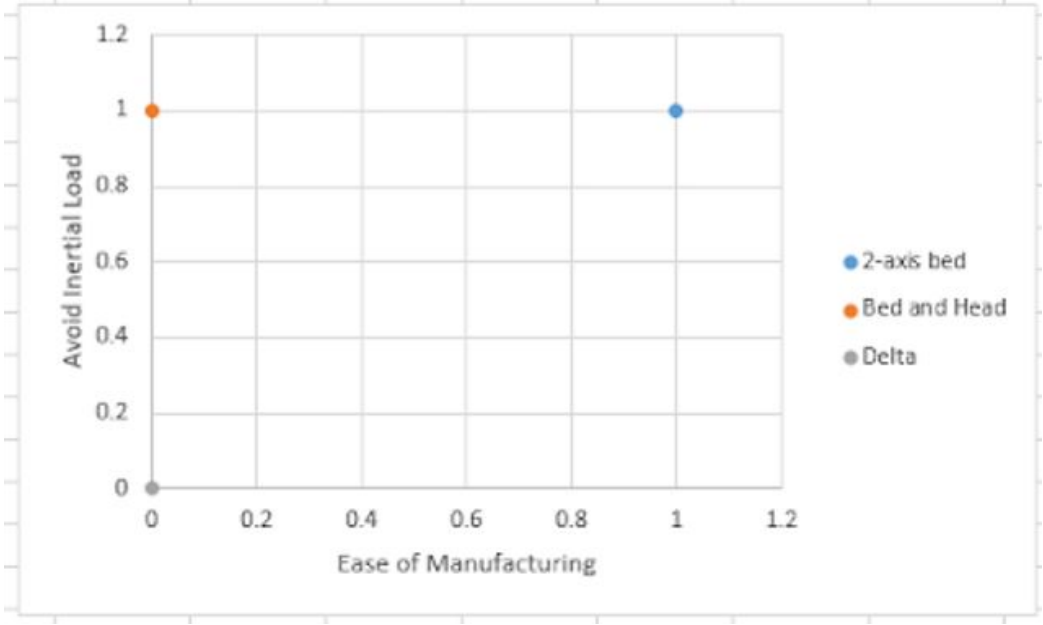
Chocolate	Weight	Belgian Dark Chocolate	Ukrainian Chocolate	Dense Milk Chocolate
Cost	20%	0	-1	1
Cooling Rate	30%	1	0	-1
Taste	30%	1	1	0
Availabitity	20%	0	-1	1
Total		0.6	0.3	0.1

Concept Generation - Bed - Concepts

There were two concepts for the bed which was the delta and the cartesian beds. The delta would operate in 3 Dimensional coordinate system while the cartesian would Operate in a simple X-Y 2 dimensional.



Concept Evaluation - Bed



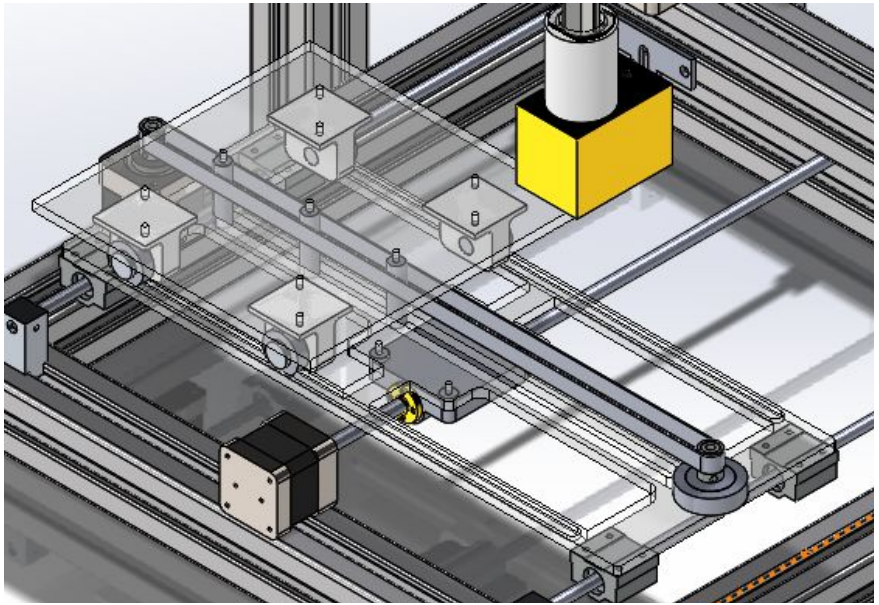
Head Heating

4 ohm heating wire

Temperature control circuit

DC to DC converter

2 Axis Bed Method



Nema 17 Motor Calcs

Torque of motor = 44 N*cm

Lead screw Diameter = .8cm

From daycounter torque calculator

Friction = .12

Pitch diameter = 4mm

Threads per cm = 4

Total force = 150 lb

Weight of full table = 1.73 lb

Friction of bearings = .3

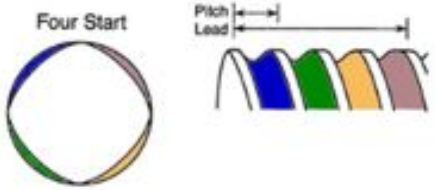
Total force needed to be pushed = .525 lb

Belt

44 N*cm / .4 cm = 110 lb

Needs to move even less than lead screw so will be able to do so with almost 0 motor load

Code Customization



Steps per mm.

Lead = the amount of linear motion in one rotation

```
09:52:29.778 -> $0=5.367 (x, step/mm)
09:52:29.778 -> $1=25.000 (y, step/mm)
09:52:29.778 -> $2=25.000 (z, step/mm)
```

Lead screw 4 start with pitch of 2mm = 8mm translation / rotation

200 steps / rotation

25 steps / mm

Code Customization

Pulley translation

Diameter = 11.86 mm

Circumference = 37.26 mm

200 steps / rotation

5.367 steps / mm

```
09:52:29.778 -> $0=5.367 (x, step/mm)
09:52:29.778 -> $1=25.000 (y, step/mm)
09:52:29.778 -> $2=25.000 (z, step/mm)
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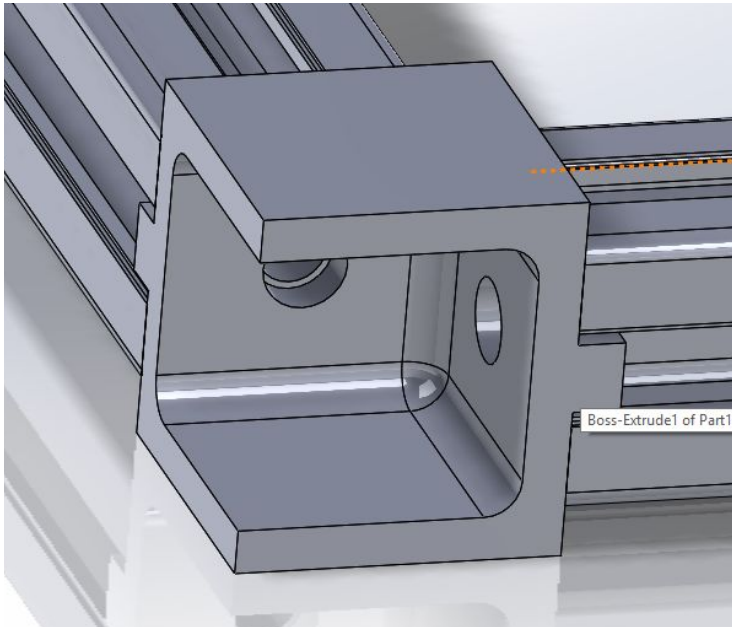
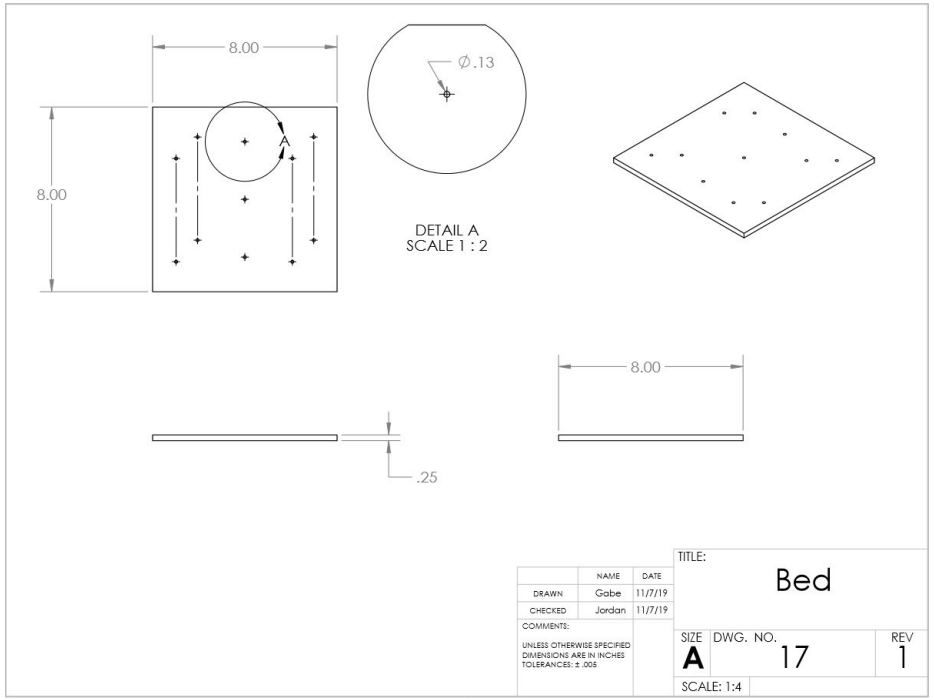
Redesign

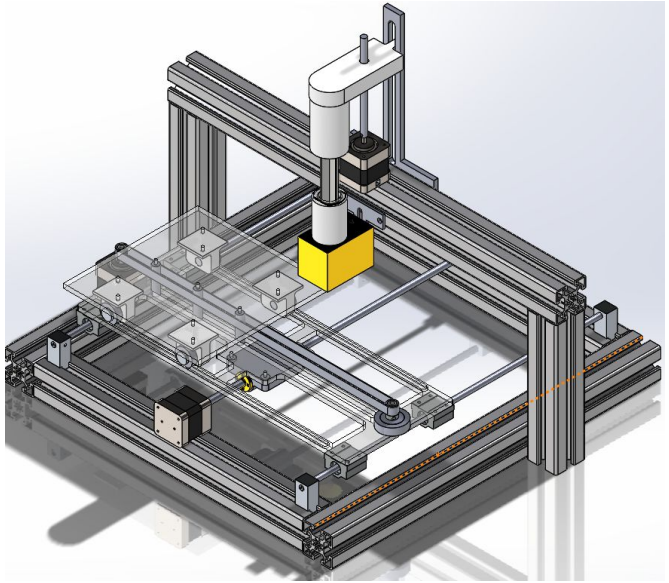


Drawings & Bill of Materials

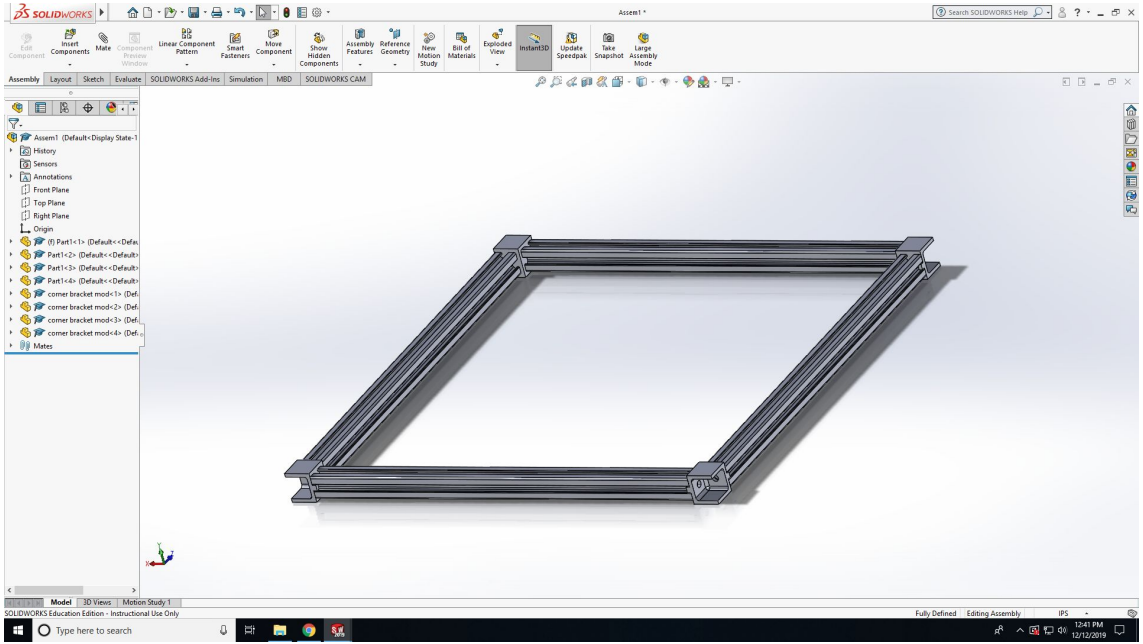


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Extruded Aluminum	Buy	2
2	Rail Holder	Manufacture	4
3	Rail	Buy	2
4	Linear Bearing	Buy	4
5	Largerail	Manufacture	1
6	BED	Manufacture	1
7	TableGuide	Manufacture	3
8	3dprintedbedlift	Manufacture	4
9	hold up pin	Manufacture	4
10	bearing	Buy	5
11	NEMA17	Buy	3
12	Shaft	Buy	3
13	GT2 Timing Gear Alumium For Belt	Buy	2
14	Bearing holder	Manufacture	1
15	non_motor_shaft	Manufacture	1

SOLIDWORKS Design



Redesigns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Edit Component
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Linear Component Pattern
Smart Fasteners
Move Component
Show Hidden Components
Assembly Features
Reference Geometry
New Motion Study
Bill of Materials
Exploded View
Instant3D
Update Speedpak
Take Snapshot
Large Assembly Mode
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Sketch
Evaluate
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Annotations
Front Plane
Top Plane
Right Plane
Origin
Mates
Model
3D Views
Motion Study 1
SOLIDWORKS Education Edition - Instructional Use Only
Fully Defined
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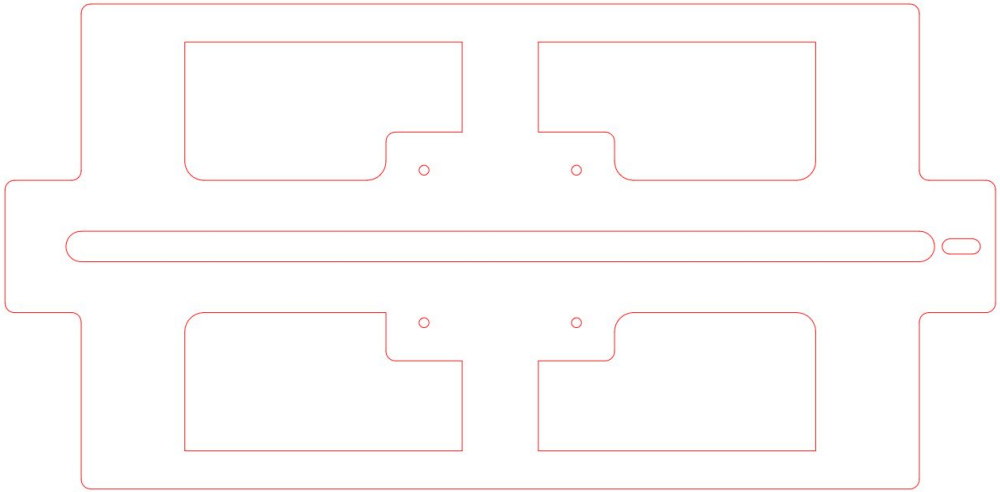
Redesigns



Cost Breakdown

Vendor Links on Website.

Item	Price
T&B Gt2 2 Meters Timing Belt and 2 X Aluminum 20t 8mm Pulleys Set	$8.99
Fenstore Linear Rail 2 Pcs 8mm x 400mm Cylinder Liner Rail Linear Shaft Optical Axis + 4 Pcs Rod Rail Shaft Support	$23.95
4pc 2020 CNC 3D Printer Parts European Standard Anodized Linear Rail Aluminum Profile Extrusion for DIY 3D Printer	$29.99
PZRT 2PCS Silver 2020 Aluminum Profile European Standard Anodized Linear Rail 2020 Aluminum Profile Extrusion	$15.99
OctagonStar T8 L400mm 8mm Lead 4 Start Lead Screw and Nut	$9.90
Professional 3D Printer CNC Kit, GRBL CNC Shield +UNO R3 Board+ RAMPS 1.4 Mechanical Switch Endstop+DRV8825 GRBL Stepper Motor Driver+Nema 17 Stepper Motor	$57.47
uxcell 635-2RS Deep Groove Ball Bearing 5x19x6mm Double Sealed ABEC-3 Bearings 10-Pack	$8.79
Shipping + Tax	$18.58
	$173.66

Testing Plan

- Move bed 1 inch and pause. Measure actual distance. Repeat for entire build area. Move bed 1 inch. Place dial indicator on table. Move back .25 inch and measure actual movement. Repeat 4 times.
- Temperature gauge will be set on syringe and measured for variation throughout the extrusion process. - Temperature consistency test
- Volume per second will be measured as the feed rate. It will be evaluated for the jog speed of 10mm/s
- The printer will be tested to an accuracy of 3mm
- The chocolate will be tested to be at the correct temperature where it does not run onto the bed.
- The team will attempt to clean the printer after use to see the level of ease.

Testing Results X-Axis

X-Axis	Computer Distance	Actual Distance	Units	X-Axis	Computer Distance	Actual Distance	Units
	25	25	mm		10	10	mm
	25	27	mm		15	16	mm
	25	25	mm		20	22	mm
	25	25.5	mm		25	25	mm
	25	25	mm		30	31	mm
AVG		25.5					

X-Axis	Computer Distance	Actual Distance	Backlash	Units
	25	25	0	mm
	25	25	0	mm
	25	25	0	mm
	25	26	1	mm
	25	25	0	mm

Testing Results Y-Axis

Y-Axis	Computer Distance	Actual Distance	Units	Y-Axis	Computer Distance	Actual Distance	Units
	25	13	mm		10	Motor Coupler Failure	mm
	25	23	mm		15	Motor Coupler Failure	mm
	25	Motor Coupler Failure	mm		20	Motor Coupler Failure	mm
	25	Motor Coupler Failure	mm		25	Motor Coupler Failure	mm
	25	Motor Coupler Failure	mm		30	Motor Coupler Failure	mm

Testing Results Temperature

Chocolate takes approximately 30 min to melt uniformly.

Temp	Time	Temperature Measured	Units
	10	76	ºC
	20	87.1	ºC
	30	88.8	ºC
	40	82.7	ºC
	50	76.6	ºC
	60	88.3	ºC
Average Temp	83.25ºC	Difference (Max-Min)	12.8ºC

Testing Results Z-Axis

Inconclusive

Customer Requirements and Engineering Specifications

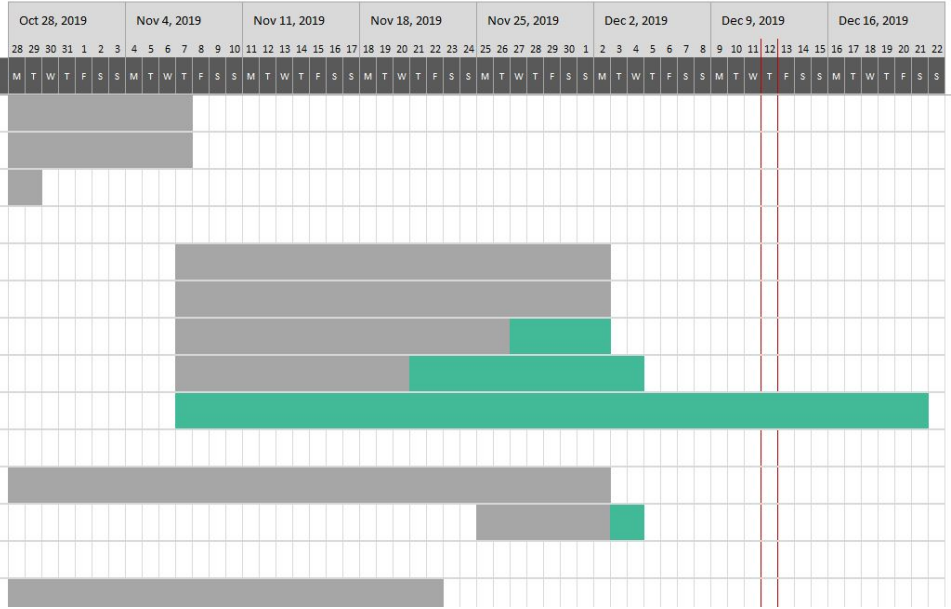
- Has a two letter function: i and l
- Can create - symbol
- Severely limited in final functionality for customer
- Two axis bed to avoid inertial loads from the head
- Motors that can apply .525 lb of linear force
- Extruder head between 80 and 90 degrees celsius
- Feed rate of 4000 mm/min
- 24 volt power supply
- 4 ohm heating element
- Accuracy of .5 mm in at least one axis

Gantt Chart and Timeline

Project Start: Wed, 8/28/2019

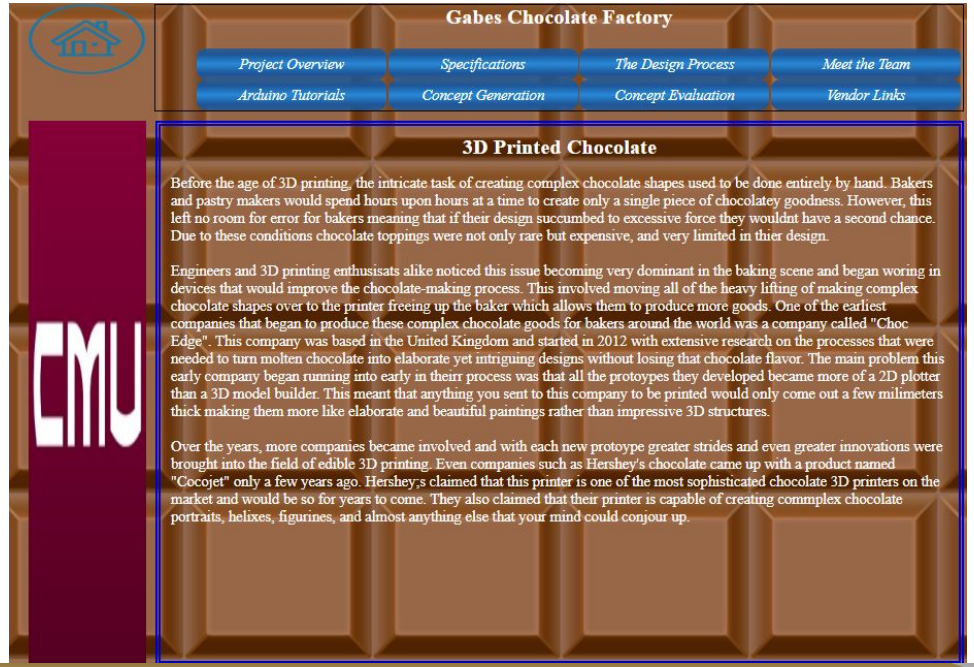
Display Week: 10

TASK	ASSIGNED TO	PROGRESS	START	END
Extruder Head	All Members	100%	10/22/19	11/7/19
Material Selection	All Members	100%	10/22/19	11/7/19
Purchase Report	All Members	100%	10/22/19	10/29/19
Prototyping				
Sub-Body Assembly	All Members	100%	11/7/19	12/2/19
Body Assembly	All Members	100%	11/7/19	12/2/19
Extruder Heads	All Members	80%	11/7/19	12/2/19
Material Feed Line	All Members	50%	11/7/19	12/4/19
Coding	George & Jordan	100%	11/7/19	12//2019
Testing and Website				
First Testing	All Members	100%	10/21/19	12/2/19
Second Testing	All Members	80%	11/25/19	12/4/19
Website shell	Gabe & George	100%	9/16/19	9/26/19
Website Design	Gabe & George	100%	9/16/19	11/22/19

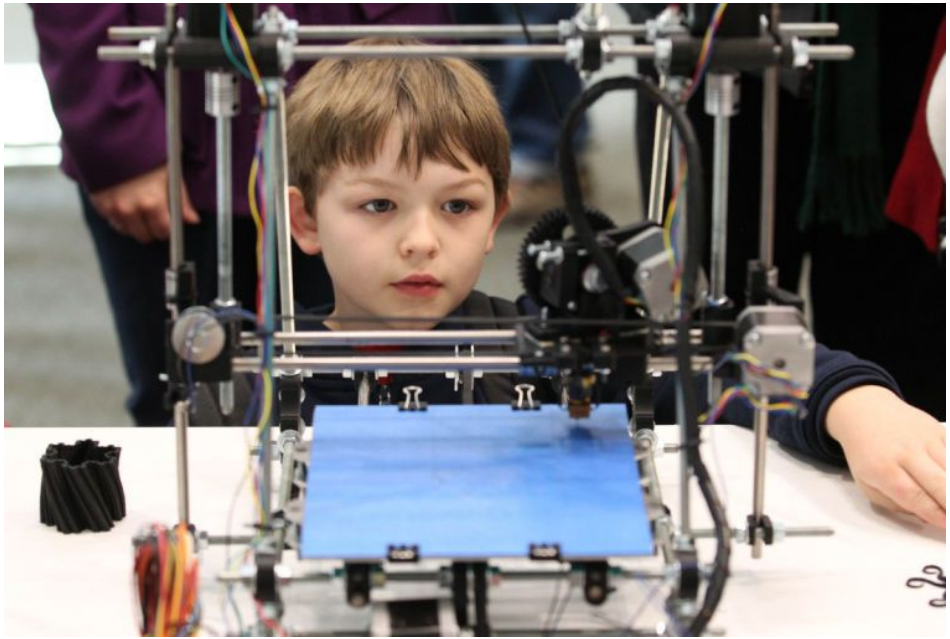


Website

https://org.coloradomesa.edu/~gavandorpe/Gabes_Chocolate_Factory/



Demonstration



Questions?