GNG 1103 – Engineering Design

Faculty of Engineering
University of Ottawa

Conceptual Design
Group 9

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Abstract

This document covers the project schedule and costs. It includes clear and detailed drawings for a prototype as well as outlines a plan and schedule for prototyping and testing. It also includes a materials/equipment list for the 3 prototypes that are to be made over the rest of the semester. The main purpose is to determine when tasks are to be completed to ensure the product is finished by the end of the semester.

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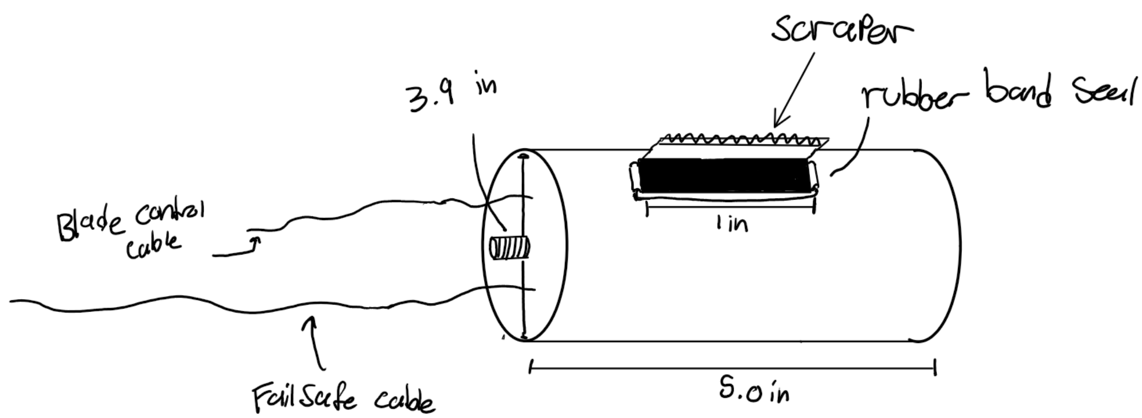
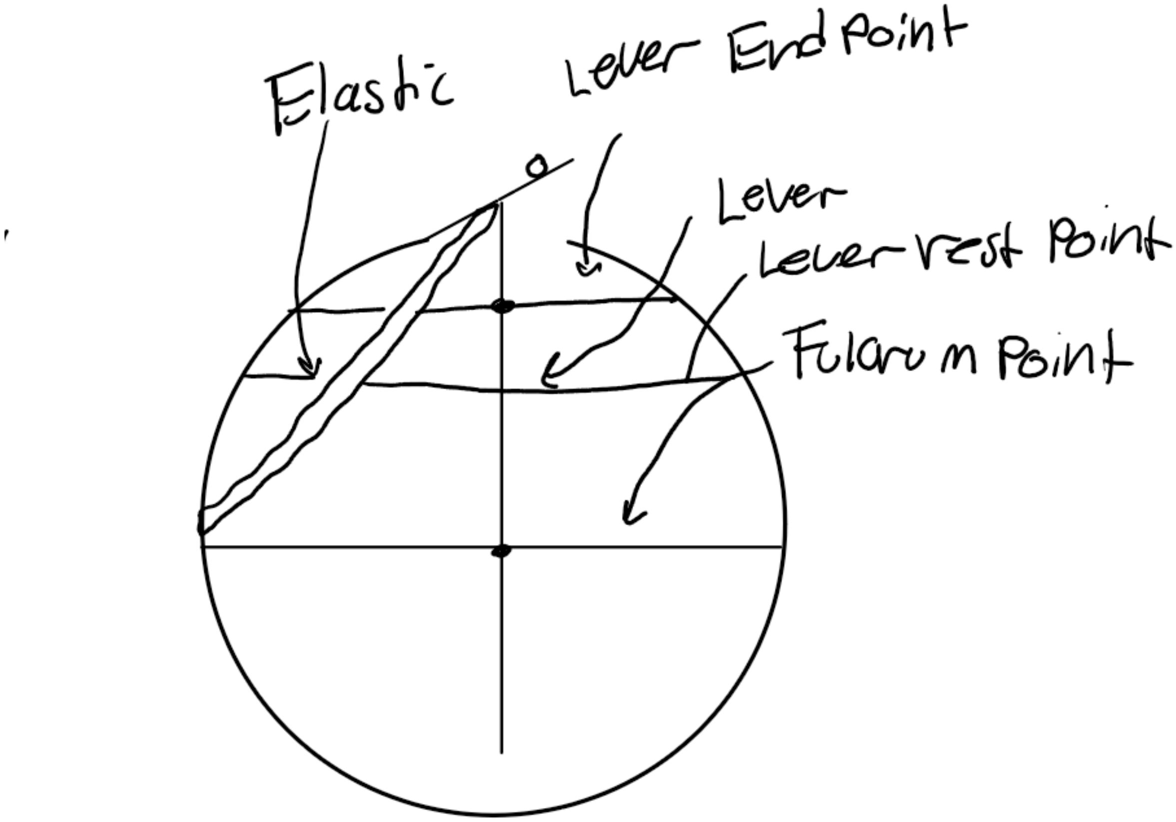
Design/Sketch




Elastic
Lever End Point
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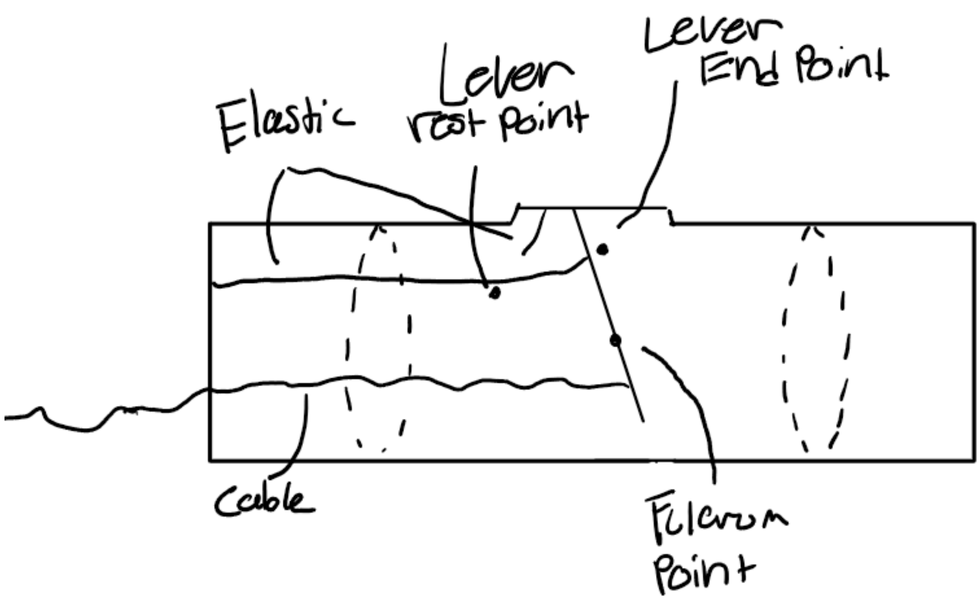
Lever
End Point
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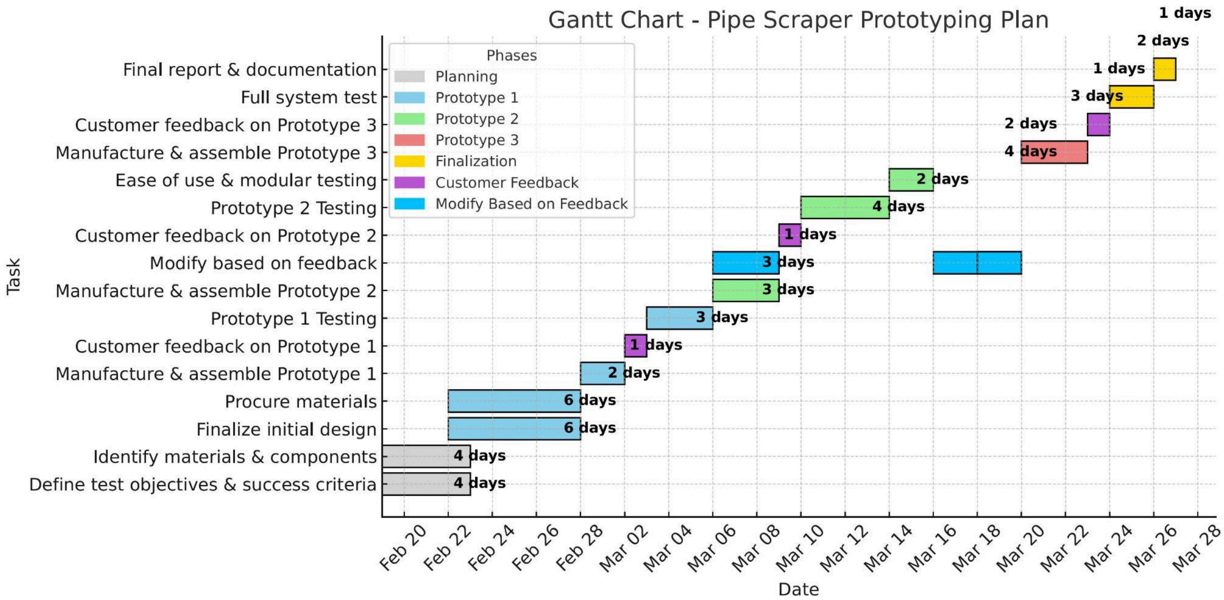
rest point
Elastic
Cable
Fulcrum
Point

Gantt Chart



Gantt Chart - Pipe Scraper Prototyping Plan
Phases
Planning
Prototype 1
Prototype 2
Prototype 3
Finalization
Customer Feedback
Modify Based on Feedback
Task
Final report & documentation
Full system test
Customer feedback on Prototype 3
Manufacture & assemble Prototype 3
Ease of use & modular testing
Prototype 2 Testing
Customer feedback on Prototype 2
Modify based on feedback
Manufacture & assemble Prototype 2
Prototype 1 Testing
Customer feedback on Prototype 1
Manufacture & assemble Prototype 1
Procure materials
Finalize initial design
Identify materials & components
Define test objectives & success criteria
1 days
2 days
1 days
3 days
2 days
4 days
2 days
4 days
1 days
3 days
3 days
3 days
1 days
2 days
6 days
6 days
4 days
4 days
Feb 20
Feb 22
Feb 24
Feb 26
Feb 28
Mar 02
Mar 04
Mar 06
Mar 08
Mar 10
Mar 12
Mar 14
Mar 16
Mar 18
Mar 20
Mar 22
Mar 24
Mar 26
Mar 28
Date

Equipment/Materials List

Prototype 1

- Pop can
- Magnets (2x)
- Elastic
- Hot glue
- Cooking twine
- Cardboard

Prototype 2

- Filament (1.75mm)
- 3D printer
- Cable
- Saw blade
- Elastic
- Superglue
- Bolt

Prototype 3

- Filament (1.75mm)
- 3D printer
- Cable
- Saw blade
- Elastic (2x)
- Superglue
- Bolt
- 6 ft pipe (2x)
- 3 ft pipe
- Handle
- Threading tool

❖ A BOM has also been provided at the end of the pdf file.

Prototyping Test Plan

❖ Why do we want to prototype?

➢ We would like to supervise our creation in detail and highlight the mistakes and successes we have accomplished in the tool's prototype designs. The tool can collect a 30-80 mg sample from 15 feet inside a 4-inch diameter pipe. This tool will focus on the insertion, collection, extraction, failsafe, and feedback subsystems. We will identify and evaluate potential failures under realistic conditions to reduce risk.

❖ What do we want to measure?

➢ **Quantitative Metrics:**

- Sample size collected (mg)
- Time to collect a sample
- Number of rotations for collection (rotations per sample size)

➢ **Qualitative Metrics:**

- Ease of use
- Reliability of feedback
- Satisfaction with the design

❖ Testing the whole system or just a part of it?

➢ **Testing:** Some sub-systems
➢ **Testing Prototypes:** Design 1, Design 2, Design 3

❖ What type of prototype?

➢ A high-fidelity prototype.

❖ Test Plan:

Provided at the end of the PDF

❖ Prototype 1:

Prototype 1 is a high-fidelity prototype intended to test the ability of a scraping tool to collect samples and retrieve them safely. The first test is for sample collection efficiency by yanking the tool through a pipe with a tension cable. The test requires only a simple scale to weigh the sample collected and basic materials like cardboard to serve as the pipe. The price is minimal, as only domestic items and basic tools are utilized. The second test verifies the tool's extraction reliability by extracting a jammed tool using a rescue cable and taking a measurement of the extraction force with a spring scale. Both tests take about 30 seconds to one minute. The tool is pulled through the pipe and then it is pulled back out through a cable, aligning it to support effective sample harvesting and easy tool removal. Data collected is sample mass and the force of extraction, which are crucial in confirming the tool is working. Key success indicators include harvesting 30-80 mg of sample and pulling out the tool with minimal force. These tests can be performed immediately and are under the project timeline.

❖ Prototype 2:

Prototype 2 is a physical high-fidelity model with a focus on the simplicity of assembling and collecting the tool. The third test tests sample collection by rotating the tool inside the pipe and weighing the sample with a simple scale. Simple materials like sandpaper are used for grating surfaces. The fourth test measures assembly efficiency by determining how long it takes to assemble and disassemble the tool and fit it into the pipe. It requires simple bolts and superglue, which keeps the cost low. The tests both take around 30 seconds to a minute. This prototype directly addresses the purpose by testing whether the tool can effectively gather samples and be easily assembled. Information collected is sample mass and tool size, both critical to guaranteeing functionality. Success is measured by obtaining 30-80 mg of sample and verifying the tool can fit within the pipe. These tests are possible with materials on hand and can be completed rapidly, offering timely feedback.

❖ Prototype 3:

Prototype 3 is a low-fidelity physical model that focuses on the robot's mobility and extraction reliability. The fifth test examines the robot's movement in a pipe by measuring the time taken to move 5 feet. It requires an Arduino to power the robot and simple motors, and it takes around 2 minutes per trial. The sixth test is one of the extractability tests for the robot using a cable, with motor failure simulation and measurement of extraction force. This test takes about a minute and requires a securely attached cable. These tests ensure that the robot meets goals by ascertaining movement efficiency and safe extraction. Travel time and extraction force data are measured, which are very important in determining performance. Success criteria are that the robot travels 5 feet in under 2 minutes and can be extracted in a minute or less with reasonable force. These tests are achievable with basic electronics and equipment and can be completed within a short time, well within project time.

❖ Summary:

- ➢ This test plan evaluates subsystems using precise materials at ambient temperature. Success points are successful insertion, consecutive 30-80 mg sample collection in trial runs, and safe tool extraction without damage. Evaluation is focused on risk management (failure points and force measurements), performance (operating times and sample sizes), and learning (usability and client feedback). The design will be iterated until all performance goals are met. Everything considered in this test plan is high-fidelity.

Prototype 1	Test Number	Probable Critical Issue	Test Objective (why)
	1	Tool collects sample within range	Collection Measurement (Collection)
	2	Tool can be extracted easily	Failsafe Measurement (Extraction reliability)
Prototype 2			
	3	Tool collects sample via rotation	Collection Measurement (Collection)
	4	Sections are easy to assemble/disassemble	Assembly Measurement (Assembly efficiency)
Prototype 3			
	5	Robot can move through pipe	Performance Measurement (Mobility)
	6	Robot can be pulled out with cable	Failsafe Management (Extraction reliability)

Test Description (what)	Analysis Method (how and when)
Scraping test: Use the scraping tool by using the tension cable	Perform 3 trials by pulling the tool through a pipe. Weigh sample on a basic scale. Estimated time: Around 30 seconds to a minute.
Extraction test: Pull tool out using a backup cable.	Simulate a stuck tool and use the cable to pull it out. Measure force with a spring scale. Estimated time: 30 seconds to a minute.
Rotate tool in a pipe and weigh the sample.	Rotate manually and weigh sample on a basic scale. Perform 2 trials. Estimated time: 30 seconds to a minute.
Assembly test: Time how long it takes to connect sections (For metrics)	Assemble and disassemble and see if the tool fits inside the pipe. Estimated time: 30 seconds to a minute.
Movement test: Operate robot in the pipe.	Measure time for robot to travel 5 ft. Perform 2 trials. Estimated time: 2 minutes.
Cable extraction test: Pull robot out manually.	Simulate motor failure and extract robot with cable. Estimated time: 1 minute.

Determine Measurables	Metrics	Level and Fidelity of Prototype	Kind of Prototype	Results	Interpretation and Feedback
Mass of sample collected	Sample mass (mg)	High Fidelity	Physical	TBD	Pass if sample is between 30-80 mg.
Extraction force	Force (N)	High Fidelity	Physical	TBD	Pass if tool can be extracted with a low amount of force
Mass of sample collected	Sample mass (mg)	High Fidelity	Physical	TBD	Pass if sample is between 30-80 mg.
Size of Tool	Size (in)	High Fidelity	Physical	TBD	Pass if the tool can be fit inside the pipe
Travel time (s)	Time (s)	LoFi	Physical	TBD	Pass if robot travels 5 ft in <2 min.
Extraction force (N)	Force (N)	LoFi	Physical	TBD	Pass if robot is extractable within a minute using a reasonable amount of force

Notes			
Use simple cardboard or easy to use materials for the pipe.			
Use basic tools for cable attachment.			
Use simple materials like sandpaper for grating.			
Use bolts and superglue			
Use an arduino to moderate the robot			
Ensure cable is securely attached.			

Prototype 1						Prototype 2						Prototype 3				
Item Name	**Material**	**Item Quantity**	**Item Price**	**Item Link**		**Item Name**	**Material**	**Item Quantity**	**Item Price**	**Item Link**		**Item Name**	**Material**	**Item Quantity**	**Item Price**	**Item Link**
Pop Can	Alumninum	1	-	-		Filament	PLA	1.75mm	$30	Filament		6 ft pipe	ABS	2	$21.40	6 ft pipe
Magnets	Metal	2	TBD	TBD		Cable	Galvanized Steel	1	$15.98	Cable		3 ft pipe	ABS	1	$10.70	3 ft pipe
Elastic	Rubber	1	-	-		Saw Blade	Bi-Metal Steel	1	$4.99	Saw Blades		Handle	TBD	1	-	-
Hot Glue	Silicon	1	-	-		Elastic	Rubber	2	-	-						
Cooking Twine	Cotton	1	-	-		Superglue	Cyanoacrylate	1 bottle	$8.79	Superglue						
Cardboard	Cardboard	80 in^2	-	-		Bolt	Steel	1	-	-						