GNG 1103 – Engineering Design Faculty of Engineering – University of Ottawa

Conceptual Design

Group 9

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Problem Statement:

There is a need for a tool that can take a sample ranging from 30 to 80 mg from 15 feet inside of a 4-inch diameter pipe. The tool needs to be removable from the pipe in the event of a failure, while also being usable in both vertical and horizontal orientations.

Subsystems

Insertion:

The insertion sub-system is responsible for getting the tool into the pipe.

Extraction:

The extraction sub-system is responsible for getting the sample out of the pipe in a safe way. The sample should be extracted in a way where user contact is not necessary.

Collection:

The collection subsystem is responsible for removing a sample from the inside of the pipe.

Failsafe:

The failsafe subsystem is a critical component designed to prevent damage to the pipe and avoid expensive removal procedures if the tool malfunctions or becomes stuck inside the pipe. Given the user's needs, the failsafe must ensure that if the tool breaks down, loses power, or becomes stuck there is a reliable way to retrieve it safely without damaging the pipe or requiring destructive removal methods.

Feedback:

The feedback subsystem within our design is a system that provides real-time information on the state of the tool. It provides the user with the amount of samples collected and whether the tool is working properly. This is an important part of our design as one of our users needs a highly emphasized sample size.

Subsystem Design Concepts

Team Member	Insertion	Collection	Extraction	Failsafe	Feedback
Derek	The tool is extendable/foldable/ extended down the pipe. Push the inner rod to extend the tool.	Steel blade or brushes. Magnet draws shavings inside of the tool. Twist the tool to scrape shavings from the pipe which are collected into the tool itself. (Tool is hollow).	The metal rod inside the tool is attached to the end. Pull on the inner rod to retract the sections of the tool.	The wire is attached to each “foldable section” and can be individually pulled out if the tool falls apart at connection points.	Measurements are indicated on the tool to show how much the tool has turned. A micrometre of sorts. Every 2pi rotation is calibrated to how many “shavings” are retrieved.
Trey	The tool has wheels to smoothly move down the pipe.	The tool uses a diamond file driven by a motor. The filings are swept out of the pipe with a brush at the front of the tool and are collected at the opening of the pipe.	The tool may be attached to a cable where it can be smoothly pulled out using the wheels by the operator.	A rod is used on the opposite end of the pipe to push the tool out.	File rotation counter.
Berk	The sample is slid inside with a rail system	The tool files the sample and then the sample is collected with a vacuum into a container	The tool is pushed out of the tube with an air pressure system	An air pressure system can be used to push the tool	Information/feedback on how much sample dust the vacuum has collected
Tim	The tool is pushed into the pipe using several sections of a rod that can be screwed together.	A thin slit with sharpened sides is rotated, collecting samples in the center of the tool. The section containing the sample is detachable from the rest of the tool.	The tool is extracted from the pipe with a string.	A reserve string that can be used to extract the tool.	A mechanism that prevents the tool from rotating further to indicate that enough of the sample has been collected.
Team concept	A cable is fed through the pipe and out the other end which is attached to the scraping mechanism.	The end of the pipe has a cap where the scraper meets and contains the sample.	The cable is completely pulled through the pipe and pulls the tool out with it.	The cable on the other end to pull it back out.	Markings on the cable to indicate how far the tool is inside the pipe.

Insertion:

The insertion sub-system is responsible for getting the tool into the pipe.

Insertion			
Team Member	Concept	Drawbacks	Advantages
Derek	The tool is extendable/foldable/ extended down the pipe. Push the inner rod to extend the tool.	As the tool is extended further into the pipe it may lose strength and stability as the length increases.	Easily portable and lightweight
Trey	The Tool has wheels to smoothly move down the pipe and could be operated with motors and a microcontroller or by being pushed into the pipe.	Including wheels in the tool can be overly complex depending on the design.	Allows for a smooth and quick insertion into the pipe.
Berk	The tool is easily slid in with a rail system so there is no friction on the sample at all and the sample is not damaged	It might be a bit costly	Easy to use
Tim	The tool is pushed into the pipe using several sections of a rod that can be screwed together.	Collection time may be longer as you need to manually assemble each part as you push the tool deeper into the pipe.	A durable connection is easy to make, tool can be rotated.
Team concept	A cable is fed through the pipe and out the other end which is attached to the scraping mechanism.	Feeding the cable through the pipe may be a bit difficult.	Does not require any long tubes or structures.

Extraction:

The extraction sub-system is responsible for getting the sample out of the pipe in a safe way. The sample should be extracted in a way where user contact is not necessary.

Extraction			
Team Member	Concept	Drawbacks	Advantages
Derek	The metal rod inside the tool is attached to the end. Pull on the inner rod to retract the sections of the tool.	If pieces are not fitted properly it may lead to issues with them being retracted. Sections may be stiff and difficult to retract.	The tool retracts to a small size, easy to use and handle. Cost-effective.
Trey	The tool is attached to a cable where it can be smoothly pulled out using the wheels by the operator.	If the cable breaks or becomes detached from the tool there is no way to get it out.	Easy to implement and low cost.
Berk	The tool is extracted with an air pressure system where the sample is pushed out of the pipe with air pressure	It might be hard to get the sample out because a strong amount of air pressure is needed	Easy to use
Tim	The tool is extracted from the pipe with a string.	Might require a lot of pulling force to pull the tool out	Easy to use and low-cost
Team concept	The cable is completely pulled through the pipe and pulls the tool out with it.	It may require a lot of force to pull the tool through the pipe	Simple and efficient extraction process. It is very efficient as the extraction and collection are very closely related to each other.

Collection:

The collection subsystem is responsible for removing a sample from the inside of the pipe.

Collection			
Team Member	Concept	Drawbacks	Advantages
Derek	Steel blade or brushes. Magnet draws shavings inside of the tool. Twist the tool to scrape shavings from the pipe which are collected into the tool itself. (Tool is hollow).	May require a lot of force to manually twist the tool and create friction	Easy to use with one or two persons. Not complex. Simple concept.
Trey	The tool uses a diamond file driven by a motor or an operator. The filings are swept out of the pipe with a brush at the front of the tool and are collected at the opening of the pipe.	May not work in a vertical setting. The sample may come in contact with the operator or could fall on the ground when it is swept into the container. Using a motor would require wireless control which may be too complex or out of budget.	Using a file may be easier to collect a sample than scraping the pipe
Berk	The tool uses a file where the sample is filed down to dust particles and then picked up by a vacuum	The vacuum may not be able to pick up all the dust, if the pipe is dusty inside the sample will get ruined.	Really easy to use and is a very simple system
Tim	A thin slit with sharpened sides is rotated, collecting samples in the center of the tool. The section containing the sample is detachable from the rest of the tool.	Might require a lot of force to scrape the pipe. Sharpened sides may dull as it's used.	Easy to use and rotate
Team concept	The end of the pipe has a cap where the scraper meets and contains the sample.	The whole tool would have to be sent to the lab as it is part of the container.	Allows for the sample to be easily contained

Failsafe:

The failsafe subsystem is a critical component designed to prevent damage to the pipe and avoid expensive removal procedures if the tool malfunctions or becomes stuck inside the pipe. Given the user's needs, the failsafe must ensure that if the tool breaks down, loses power, or becomes stuck there is a reliable way to retrieve it safely without damaging the pipe or requiring destructive removal methods.

Failsafe			
Team Member	Concept	Drawbacks	Advantages
Derek	A wire is attached to each “foldable section” and can be individually pulled out if the tool falls apart at connection points.	If the tool breaks apart at points other than connection points it would be difficult to retrieve small pieces.	Simple and cost-effective. Not motorized so don’t need to worry about malfunctions. Reliable.Cost-effective.
Trey	A rod is used on the opposite end of the pipe to push the tool out.	A 15ft rod would be awkward and difficult to operate.	Simple and reliable.
Berk	The sample will be attached to a strong cable which can then be pulled out	Might need a significant amount of force	Easy to use, the cable won’t break easily, low cost.
Tim	A reserve string that can be used to extract the tool.	If the tool is lodged in a pipe it may require a significant amount of force to pull the tool out with a string.	Simple to use.
Team concept	The cable on the other end to pull it back out.	If the tool is stuck against something inside the pipe it may be too difficult to pull the entire tool out with a cable.	Easy to implement. Cost-effective solution

Feedback:

The feedback subsystem within our design is a system that provides real-time information on the state of the tool. It provides the user with the amount of samples collected and whether the tool is working properly. This is an important part of our design as one of our users needs a highly emphasized sample size.

Feedback			
Team Member	Concept	Drawbacks	Advantages
Derek	Measurements are indicated on the tool to show how much the tool has turned. A micrometre of sorts. Every 2pi rotation is calibrated to how many “shavings” are retrieved.	Heavily requires calibration. If there is any variance it would lead to an improper reading.	Does not require electronics. Easy for users to track how many rotations the tool has done. Cost-effective
Trey	File rotation counter.	Would require wireless feedback which is complex and costly.	Consistent collection duration between trials.
Berk	File movement counter, tells the user how many times it has moved and filed the sample so the user can know how much sample (as in weight or amount) they have.	Requires a pretty costly circuit	Simple, non-complex system
Tim	A mechanism that prevents the tool from rotating further to indicate that enough of the sample has been collected.	Only indicates when a full sample has been collected. Does not indicate how far into the collection process you are.	Ensures the largest amount of sample is collected each time.
Team concept	Markings on the cable to indicate how far the tool is inside the pipe.	Does not provide feedback on the amount of samples collected	Easy to use. Cost-efficient to implement. Not complex.

Prototype 1					
Subsystem	Insertion	Collection	Extraction	Failsafe	Feedback
Concept to use	A cable is fed through the pipe which is attached to the tool such that the tool can be pulled through the pipe.	The part that is pulled through the pipe has a hemisphere shape with sharp bits to dig into the wall of the pipe as it is being pulled through to collect the sample.	The cable is completely pulled through the pipe and thus pulls the scraper to the end.	Having a cable on the other end of the pipe will allow the scraper to be pulled out in the direction it came in with ease.	Markings on the cable to indicate how far the tool is inside the pipe.

Prototype 2					
Subsystem	Insertion	Collection	Extraction	Failsafe	Feedback
Concept to use	The tool is split into 5 sections of 3 ft pipe where each section is inserted into the tube and the next section is screwed on the back of it.	The tool uses a file where the sample is filed down to dust particles and then picked up by a vacuum. In a vertical setting, the sample would fall into the container at the other end of the pipe.	The tool is pulled out and unscrewed section by section.	A rod is used on the opposite end of the pipe to push the tool out.	Measurements are indicated on the tool to show how much the tool has turned. A micrometre of sorts. Every 2pi rotation is calibrated to how many “shavings” are retrieved.

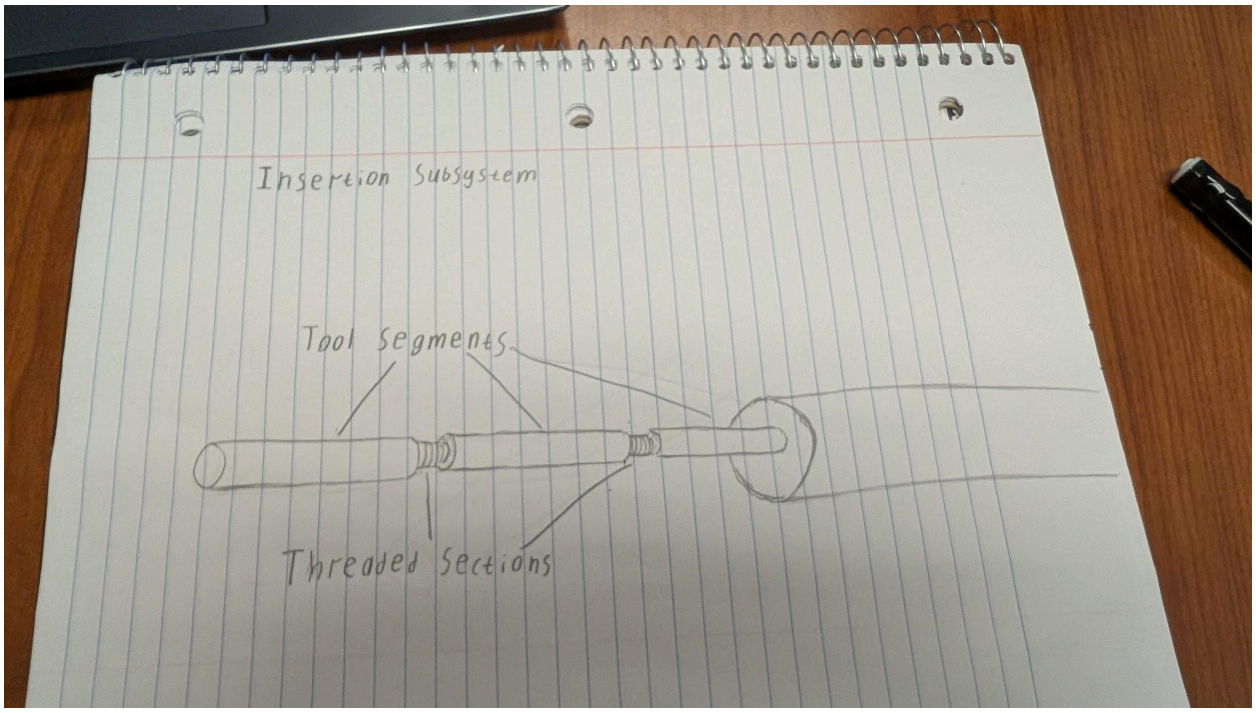
Prototype 3					
Subsystem	Insertion	Collection	Extraction	Failsafe	Feedback
Concept to use	The Tool has wheels to smoothly move down the pipe and could be operated with motors and a microcontroller or by being pushed into the pipe.	The tool uses a diamond file driven by a motor or an operator. The filings are swept out of the pipe with a brush at the front of the tool and are collected at the opening of the pipe.	The tool is extracted with an air pressure system where the sample is pushed out of the pipe with air pressure.	The tool will be attached to a strong cable which can then be pulled out	The tool counts the number of rotations of the file and sends it back to the user.

Chosen Prototype:

We believe that prototype 1 is the most feasible and effective prototype. The design has a very simple collection process and failsafe. The pull-through system with the cap at the back allows the sample to be easily contained and collected. In addition to this, we stay on track with our design criteria of being modular and man-portable while accomplishing the task of collecting the sample. Some difficulties we may face with this prototype is the amount of force required to pull the tool through the pipe due to friction between90 the scraper and the rubber stopper. In addition to this, it may be difficult to actually scrape the pipe in this way, by pulling the tool through. Another drawback is the lack of feedback, having markings on the cable only shows how far the tool has gone through the pipe and not how much sample has been collected.

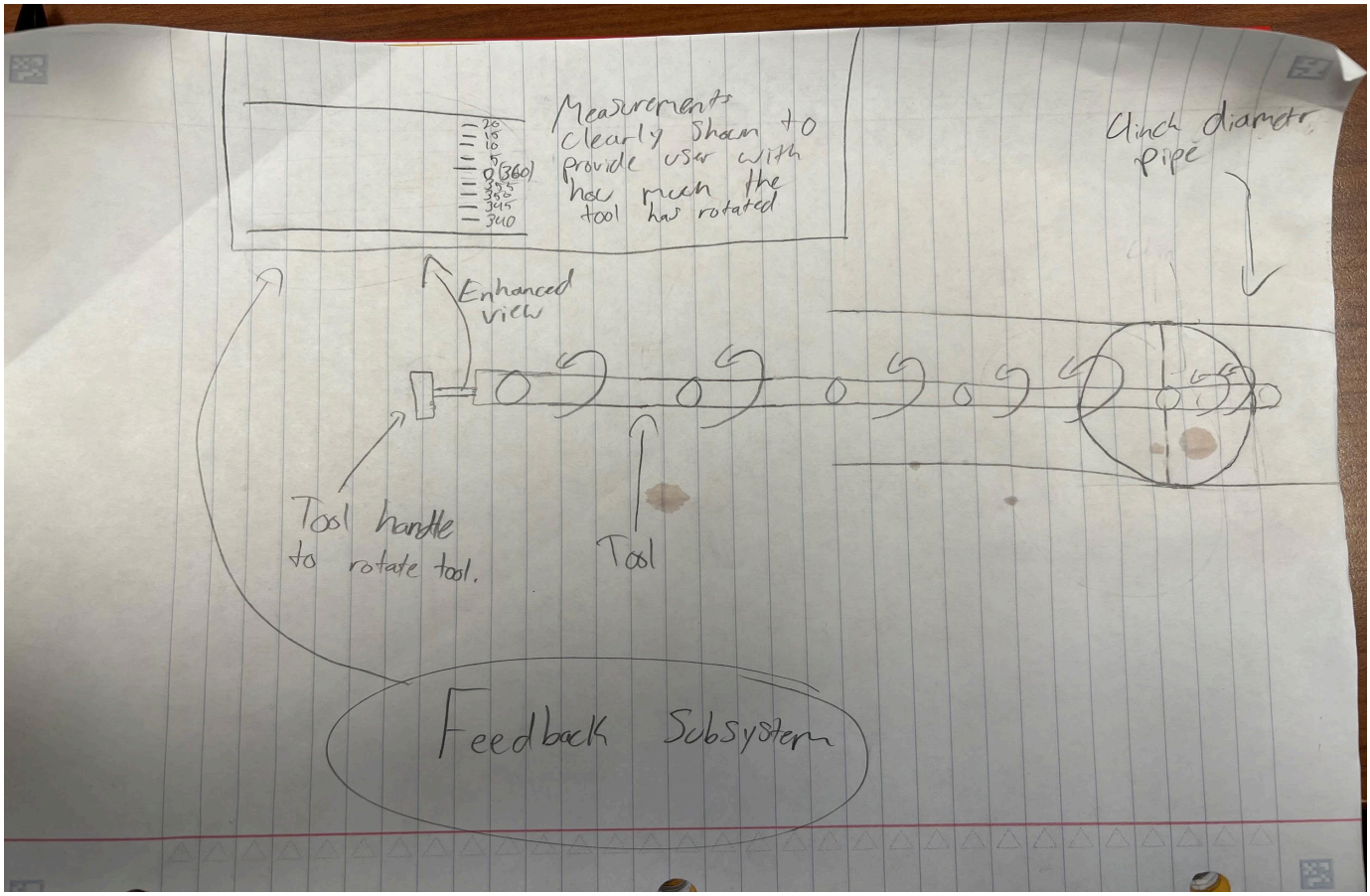
Insertion Subsystem Sketch:

Tim



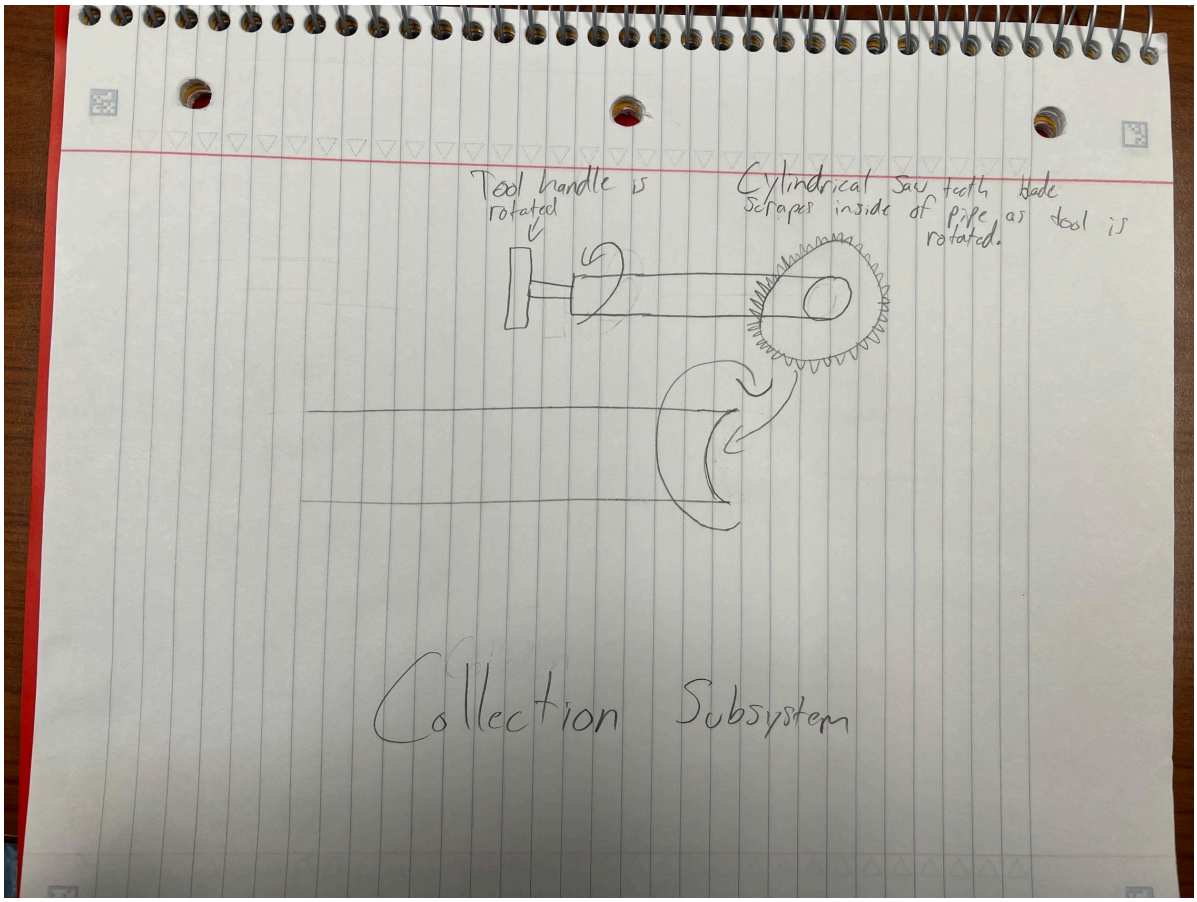
Feedback Subsystem Sketch:

Derek



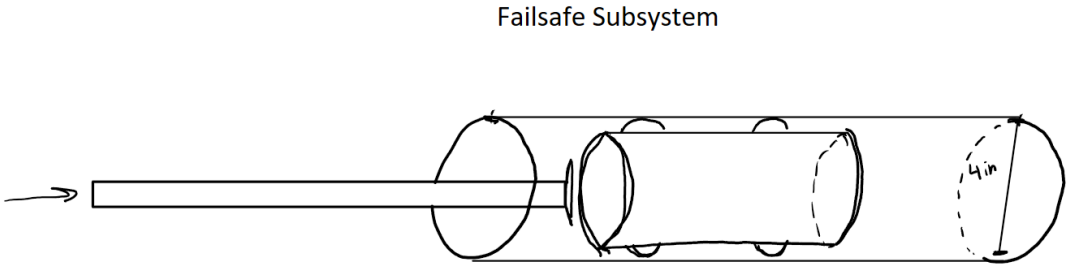
Collection Subsystem Sketch:

Derek



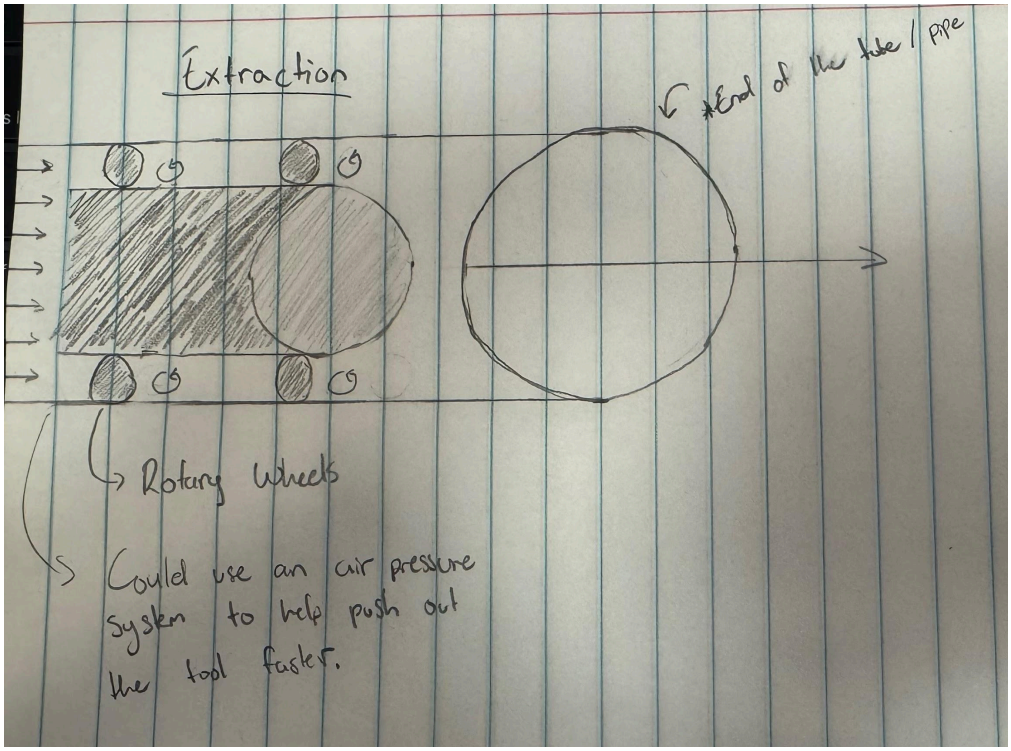
Failsafe Subsystem Sketch:

Trey

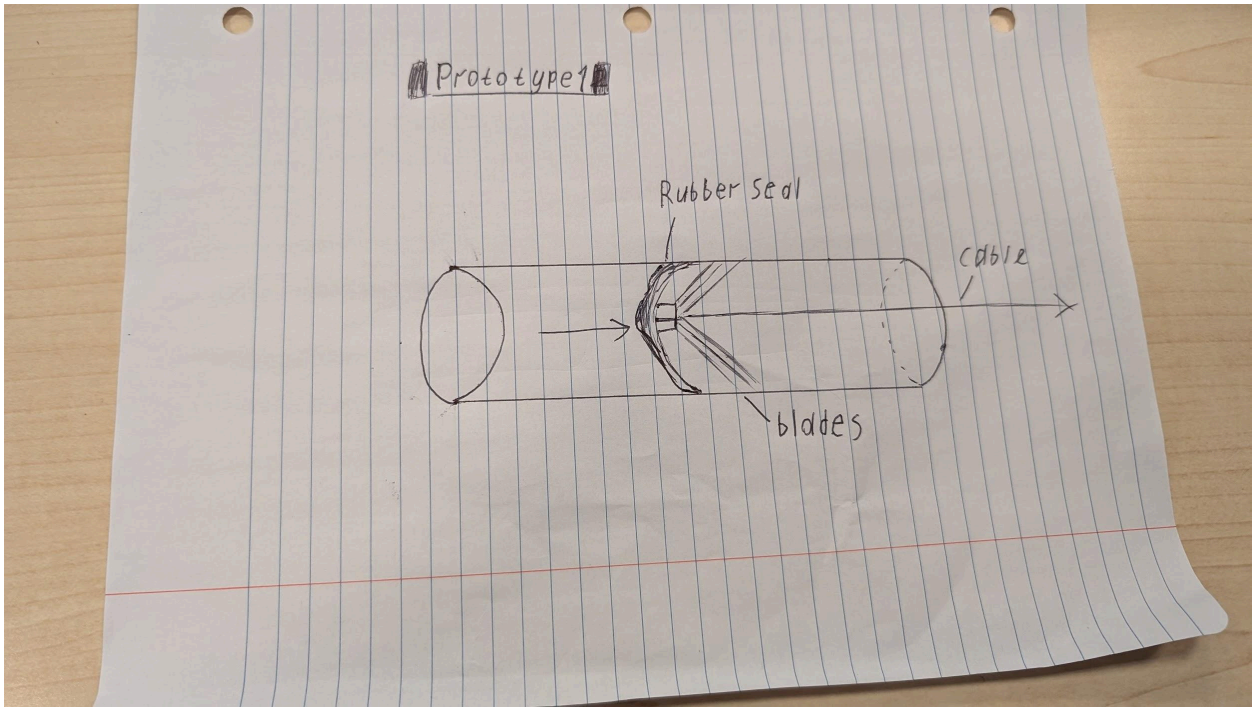


Extraction Sub-system Sketch:

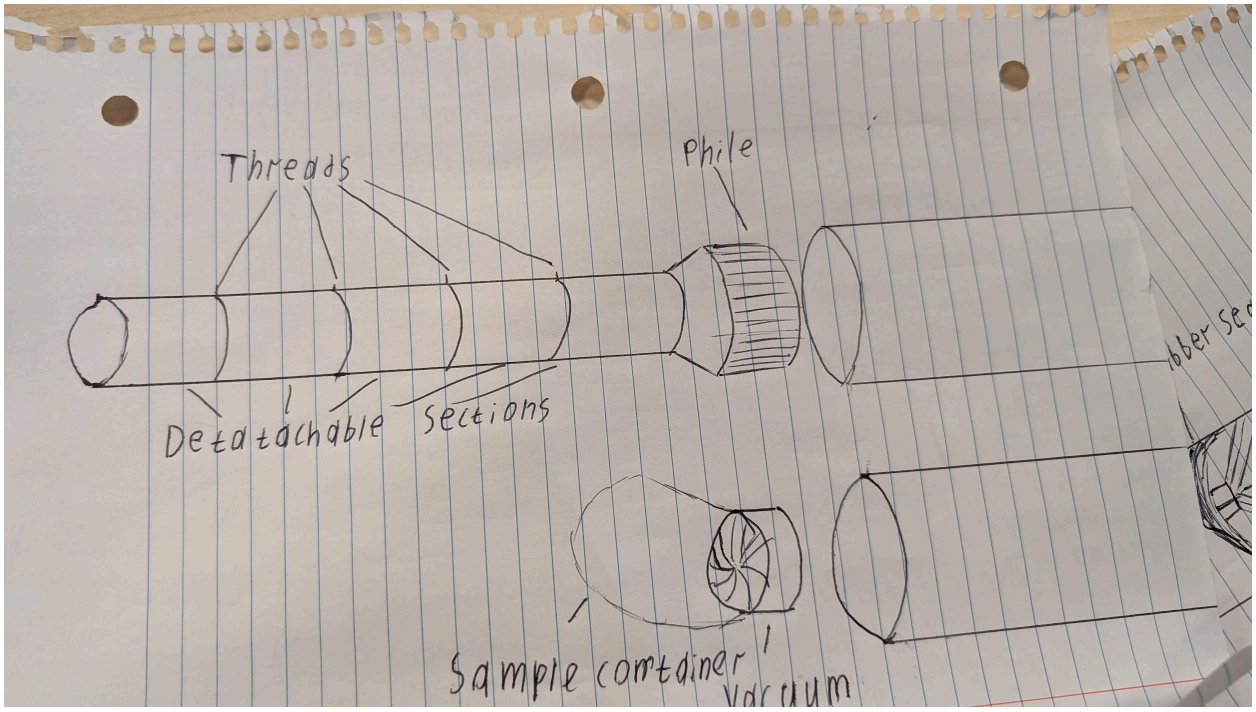
Berk



Prototype 1 Sketch



Prototype 2 Sketch



Prototype 3 Sketch