



Canadian Nuclear
Laboratories

Laboratoires Nucléaires
Canadiens

Group 16 - Sample Snatchers

Meet the Team!



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Summary of the Project:

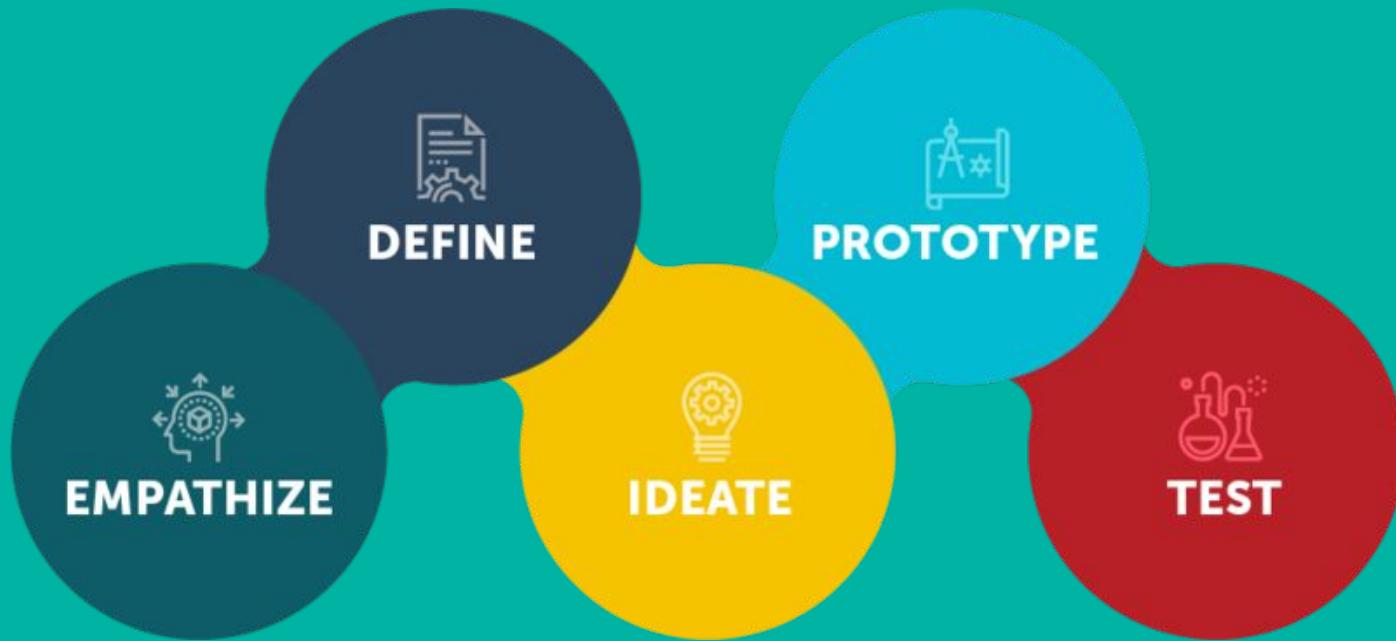
Objective:

Obtain a metal sample from inside a (horizontal or vertical) tube at 15 ft from the inlet of a 4 inch (ID) tube.

Problem Statement:

"Operators who service nuclear reactors need a device to collect metal samples from pressure tubes while minimizing exposure to contaminated material. The solution should be compact and completely removable from the pressure tube, and it should also be able to report the stage of operation within a limited timeframe."

Our Approach - The Design Thinking Process



Empathize

Raw Data Collection → Interpreted Need Statements

	User Statement	Interpreted Need
Typical Uses	To take a sample from the inside of a tube	The sample collected can be varied
	Limits exposure to the operator	The sample is contained to limit exposure
Likes - Current Tool	All parts can be removed from the tube	The design can be completely removed
	Can be moved around by one individual	Should be modular/lightweight
	The device is able to be powered with available resources	Necessary power sources should be included
	The operator is informed of the status of the machine	The design can report the current stage in its process
Dislikes - Current Tool		Is a novel creative solution
	The client loves many things about the existing device	
Suggestions	Russian nesting doll the sample	The sample is contained in multiple layers
	Your device must operate within the timeframe on design day	The device is reasonably fast

Define

Hierarchy of Needs → Design Criteria

Number	Need	High Priority	Design Criteria
1	Sample is contained to limit exposure	 SAFETY	Thickness (mm) Material (Density)
2	Design can be completely removed	 SAFETY	Maneuverable
3	The device can reach sample site 15ft in tube		Distance (ft)
4	Device can fit inside pressure tube		Diameter (in)
5	The sample collected can be varied		30mg - 80mg sample collection
6	The design is able to report current stage in it's process		Display feedback
7	Should be modular/lightweight		Weight (lbs) size (cm ³)
8	Necessary power sources should be included		Batteries/Compressed Air/Rat
9	Is a novel creative solution		Unique (by comparison)
10	Device is reasonably fast		Time (s)

Engineering Design Specifications

Design Specifications		Relation (=, < or >)	Value	Units	Verification Method
	Functional Requirements				
1	Collect a metal sample from tube wall	=	30-80	mg	Test
2	Completely Removable	=	Yes	N/A	Test
3	Enclosed Sample	=	Yes	N/A	Test
4	Stage Reporting	=	Yes	N/A	Test
5	Visual for process	=	Yes	in, dpi	Test
6	Device speed	<	7	min	Test
7	Power source included	=	Yes	N/A	Analysis
8	Distance Traveled	=	15	ft	Test

Design Specifications		Relation (=, < or >)	Value	Units	Verification Method
	Non-Functional Requirements				
1	Aesthetics	=	Yes	N/A	Survey
2	Safety	=	Yes	N/A	Analysis
3	Corrosion Resistant	=	Yes	N/A	Analysis
4	Operation Time	<	10	mins	Test
5	Creative Solution	=	Yes	N/A	Analysis
Design Specifications		Relation (=, < or >)	Value	Units	Verification Method
	Constraints				
1	Weight	<	2	kg	Analysis
2	Size (Diameter)	<	4	in	Analysis
3	Size (Length)	<	4	ft	Analysis
4	Sample Exposure	<	Yes	N/A	Test
5	Sample Collection	=	30 - 80	mg	Test

Benchmarking

Device Specifications ↓	Device →	CWEST	Arterial Catheter	Drain Snake	CSA420 Endress	Mars Rover - Curiosity
Company	Kinectrics	Generic	Generic	Endress & Hauser	NASA	
Cost	\$\$\$\$\$\$\$\$\$\$	\$	\$	\$\$\$	\$\$\$\$\$\$\$\$\$\$\$\$\$	
Stability	BRIMs	Guided by artery	None	Manual	Multiple surface contact points	
Shape	Tube	Wire	Wire	Tube	Rectangular	
Power	External: BRIMs	N/A	External: Man power	External: Man power	Solar + Radioisotope	
Failsafe	BRIMs	Pressure Drop	None	None	Safe-mode software, sensors	
Controls	BRIMs	Direct hand	Direct Hand	Control panel	Digital signalling	
Sampling Method	Scraping	Suction	Friction	Water Pressure	Drill, Scoop	
Size	~4 ft	20 gauge	35.5" x 0.45"	381 mm x 75 mm	10' x 9'7" x 7'	
Sample Size	30-80mg	1 mL	N/A	Liquid	45mm³	
Material	Zirconium	Polyurethane, Silicone, Nitinol, Stainless Steel	plastic, metal	Polyamide PA, Stainless Steel	7075 Aluminum, Titanium. Aerogel	

Ideate

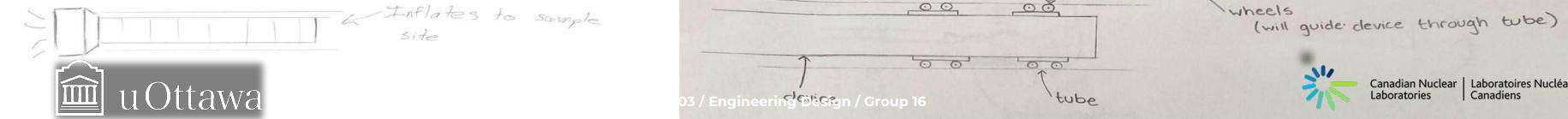
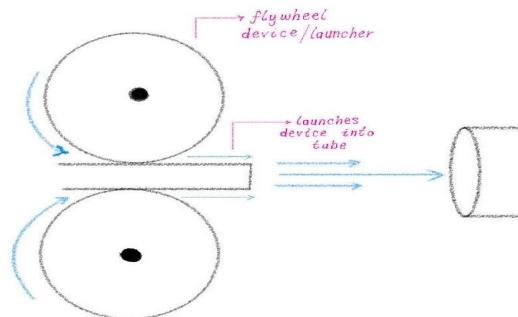
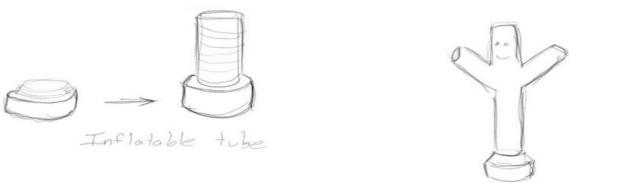
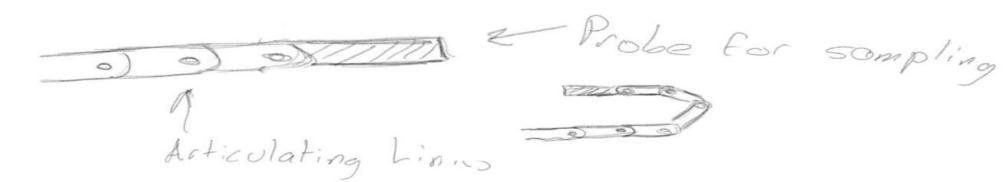
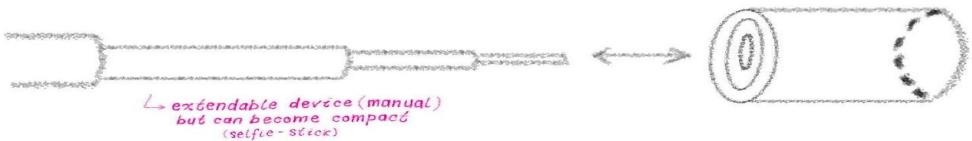
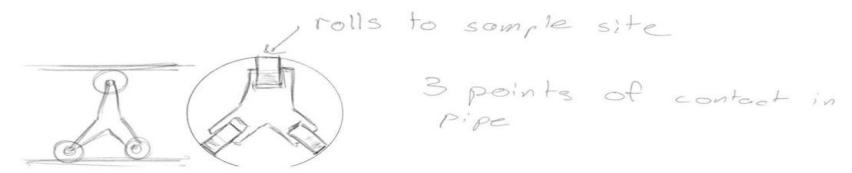
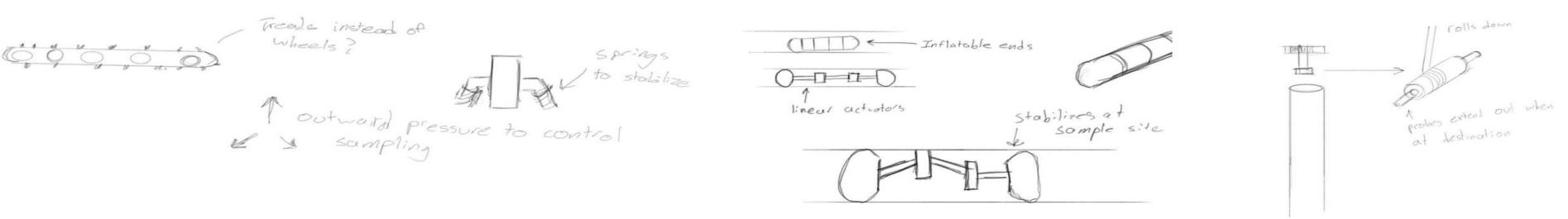
Subsystems

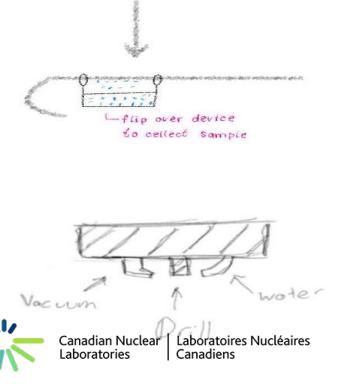
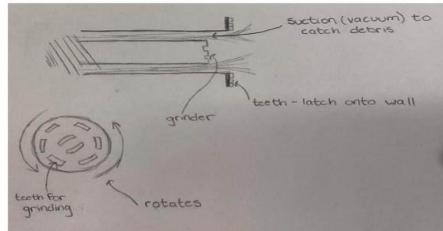
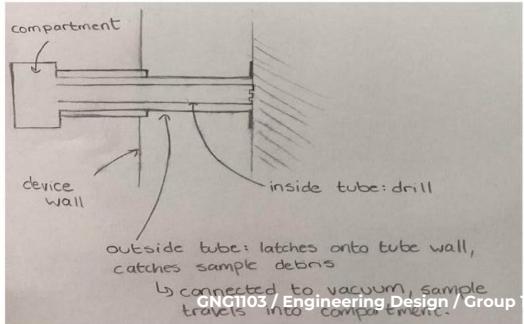
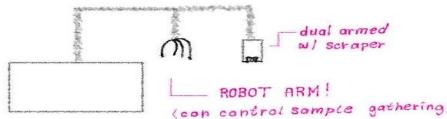
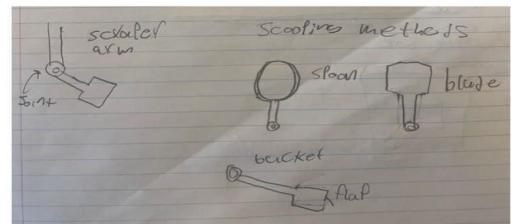
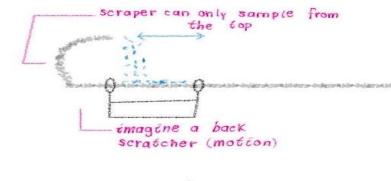
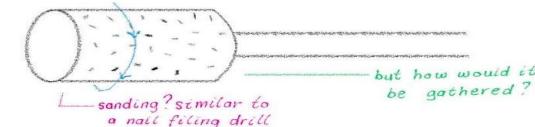
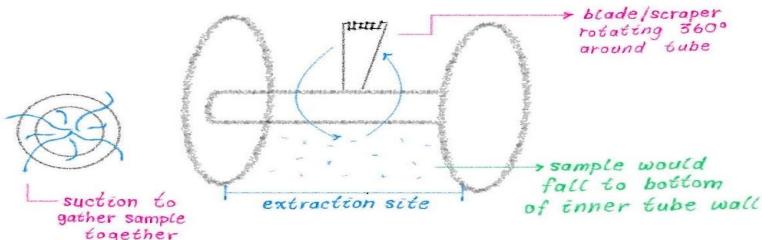
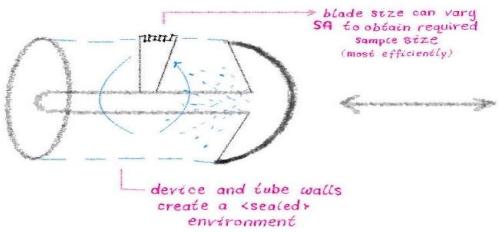
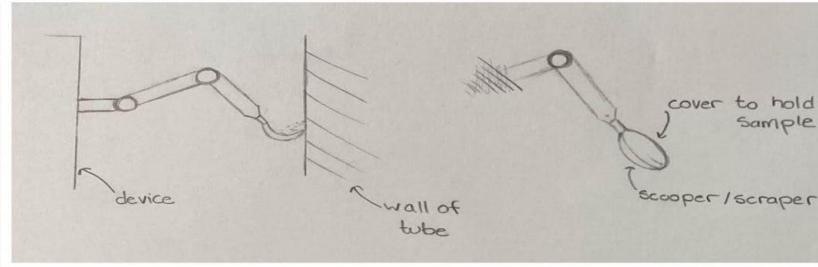
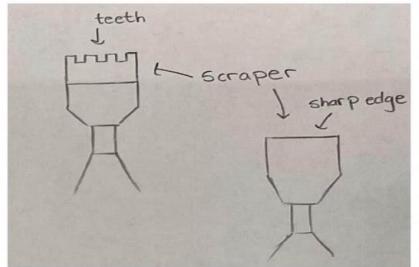
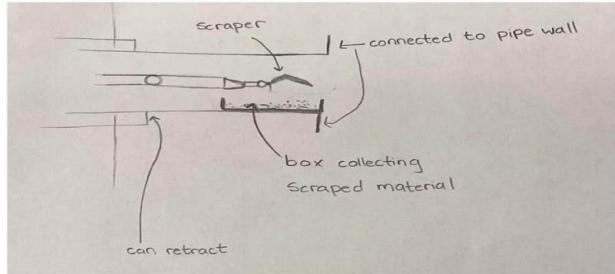
Subsystem 1: **Movement** - Navigating to and from the sample site inside the fifteen-feet tube.

Subsystem 2: **Sampling** - The method in which sampling is conducted.

Subsystem 3: **Containment** - Ensuring the sampled material doesn't contact the operator.

Subsystem 4: **Failsafe** - The ability to retrieve the entire device from the tube.





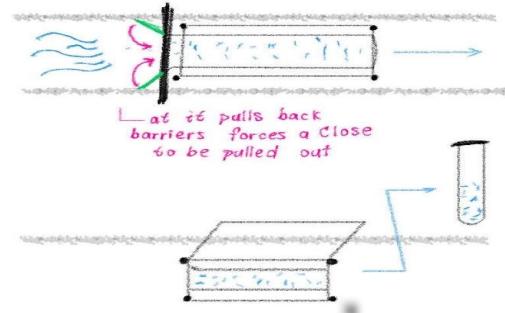
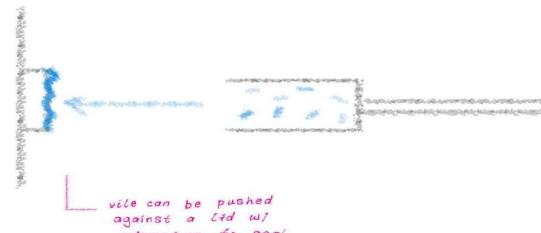
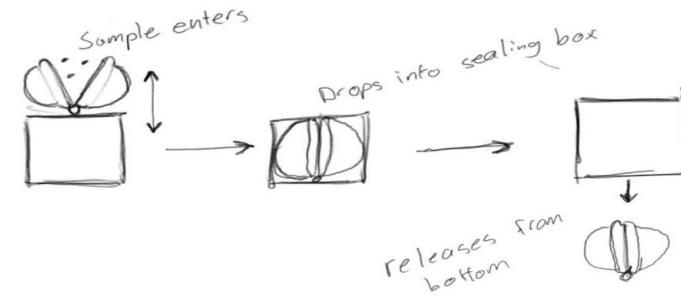
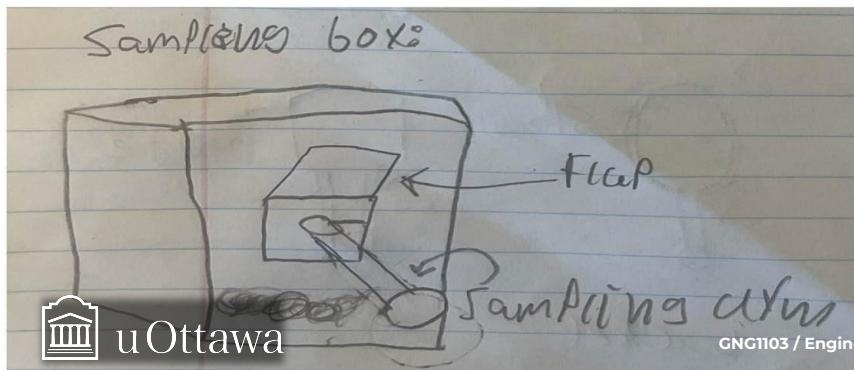
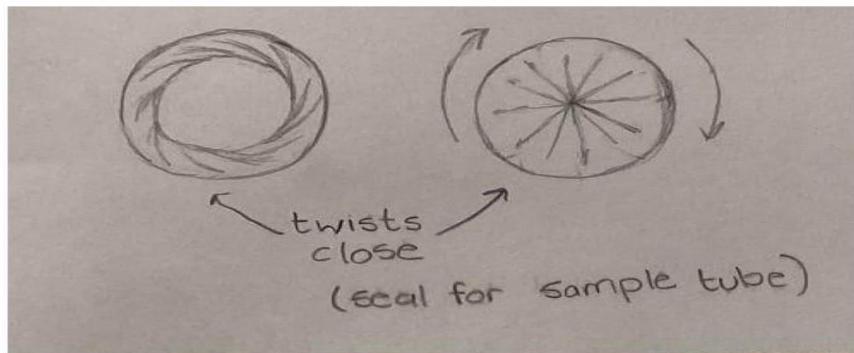
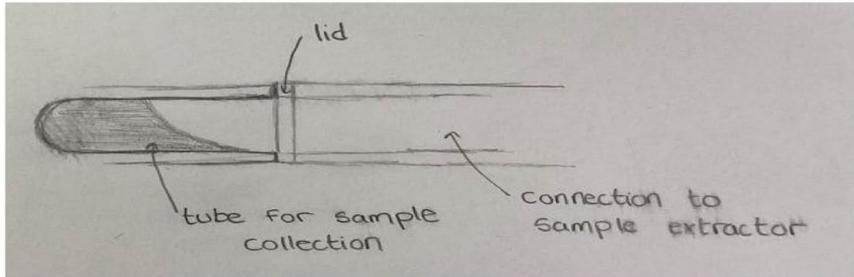
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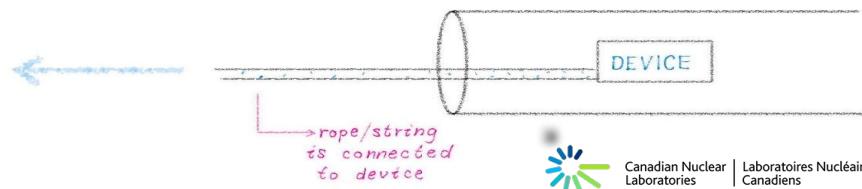
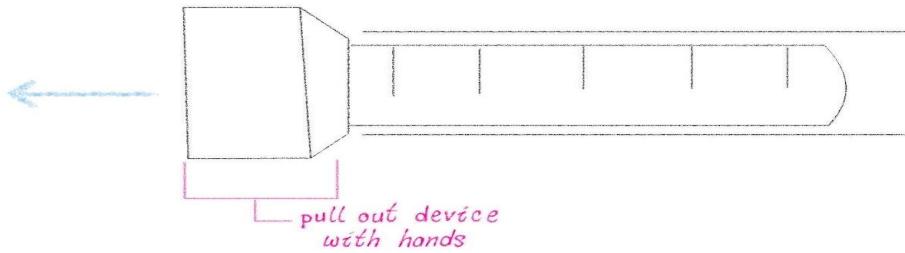
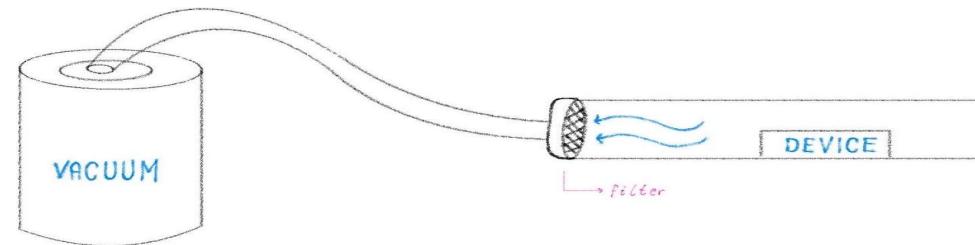
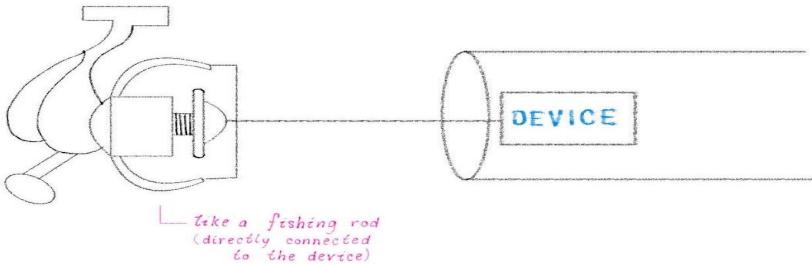
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GNG1103 / Engine



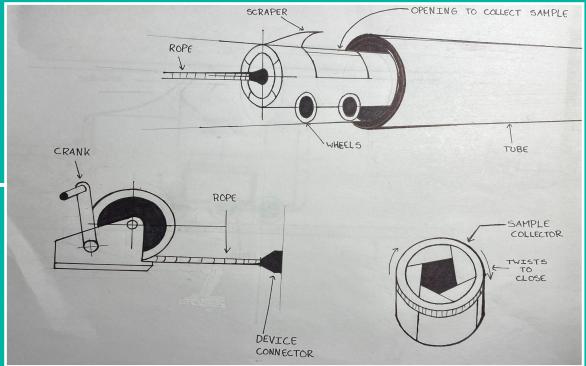
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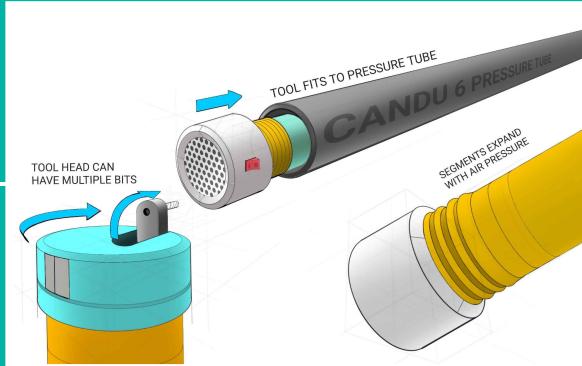


Developed Concepts

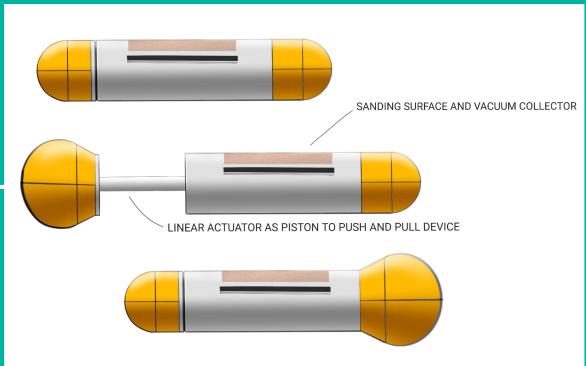
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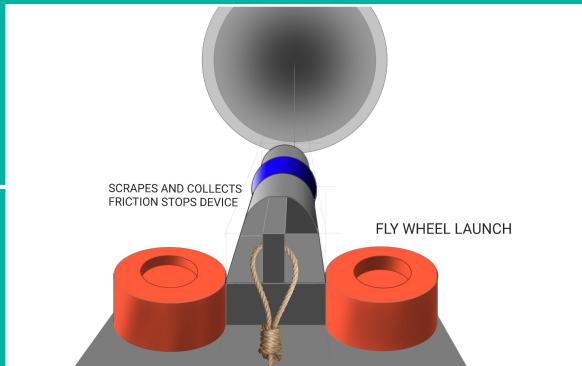
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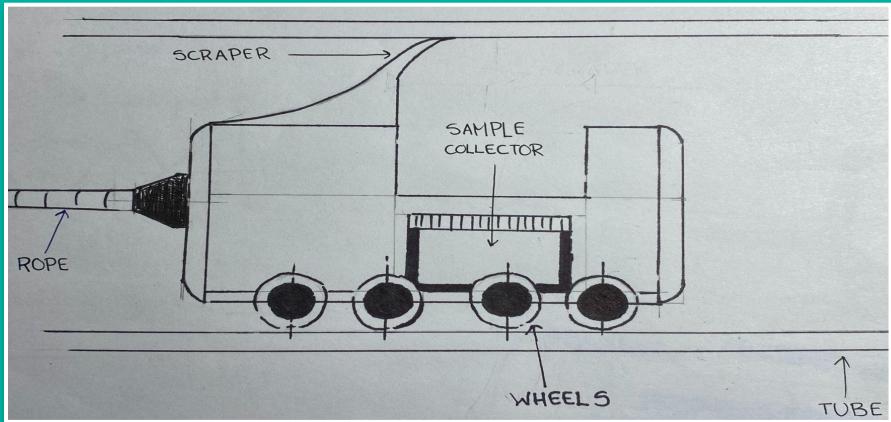
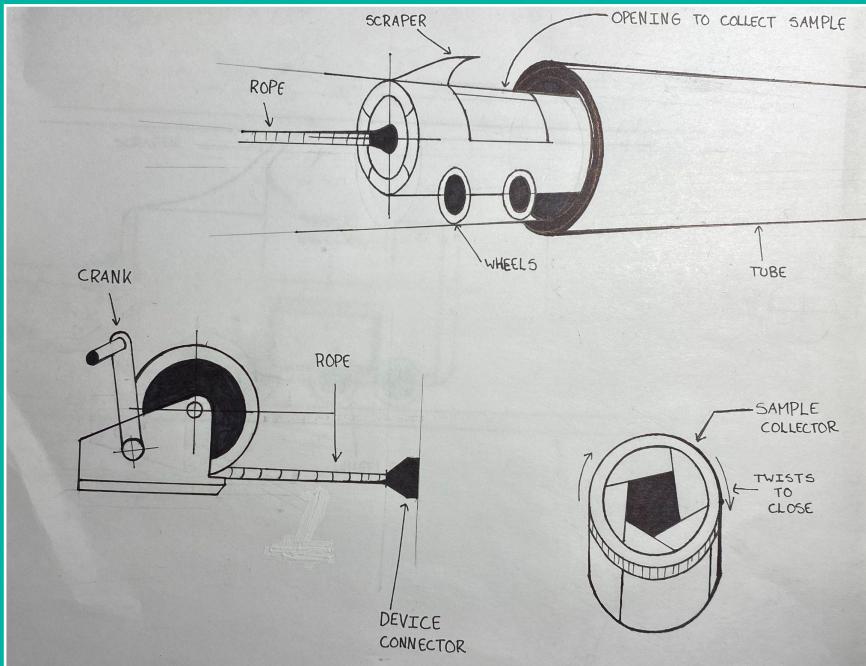
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Ideate - Evaluation of Concepts

Concept Number →	Concept 1	Concept 2	Concept 3	Concept 4
Design Criteria ↓				
Containment	Easy to implement a controllable solution	The sanding pad would be highly contaminated	The multi-tool head could implement a better subsystem	The flap could break off
Removable	Dependent on reel in the event of motor failure or power loss	Could get stuck	The air pump can be run in reverse to pull the inflatable back in	High risk of damage or loose parts
Modular/Lightweight	Depends on materials.	Depends on materials.	The device packs down small	The launcher may be heavy
Creative Solution	It's a drone.	Is a creative solution (via inchworm)	Is a creative solution (via an inflatable tube)	Is a creative solution (via flywheel launcher)
Reasonably Fast	Motors provide good speed and torque	Many steps for movement slow down speed	Inflates faster than a twin-size air mattress	Very high-speed launch
Fits Inside Tube	Need to consider motor size	It might not be able to be sized appropriately	Powered components can be outside tube	Can launch a smaller device
Complexity	Many resources for similar designs	It has a lot of mechanical operations for a single action	Combining the functions of all components.	Combining the functions of all components.
TOTAL	16	11	19	15

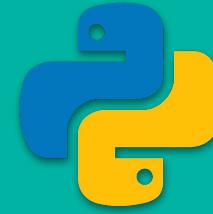
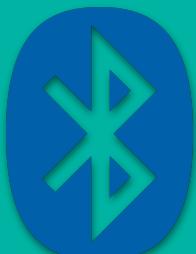
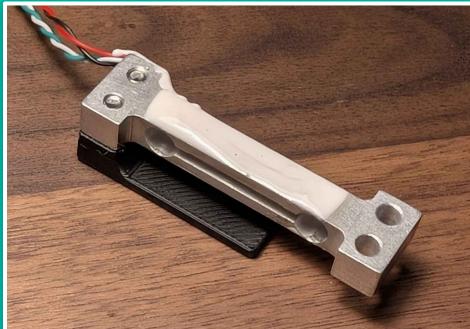
Selected Concept



The
Sample Subway

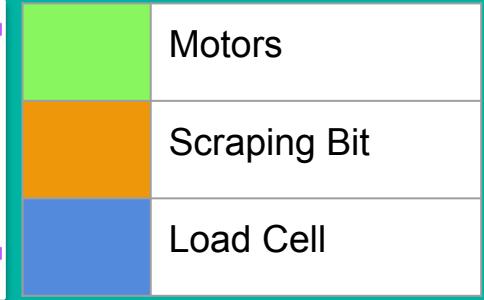
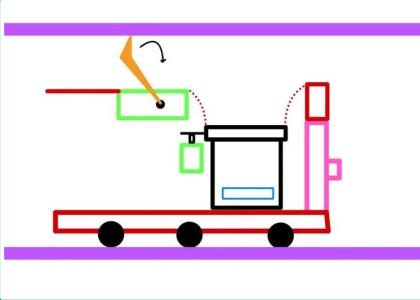
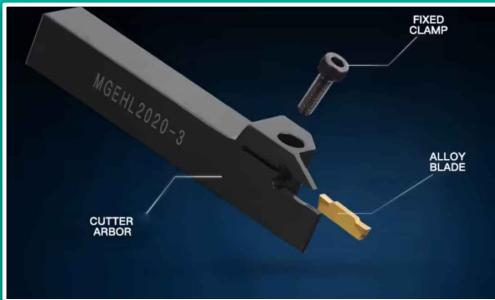
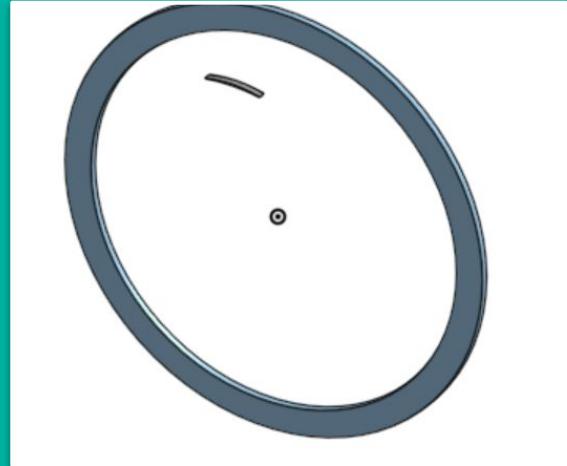
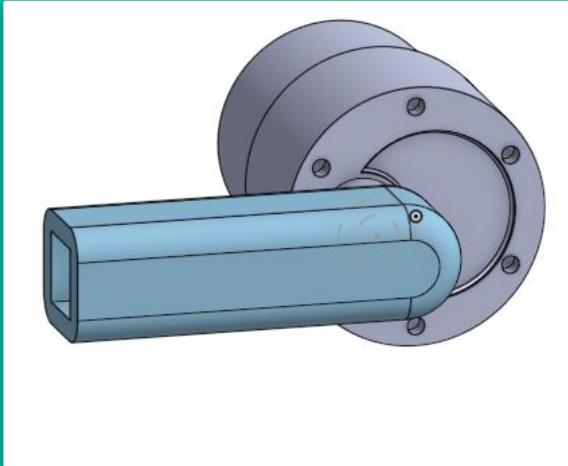
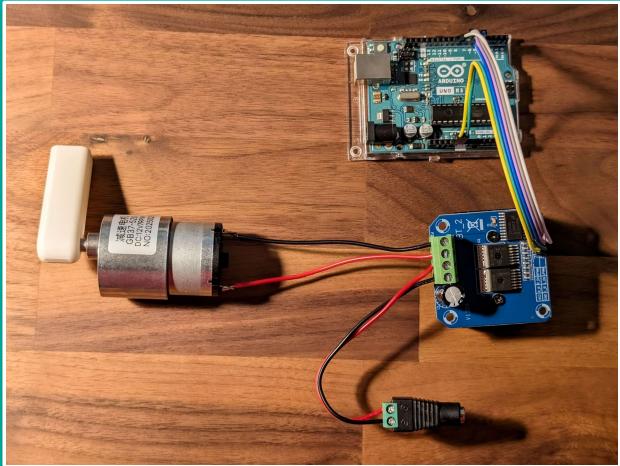
Prototype & Test

Prototype I - Measurement Mechanism



```
18:49:56.868 -> Weight: 3090 mg  
18:50:06.717 -> Weight: 3104 mg  
18:50:16.474 -> Weight: 3108 mg  
18:50:26.320 -> Weight: 3109 mg  
18:50:36.105 -> Weight: 3108 mg  
18:50:45.891 -> Weight: 3103 mg  
18:50:55.706 -> Weight: 3105 mg  
18:51:05.503 -> Weight: 3091 mg
```

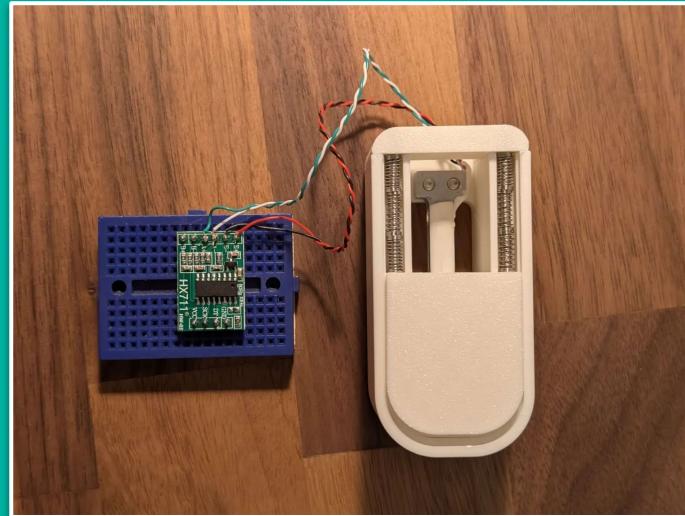
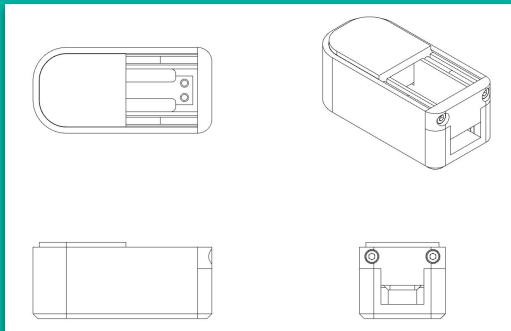
Prototype II - Sampling Mechanism



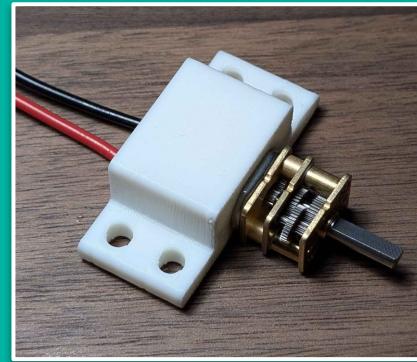
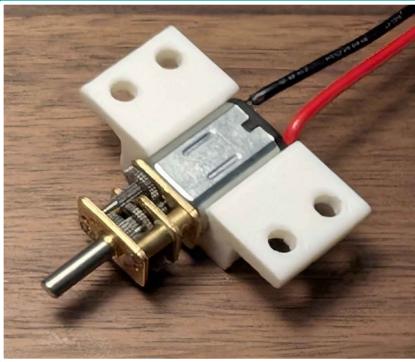
Prototype III - Containment Mechanism

3D Print Prototypes

CAD Model



Prototype IV - Movement System



Prototype V- BMS & Power Delivery



Bill of Materials (BOM)

Sample Snatchers - Bill of Materials						
Components that come in bulk quantity have had their price modified to the amount that will realistically be used. This amount will generally be estimated to be higher than lower. Each section has a name scheme to identify components later on quickly. Quantities will be updated more accurately as the final design is developed.						
Battery and Power Delivery (PDXX)						
Item #	Part	Vendor	Description	Qty	Cost	Link for Purchase
PD01	22 awg Wire	Amazon	Wires for connecting components to circuit	1	CAS0.80	Generic
PD02	XT60 Connectors	Aliexpress	Connectors for battery pack	1	CAS1.60	Link
PD03	16 awg Wire	Amazon	Wires for 12v components	1	CAS0.80	Generic
PD04	P42A Molicei Battery 21700	18650 Battery	For battery pack assembly	3	CAS15.00	Link
PD05	3S Battery Management System	Aliexpress	For safety	1	CAS2.94	Link
PD06	Power button	Aliexpress	Push button for power	1	CAS1.85	Link
PD07	LM2596	Aliexpress	Step down buck converter, 36V/24V/12V/5V/3V	1	CAS0.45	Link
PD08	USB-C PD Trigger Card	Aliexpress	Allows for PD charging to the BMS	1	CAS2.49	Link
PD09	Resistors + Capacitors	Aliexpress	Various resistors + Capacitors	1	CAS0.30	Generic
PD10	Kapton Tape	Aliexpress	Tape for sealing battery cells in pack safely	1	CAS1.00	Generic
Control and Logic (CLXX)						
Item #	Part	Vendor	Description	Qty	Cost	Link for Purchase
CL01	ESP32-WROOM-C3	Elegoo	Controller w/ WiFi + BT	1	CAS9.99	Link
CL02	H-Bridge Motor Driver BTS7960	Aliexpress	Driving 12V motor for scraping	1	CAS7.41	Link
CL03	HX711 Sensor	Aliexpress	Strain gauge for mass analysis	1	CAS1.80	Link
Measurement (MXX)						
Item #	Part	Vendor	Description	Qty	Cost	Link for Purchase
M01	100g Load Cell	Aliexpress	Strain gauge to measure mass	1	CAS4.93	Link
Structural Components (SCXX)						
Item #	Part	Vendor	Description	Qty	Cost	Link for Purchase
SC01	PLA - ~0.5 KG	Bambu	Filament for chassis	1	CAS7.99	Link
SC02	M3 Female Threaded Insert	Aliexpress	Heat set threaded inserts for chassis	1	CAS0.80	Link
SC03	M3/M4 Machine Screws	Aliexpress	Various length M3 Machine Screws	1	CAS1.00	Generic
SC04	608 ZZ 608RS	Aliexpress	Ball bearings	3	CAS1.80	Link
Sampling Tooling Components (STXX)						
Item #	Part	Vendor	Description	Qty	Cost	Link for Purchase
ST01	MGEHR1212 + Bits	Aliexpress	Lathe Bit and armature	1	CAS9.28	Link
ST02	GB37-520 7rpm 12v Motor	Aliexpress	For moving the armature with lathe bit	1	CAS11.28	Link
Total			CAS83.51			

Thank you for listening to our TED Talk!