Teacher's Guide

PancakeBot®
*batter's not included

Lesson Plans
Quick Start Lesson Plans Visit SCOPES-DF.org

Technology Type
3D Printing*, CNC, Micro Controllers, Food & Bio Printing

Themes Covered

Science
Chemistry of cooking, air flow

Technology
CNC, Food Printing,

Engineering
Belts, pulleys, stepper motors

Art
Create visual appealing edible designs

Math
Cartesian coordinates, Polar coordinates, algorithms

Grade Level:
Elementary-Collegiate

Synopsis

The latest version of PancakeBot stands out as the first and only easily accessible STEAM project that works with food to inspire, innovate, educate, as well as provide a source of revenue if used as an entrepreneurial tool.

Most importantly, making Pancakes with technology is just plain FUN!

The initial setup for this version of PancakeBot is quick and simple. The most difficult part, believe it or not, is making the batter!

The purpose of this guide is as follows:

- Inform you about Safety requirements
- Provide a background to help students understand how the idea came about.
- Provide Quick Start Guidance
- Familiarize you with PancakeBot Controls & Best Practices
- Introduce you to Pancake Painter design software
- Provide helpful tips for caring for you PancakeBot

PancakeBot was originally conceived as a fun project to inspire my children to look at technology in a different way. The consumer version of the PancakeBot is far better than the LEGO version, however, it still requires some special handling and practice to get it right.
I am confident that with a maker mindset, you and your students will be able to quickly master the quirks of your PancakeBot and will create beautiful designs. Remember to keep on making and enjoy the journey and all the learning it has to offer along the way.

Miguel Valenzuela
Inventor of PancakeBot

*PancakeBot is a Pancake Printer that uses 3D/CNC Technology, however, it does not have a traditional "Z" Axis as most traditional 3D Printers.

VOCABULARY

(Language Standards, etc.)

This guide contains several technical and scientific words, phrases and terms that may be unfamiliar to the students. It is encouraged that students review some or all of the vocabulary below.

Encourage students to break down words into their root words to better understand the meaning behind the words. Ask them to associate other words with the different roots and guess what other words mean based on their roots.

Scientific
Reaction, Maillard, caramelization, enzymes, starch, sugars, amino acids, reducing, ingredients

Mathematical
Cartesian Coordinates, vector, algorithm, polar coordinates

Technical
Belt, pulley, stepper motor, DC, AC, microcontroller, polarity, milliseconds, feed rate, pneumatic, pressure, vacuum, vacuum pump, solenoid, toothed, gear

Programming
Algorithm, G-Code, Python, Javascript, Arduino, C Sharp

BEFORE USING PANCAKEBOT

Safety

Before using the device, you must discuss safety precautions that should be taken when using PancakeBot. These are a few main points that should be noted, but you must read the official manufacturers model to become familiar with standard safety concerns for an appliance.

- The griddle is a greaseless griddle, meaning you should not apply grease or oil on it for cooking. The Teflon surface prevents sticking.
- Check the temperatures of the pancakes to ensure they are safe before eating them. Steam may get trapped inside air pockets in the cooked pancake.
- Open Belts: Keep loose hair or clothes away from the belts while the PancakeBot is moving. The belts and motors are low powered but may pinch fingers during movement if fingers are caught between the belt and the drive motors.
- Always assume the griddle is hot. The griddle will remain hot for at least 10 minutes even after it is unplugged and turned off.
  Take care when removing the thermostat heating probe. The metal probe should always be assumed to be hot.
- Always unplug the electric cord from the power outlet after use.
- The griddle may warp slightly during extended usage. Drop the temperature down on the thermostat should this occur.
- The griddles for PancakeBot are voltage specific and there are different voltages for US(110V) and EU(220V) approved Griddles. Check the bottom of the griddle to make sure you are using the right voltage.
- Always assume a risk of fire when using any cooking appliance. Discuss any fire risks with the appropriate safety personnel.
- Last and most important, just remember to keep a safety mindset!

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Background

PancakeBot is a creation of Miguel Valenzuela, professional registered civil engineer and graduate of Cal Poly San Luis Obispo's BioResource and Agricultural Engineering program.

It was inspired in 2010 by his daughter Lily when she asked him to build a "pamcake" machine out of LEGO. What followed was a mission to create pancakes using only LEGO pieces (except for the batter bottle).

After 6 months and 20 gallons of home made batter, Miguel successfully printed Mickey Mouse shaped pancakes for Lily and her sister Maia. In 2011, Miguel shared his creation with the world through a low resolution video and home made sound. The video went viral and PancakeBot staked its claim in the internet and global Maker Movement.

The years that followed consisted of the PancakeBot family travelling to different maker faires demonstrating the LEGO version of the PancakeBot.

In 2014 Miguel developed an acrylic prototype and unveiled it at the Bay Area Maker Faire to the delight of many visitors. Soon after, the family attended the First White House Maker Faire where they exhibited their PancakeBot versions and filled the White House with the smell of Pancakes.

In 2015, the company StoreBound LLC. licensed the idea from Miguel and created the consumer version of the PancakeBot, unveiling the world's first consumer food printer to the world.
In 2019 Miguel moved away from StoreBound LLC, and facilitated the contribution of the remaining inventory of PancakeBots to the MIT Fab Foundation, in order to get the PancakeBot's out to schools and use them for educational purposes.

Miguel and his family still live in Norway and continue the PancakeBot Mission of making food printing fun and inspiring others with pancakes.

Video Links
Original PancakeBot Video

Articles
Make Magazine 2012
Tech Crunch 2012
C-NET 2014

Activities: Inventing Discussion

Creativity comes in all shapes and sizes and the biggest hurdle to innovation is execution. Many times, students do not know what to do with an idea.
Discuss with the students what they would do if they came up with an idea. Would they protect the idea? If so, how? Would they give the idea away? Discuss what tools they would use to make different prototypes.

Useful Sites for Inventors

USPTO.gov
patents.google.com

Pop Culture Popularity

PancakeBot has had a cult following amongst popular YouTubers such as Unspeakable and Preston and has found its way into the hands of celebrities like Jimmy Kimmel, Prince Charles, and Stephen Glickman.
It touches a nerve with a variety of personalities including educators, chefs, engineers and kids.

Quick Start Video

We have created a Quick Start Video that gives you an introduction of how to start making pancakes with PancakeBot. Click on the link below to get started.

vimeo.com/pancakebot/quick-start-video

The video details step by step instructions on how to make your first pancakes as well as what to look for. Main points of the video are as follows:

1. Quick start Setup
2. Batter preparation best practices
3. File Types
4. Pancake Painter Software
5. Griddle Pre-Heating
6. PancakeBot Homing and Startup
7. Proper bottle filling technique & Air Hose insertion
8. Air Hose protection
9. Control panel file navigation
10. Real time pressure and speed adjustments
11. Pancake flipping tips

Recipes

Our recommended recipe is as follows: Number of pancakes varies depending on pancake size.

Kitchen Utensils

1. Two 1.5 quart mixing bowls
2. 6-8" Fine mesh sieve, mesh holes must be no larger than 1/16"
3. Rubber spatulas
4. Cup measuring utensils
5. Spoon measuring utensils
6. Whisk or electric mixer

Liquid Ingredients

1. 1 CUP Milk
2. 1 Grade AA Egg
3. 2 TB Oil (corn, soy, etc.)

Dry Ingredients

1. 1 Cup All Purpose Flour
2. 2 TB Sugar
3. 2 TSP Baking Powder
4. ½ TSP Salt

Instructions

1. Mix liquid ingredients in first bowl
2. Mix dry ingredients in second bowl
3. Pour dry ingredients into liquid ingredients bowl and mix thoroughly.
4. Wipe down with a paper towel to dry bowl (or rinse and dry if applicable).
5. Place fine mesh sieve over empty second bowl and pour wet ingredients through sieve, using rubber spatula to press batter through sieve. Press as many clumps as possible through the sieve, but make sure no clumps get into the batter.

Note:

1. If the mix is too thick, at 1 TSP of milk to the mix at a time till you achieve the correct consistency.
2. Store your batter in a refrigerator if you will not use it within two hours.
3. If you will prepare batter the night before, hold off on the baking powder, and mix the baking powder into the final recipe before using it with PancakeBot. This prevents the CO2 from escaping overnight.

The Control Panel

The onboard Control Panel allows one to fully control the pancake printing experience without the use of a computer. Here the files can be selected from the SD Card, the print started, and speed and dispensing pressure adjustments can be made while the PancakeBot is printing.

These controls allow for you to compensate for the variation in batter viscosity due to a variety of factors.

On Board Control Panel.

While Printing Pancakes

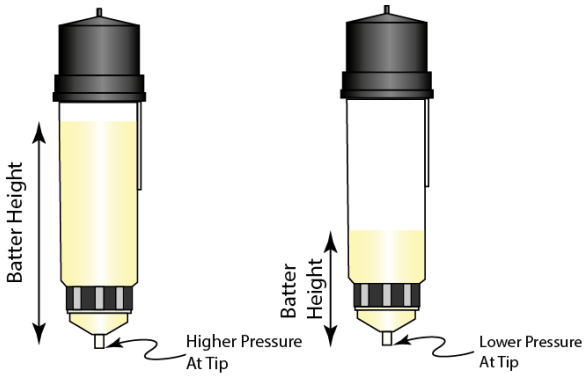
As mentioned in the Quick Start Video, adjustments to the prints can be done **WHILE** the pancake is printing. This is very important to note as the batter flow may change due to a variety of variables. While there are many different variables that affect results, there are three variables that can be controlled during printing. Those are dispensing pressure, print speed (feed rate), and griddle temperature.

Controlling Dispensing Pressure

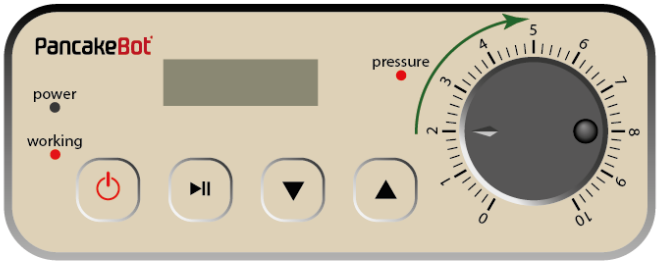
Dispensing pressure is analogous to filament feed rate in 3D printing. The pressure in the bottle influences how fast the batter comes out of the nozzle.

As the height of the batter changes, the dispensing pressure changes due to what is known as hydrostatic head or column height.

The graphic below illustrates this hydrostatic phenomena.



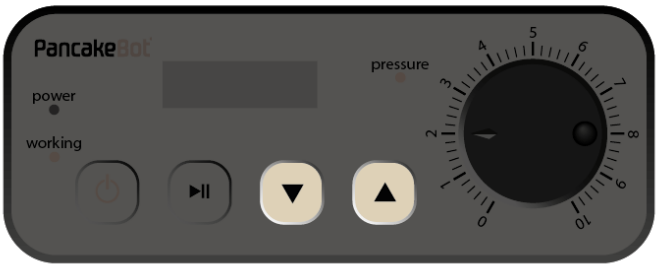
As you can see, the pressure at the tip due to hydrostatic head or column height, will be lower when there is less batter in the bottle. A lower pressure results in less batter being extruded over time and variations to the line width of the print. The solution is to either increase the pressure, or decrease the speed of the PancakeBot (decreasing the speed of the print allows for more batter to accumulate on the griddle over a distance).



Increase pressure by rotating dial clockwise.
Arrow currently points to 2.

Controlling Print Speed (Feed Rate)

The speed of the printer is initially controlled by the G-Code. Further control can be achieved by using the up and down arrows to change the speed in increments of 10%.



Control feed rate with up and down arrows in increments of 10% of initial G-Code setting.

For example, F1500 sets the feed rate to 1500 mm per minute. By pressing the up arrow, it increases the feed rate to 1500+10%(1500) or to 1650.

Controlling Griddle Temperature

Griddle temperature is independently manually controlled on the griddle and cannot be controlled with the coding or the control board. The thermostat control only lists temperatures as low, medium or high. As a rule of thumb, low temperatures fall under the Maillard reaction temperatures <126°C (cooked but white), medium is within the Maillard reaction, <126-165°C (cooked and light brown), and High is caramelization, <165°C (dark brown).

Relationship Charts

The following charts are good visual aids that illustrate the relationship between the different variables associated with pancake printing. They are intended as references that can help students understand the many variables that work together to produce desired results.

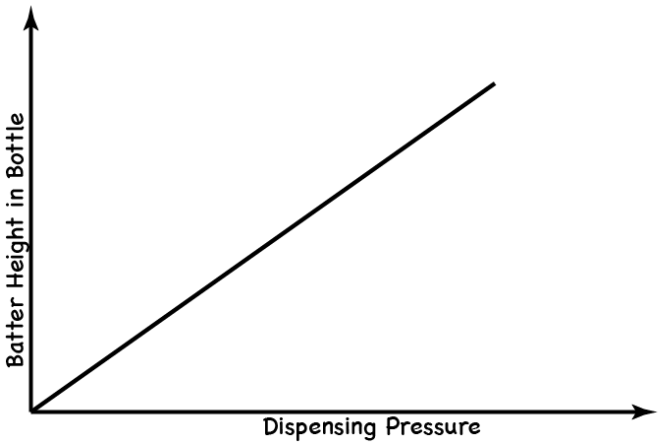


Chart 1: Dispensing Pressure vs. Batter Height in Bottle

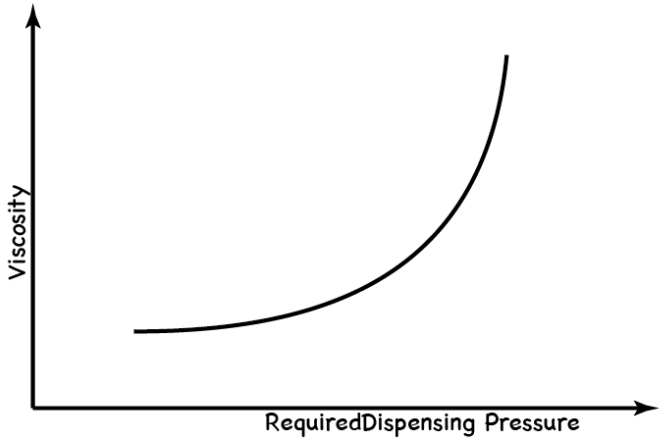


Chart 2: Viscosity vs. Required Dispensing Pressure

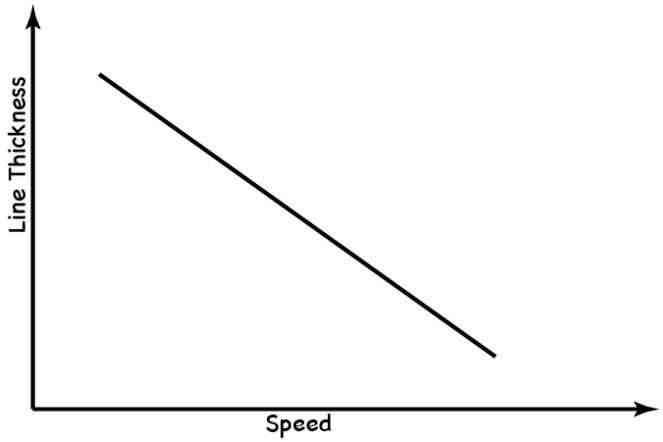


Chart 3: Speed vs. Line Thickness

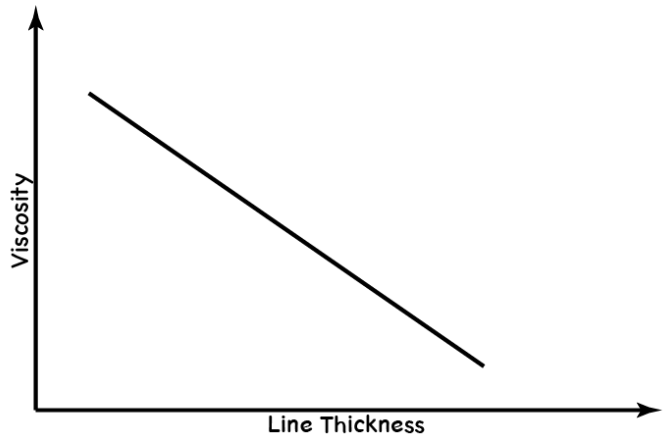


Chart 4: Viscosity vs. Line Thickness

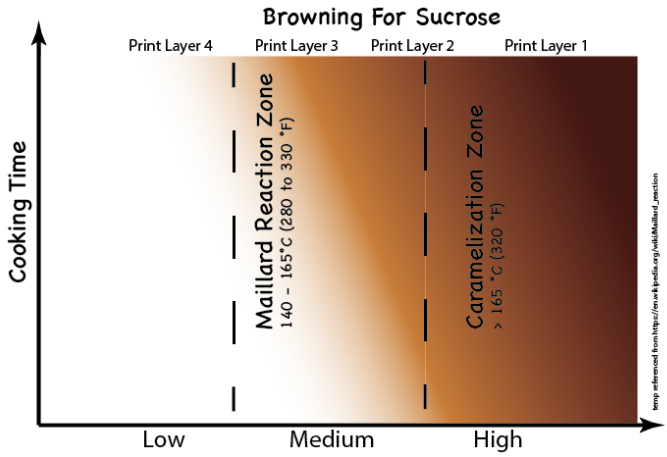


Chart 5: Browning based on Cooking Time vs. Griddle Settings

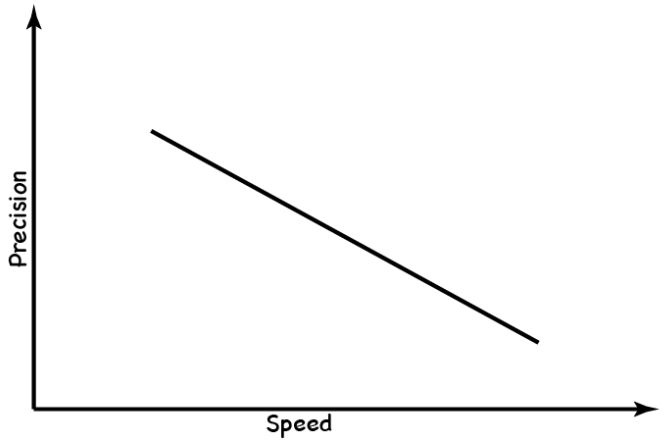
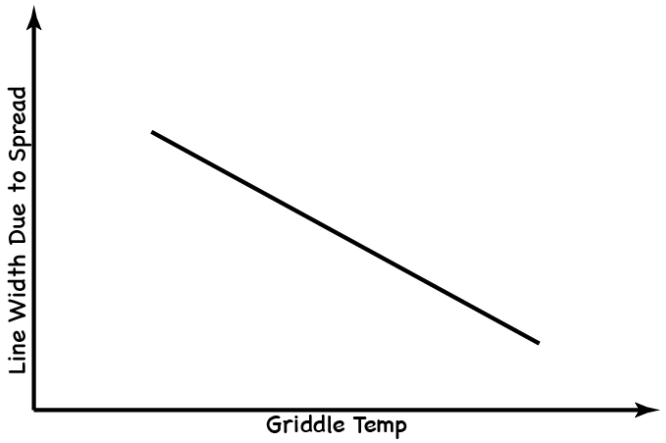


Chart 6: Speed vs. Precision



CREATING YOUR OWN DESIGNS PANCAKE PAINTER

To draw your own pancake design we have created an Introduction to Pancake Painter video. Visit the video to learn how to draw your own pancake.

Key points of the video are as follows.

1. Drawing Interface
2. Drawing Tools
3. Importing Images for manual Tracing
4. Importing Images for Auto Tracing
5. Saving Files
6. Exporting Files for Printing
7. Making Adjustments

You can download the software here:

Pancake Painter Drawing Tips

1. Think about how you would draw pancakes by hand
2. Filling over lines
3. Designing for hand fill
4. Anticipating Changes

Troubleshooting

The top three issues we have identified with users of PancakeBot and how to resolve those issues are shown below.

1. Problem: Bottle only dispenses drops
2. Solution 1: Increase the pressure by turning the pressure knob clockwise.
   Solution 2: Check that bottle lid, and bottle tip are screwed on snug and not leaking
   Solution 3: Check the vacuum hose for clogs
   Solution 4: Check that the hose is properly connected and pushing air out. You can use the Pneumatic Test File (PTF.gcode) included in the startup folder or downloadable from Github.com/PancakeBot
3. Problem: Files on SD Card cannot be read
4. Problem: Gantry Axis (Batter Bottle Holder), does not move.

For Further PancakeBot Trouble Shooting, Visit PancakeBot.com/Support or contact us at FABSupport@Pancakebot.com
Please include your school and serial number information located on the underside of the base.

CLEANUP & CARE

Properly cleaning your PancakeBot is important to continuing success.

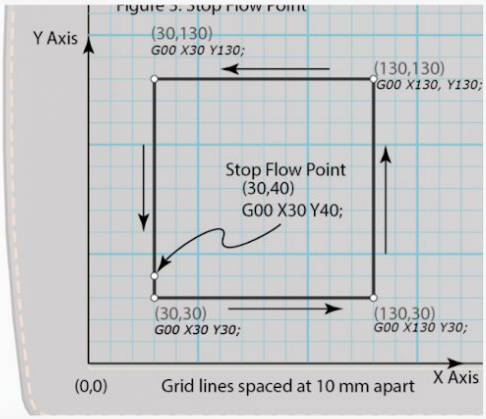
The most important thing is to keep the pneumatic system clear of batter or moisture. You can do this by cleaning the pneumatic tube after use. *Tip, do not remove the pneumatic tube from the unit, simply rinse it out with a dental syringe while it is hooked up. For users of PancakeBot 1.0, the hoses come off completely.

For users of PancakeBot 2.0, the hose comes off at the connection point of the batter blocker.

ACTIVITY SUGGESTIONS

While we keep adding more activities to the SCOPES-DF platform scopesdf.org/pancakebot, we are listing three projects you can start doing right away with your students.

Activity 1: Bytes to Bites



BYTES TO BITES: DRAWING PANCAKES WITH G-CODE

Create your pancakes with code! This lesson introduces

Activity 2: Designing 3D Prints

DESIGNING PANCAKEBOT 3D PRINTED EXTENSIONS

Hacking machines to either improve, or change the original purpose of the machine can be rewarding and gives the

Activity 3: Python Turtle

PYTHON TURTLE SPIROGRAPH PANCAKES

Spirograph is the name given to a drawing tool that makes "mathematical roulette curves" known as hypotrochoids. In

ABOUT THE PANCAKEBOT FAMILY

Miguel Valenzuela is the inventor of the PancakeBot and currently lives outside of Oslo, Norway with his family, who he credits as being co-creators of the PancakeBot. When asked by Make Magazine why he invented PancakeBot, and how he kept moving forward with the project, he replied, "Well, inspiration followed by inaction eventually leads to regret. When I was a kid, I had lots of ideas, but technology wasn't as accessible and it was difficult to find mentors where I lived. So I told myself long ago, when my daughter Lily was born, that I would do my best to help her realise her ideas if she ever had any." He has always considered this a family project, and he continues working on other projects that help inspire and motivate others to create and make.

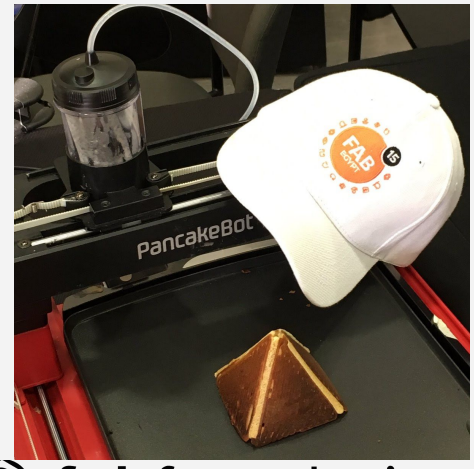
PancakeBot Relationship with the Fab Foundation

In 2019 Miguel approached the Fab Foundation to discuss the possibility of using the consumer version of the PancakeBot within the educator and Fab world. It was a natural progression, since the acrylic prototype had been created in the first Fab Lab in Norway.

Ordering Information

The PancakeBot online ordering form is found here: https://docs.google.com/forms/d/e/1FAIpQLSeSDzwVumIXJFKj9dE-yPh8jrV6yVLXQye2YfMk-YHWKc7F6g/viewform

About SCOPES-DF and The Fab Foundation



fabfoundation Guide

SCOPES-DF program provides free lessons for teachers.

Miguel has created a guide specifically for the Fab Foundation that goes significantly deeper into the workings of the PancakeBot, as well as detailed specifications of the PancakeBot. It is considered for advanced users and those interested in extending the capabilities of the technology.

Notes