Extruder Path Forward

1. **Acceptable test geometry**

Circular geometry; the diameter of this circle should be ~5 cm to start. Further testing may require a larger diameter and a more intense curve. A 5cm circle wouldn’t be a ton of rotation from the z.

1. **What will you be doing next semester?**

Working a lot on the nozzle; that’s the main focus of the extruder at this point. Another important focus will be figuring out a way to rotate the entire extruder with the structures team (ball bearing, joints with multiple DoF). Once we get those two things down it’s just a matter of making sure we have motors that can move it precisely.

CAD will be important when we order all the parts and get accurate dimensions for the extended nozzle and joint with the structures. We plan to extend the nozzle 3 cm (for prototype)

* 1. **What must be designed?**

The extruder must be fully designed, including final dimensions, materials, and how it will function.

* + 1. **What are the requirements of the design?**

The extruder must be extended to a greater length than common 3D printers while maintaining the heat until the material leaves the nozzle. It must be able to rotate upwards from the z-axis.

* 1. **What will you do if you discover a certain design won’t work?**

The current design is to rotate the entire extruder/nozzle while following the toolpath. If this is not possible, we have to consider other designs with alternate functions.

As far as a parts list goes, we plan on buying a premade extruder and modifying the nozzle. This should be fairly easy and we plan on using a very conductive metal to keep the PLA hot throughout the rest of the nozzle. The base extruder will be no more than $50. This may come with challenges so a backup is listed below.

* + 1. **What are your backups?**

1. Rotate only the nozzle while printing instead of the entire extruder.
2. Reduce the length of the extruder if there are issues with maintaining the required temperature throughout the tube.
3. For parts: create an extruder from scratch if it turns out that we can’t modify the original extruder.
4. **What will you accomplish by the end of the next semester?**

Parts to be Purchased:

Hot end:

1. <https://gulfcoast-robotics.com/products/v6-metal-j-head-hotend-1-75mm-filament-0-4mm-for-universal-extruder-for-reprap-3d-printer?utm_medium=cpc&utm_source=google&utm_campaign=Google%20Shopping&gclid=Cj0KCQiAn8nuBRCzARIsAJcdIfPhHUGISCfL8WRlSeAWNQdG0qqrcT8fYZYJujvq_r2r2dt_k54n520aAq2MEALw_wcB> (34 dollars)
2. <https://gulfcoast-robotics.com/collections/hotends/products/v6-all-metal-bowden-hotend-plus-high-temperature-printing-for-3d-printers> (25 dollars)

Cold end:

1. <https://www.amazon.com/dp/B07QDV7ZVJ/ref=sspa_dk_detail_1?psc=1&pd_rd_i=B07QDV7ZVJ&pd_rd_w=EQuvW&pf_rd_p=45a72588-80f7-4414-9851-786f6c16d42b&pd_rd_wg=kBUUe&pf_rd_r=P9PZ64CH4AWS0FMX254C&pd_rd_r=c69d8f5f-7458-446a-9734-2425cbbce875&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzTzZJUFpUVE9ZUjdUJmVuY3J5cHRlZElkPUEwNjI1MTc5NU1XSlY1VkdNTkJOJmVuY3J5cHRlZEFkSWQ9QTAzNDA2MjExN0hVVFhMNlRWNzlOJndpZGdldE5hbWU9c3BfZGV0YWlsJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ==> (40 dollars)
2. <https://www.amazon.com/Printer-Accessories-BCZAMD-Extruder-Creality/dp/B07RBL4CJC/ref=pd_cp_328_2/130-9753526-6494605?_encoding=UTF8&pd_rd_i=B07RBL4CJC&pd_rd_r=85fad698-05a5-407d-8e8f-8d59ac3c4540&pd_rd_w=Aa1jB&pd_rd_wg=Q1MEO&pf_rd_p=0e5324e1-c848-4872-bbd5-5be6baedf80e&pf_rd_r=3Y9C7Z61KXSS28XTR7TS&psc=1&refRID=3Y9C7Z61KXSS28XTR7TS> (22 dollars)

Arduino \*if we build our own

1. <https://www.amazon.com/RoboGets-Compatible-ATmega328P-Microcontroller-Electronics/dp/B01N4LP86I/ref=sr_1_1_sspa?keywords=arduino+uno&qid=1574130240&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyMEQ2REFPMlhSQkZTJmVuY3J5cHRlZElkPUEwOTIyMTc2TERYTDNEVkhUOFc0JmVuY3J5cHRlZEFkSWQ9QTAwNDY3MTUzTFRMNkI0TVNaM1BBJndpZGdldE5hbWU9c3BfYXRmJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ==> (16 dollars)

Temperature Sensor \*if we build our own

<https://www.amazon.com/HiLetgo-Temperature-Humidity-Digital-3-3V-5V/dp/B01DKC2GQ0/ref=sr_1_1_sspa?crid=27DRNHJ70UWWI&keywords=arduino+temperature+sensor&qid=1574130281&sprefix=arduino+tempera%2Caps%2C131&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzOUtNMTlZR1pPTDA0JmVuY3J5cHRlZElkPUEwNTU2MDIwM0lXUDZOTFBDRFA5USZlbmNyeXB0ZWRBZElkPUEwNzc2MDY1MTcxNUpDUVdEMVZNTyZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=>(11 dollars)

Nozzle

a. It’s looking like we’re gonna have to make our own nozzle. Not much we can buy online in terms of a longer nozzle unless we add a longer tubing on the *actual* extrusion point of the nozzle.

B. Use a heated coil to wrap around the extended part of the nozzle if the extruder doesn’t work. It would need its own power supply.

1. **What do you want to explore in terms of research?**
   1. **Methods**
2. Designing: Using data on dimensions for the parts that we plan to purchase, we will develop a finalized design for the extruder that we want to initially build and test.
3. Building: After parts are acquired, we will conduct our planned alterations and construct our initial design.
4. Integration: We will need to integrate our product with that of the extruder team before we begin testing.
5. Testing: We will proceed through our planned testing phases.
6. **What resources do you need from Dr. Mitchell?**

The majority of what we will need from Dr. Mitchell is advice on how to conduct testing and the best ways to analyze our test results.

* 1. **If you can’t get those resources, what would your budget look like?**

As of now, we will not be able to get any of our physical resources from Dr. Mitchell so it would not alter our budget.

1. **What do you need from each subteam?**
2. Structures: We will need to coordinate dimensions and materials so that we can integrate our designs without complications.
3. Scanning: We need to be sure that our extruder will be capable of following the toolpath that is required for testing. The teams will need to communicate about the design of the toolpath and the constraints that this path will place on the extruder.
4. **What will you bring to the research? In what way is the work or plan novel?**
   1. **Tests**

I. Heating: Initial testing must be conducted after the extruder is constructed to make sure that the heat can be maintained throughout the entire length of the extruder.

II. Printing on Flat Surface: We will test the extruder’s ability to print on a typical flat surface to make sure that the printer functions normally.

III. Printing on a Conformal Surface: We will begin testing the extruder’s ability to print on the concave surface.

IV. Complex Testing: If the extruder can successfully print on the initial concave testing surface, other surfaces can be designed for more complex concave surfaces.

* 1. **Verification of prior research models/proposals for future work**

As this type of printer has not been designed yet, we do not have a prior research model to follow. The proposals for future work will be dependent on how successful our testing is; further testing could involve more complex surfaces and different nozzle sizes.

1. **If you discover that your goals or methods are too complicated, what will you do?**

* Idea 1: Use a regular extruder off the internet and pull together a new project idea using a regular 3D printer
* Idea 2: Build our own extruder from scratch and try and optimize it the best we can. Try and slim down the sides and hot end for extended depth into a concave hole

1. **In general, if you were to start tomorrow, what needs to happen? How will you make it happen? When are your deadlines?**

We would order parts and start constructing the extruder. We would definitely need to look into more forms of getting funding in the near future. Our timeline goes as follows

Spring 2020

-Order all of our parts depending on budget

-Begin construction on extruder

-Plan to have a prototype done by the end of the semester

Fall 2020

-Complete construction on extruder

-Begin independent testing

Spring 2021

-Begin integrated testing with structures

-Refine bugs

Fall 2021

-Continue testing with structures

Spring 2022

-Finalize data and collect the final results

**Notes for building our own extruder**

-For a 1.75 mm extruder nozzle, use a drill press with a drill bit size of 1.35 mm (accounting for error and expansion of nozzle as heated material flows through)

-Will take around 15-20 minutes to heat up to temperature of 190-210 C

-If we extrude too fast, too much pressure builds up in the nozzle

**PLA Properties:**

* Flexural elastic modulus: 3600 MPa
* Flexural Strength: 108 MPa
* Heat distortion temperature HDT B (0,45MPa): 56 °C
* Melting temperature: 180-220 °C
* Tensile modulus: 1120 MPa
* Tensile strength at break: 39 MPa
* Flow rate: slower is better because pressure builds up if the extrusion speed is too high and stuff will start to break. 40 RPM has been thrown around in various sources

**Electronics requirements:**

* Power off of purely self-contained power supply
* Temperature sensor included in our extruder
* 12 V power supply