UNIVERSITY OF OTTAWA
Faculty of Engineering

GNG1103 Design Project – Deliverable D

Group C2

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Submitted to: Professor David Knox

Submitted on: February 13, 2022

Wrike Snapshot Link:
https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=BNmf0VsWGh9Imjv9enTHCvQYel5t9n21%7CIE2DSNZVHA2DELSTGIYA

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SUBSYSTEM DESIGNS BY EACH MEMBER

Adrianna Chouliotis

Subsystem 1

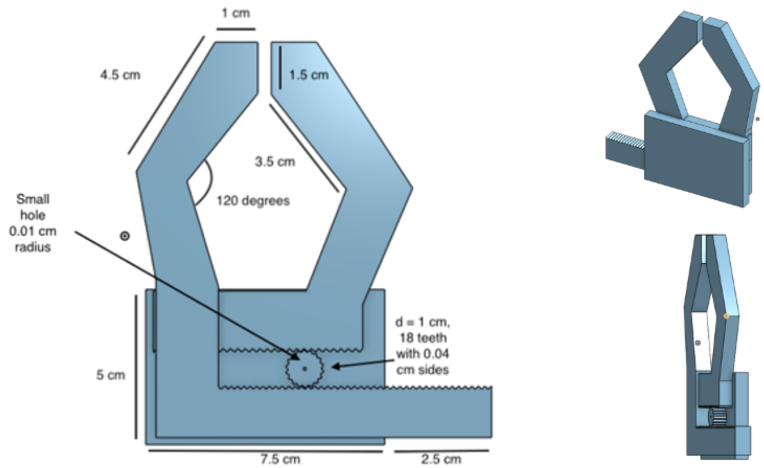


Figure 1. Subsystem 1: Gear and Tooth End Effector Claw (Adrianna)

A simple end effector design with a rack and pinion mechanism which can be used either mechanically or even with a motor in the gear. Any item can be picked up and hand adjusted, working best with the sensor or the paint gun.

Subsystem 2

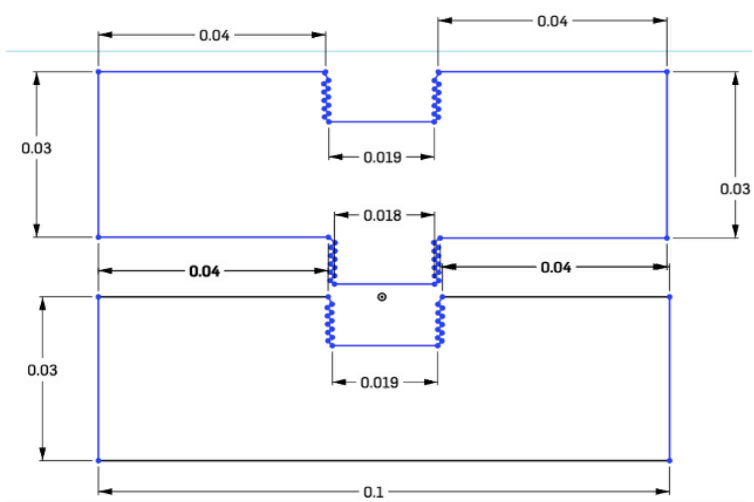


Figure 2. Subsystem 2: Screw Mechanism for End Effector Base (Adrianna)

Composed of a screw in and out mechanism, can interchange between end effector parts if they also contain a male screw on their end, and can also extend the length of reach between the end effector and the wrist joint.

Subsystem 3

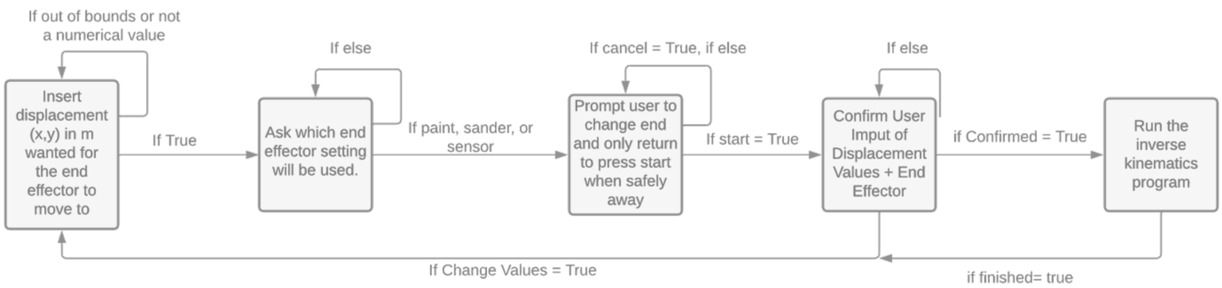


Figure 3. Subsystem 3: Interface Coding (Adrianna)

Using Python conventions, such as UserInput, Variable Containers, and if/else statements the user will be able to set up the robot arm for autonomous use, only needing to work the robot when changing end effectors and measuring distance the arm is wanted to reach.

Hunter Fleming

Subsystem 1

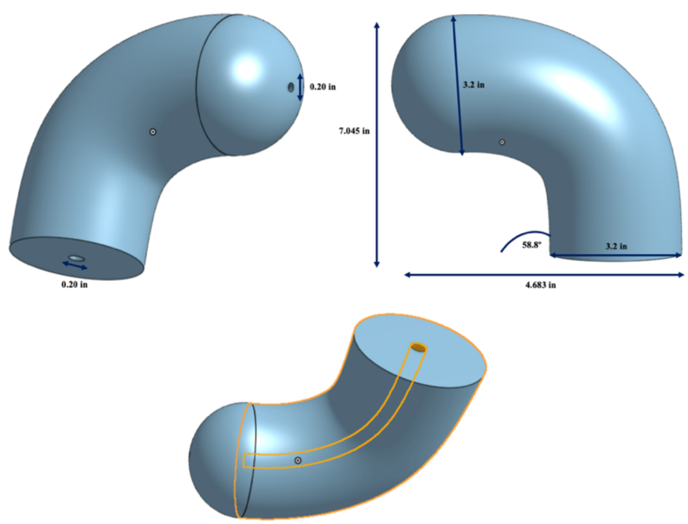


Figure 4. Subsystem 1**:** Nozzle End Effector Design (Hunter)

The nozzle has a rounded head connected by a ball mechanism. This gives a larger range of motion. The nozzle has a tube inside to dispense the paint, this tube can be contracted/expanded to reach the desired dispensing size. The head also has a 58° curve for a more stable finish.

Subsystem 2

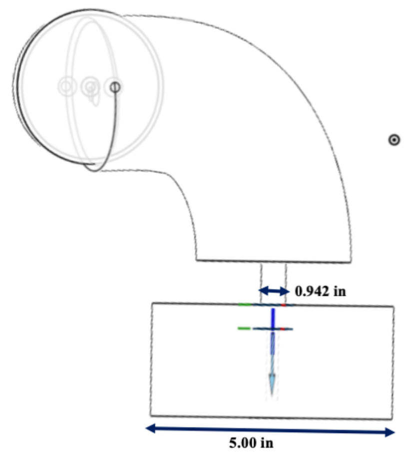


Figure 5. Subsystem 2: Screw Connection Between Nozzle and Base (Hunter)

The end effector is connected to the base with a screw-in mechanism. The casing around the tube is inserted into the slot on the base and screwed in. The base will also have a tubing system in order to connect the two tubes together.

Subsystem 3

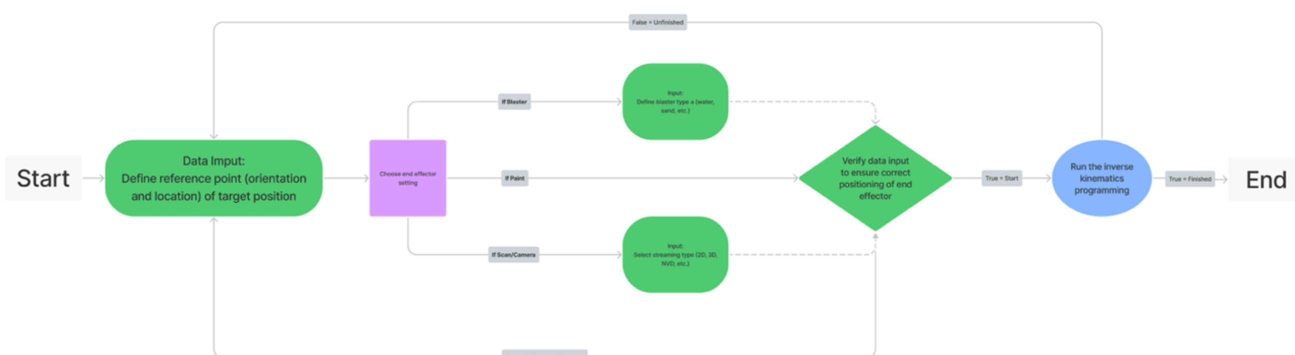


Figure 6. Subsystem 3: Interface Coding (Hunter)

Minjung Gong

Subsystem 1

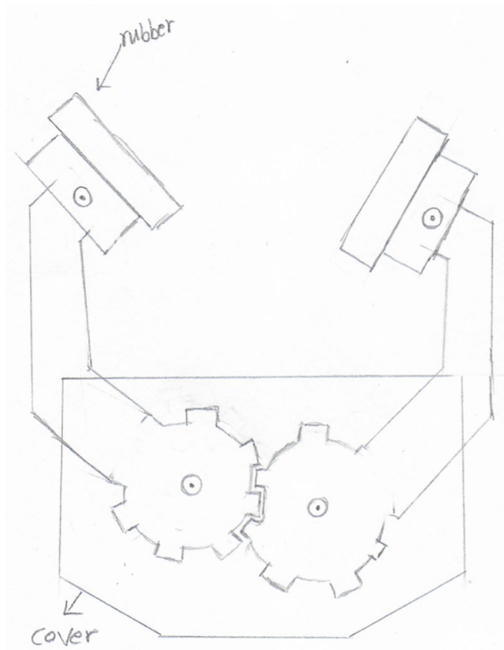


Figure 7. Subsystem 1: End Effector claw with 2 Gears Connected (Minjung)

The two halves of the claws need to be made of gears in contact with each other. If two gears are used, the range of motion on the gripper is widened. The tip of the claw is equipped with a non-slip rubber covering to hold objects more safely.

Subsystem 2

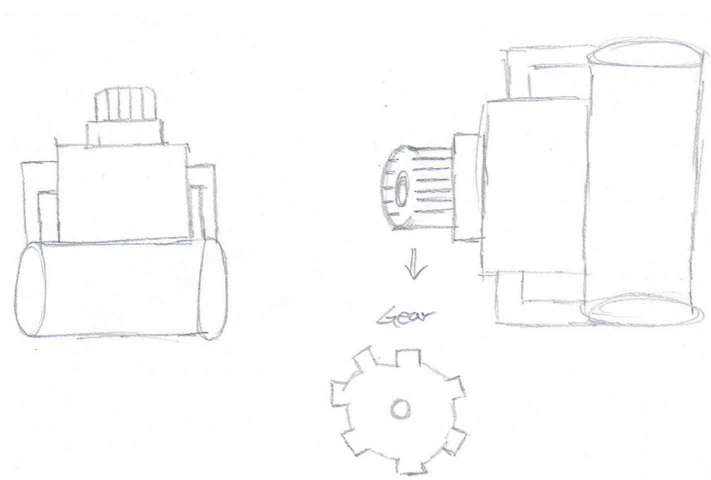


Figure 8. Subsystem 2.1: A Device that Connects the End Effector Claw and the Body of Arm

The movement of the end effector claw is made smoother when connected to the body of the arm using a cylinder.

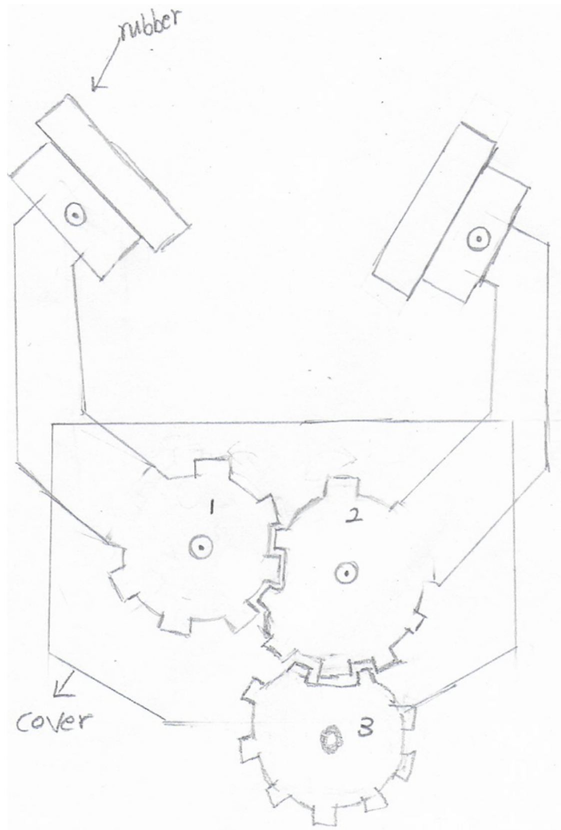


Figure 9. Subsystem 2.2: Gear of the Device that Connects to the Body of the Arm

There are three gears in use. Gear 1 and 2 are horizontal. Gear 3 is vertical. Gear 3 is only connected to gear 2. Gear 1 and 2 turn inward and the claw is close when gear 3 turns to the right. Gear 1 and 2 turn outward and the claw is open when gear 3 turns to the left.

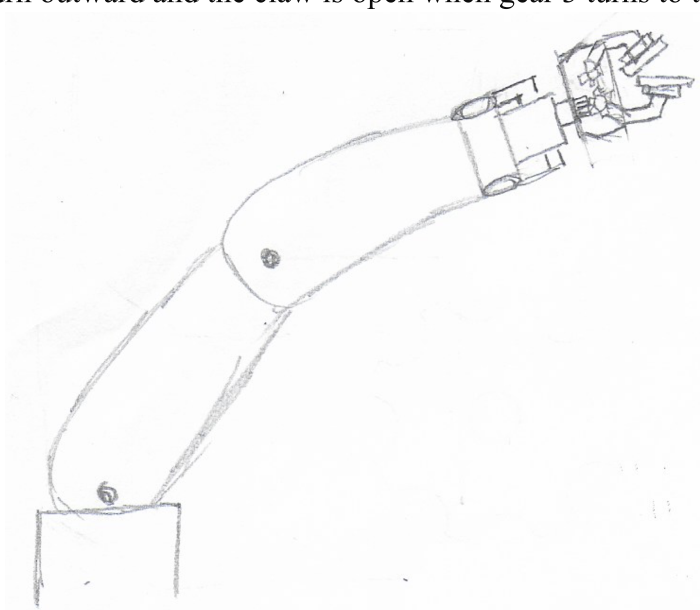


Figure 10. Subsystem 2.3: Full View of the Robotic Arm (Minjung)

Subsystem 3

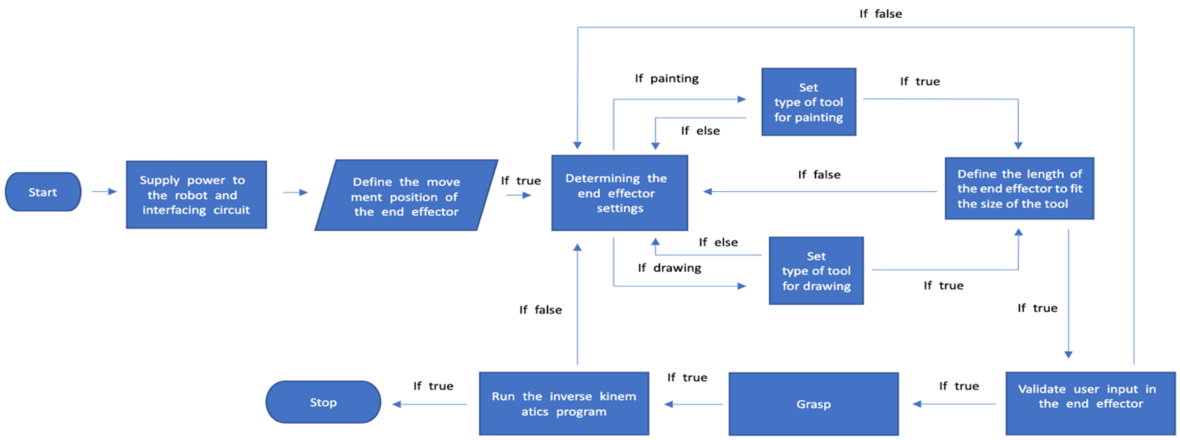


Figure 11. Subsystem 3: Interface Coding (Minjung)

Toby Thai

Subsystem 1

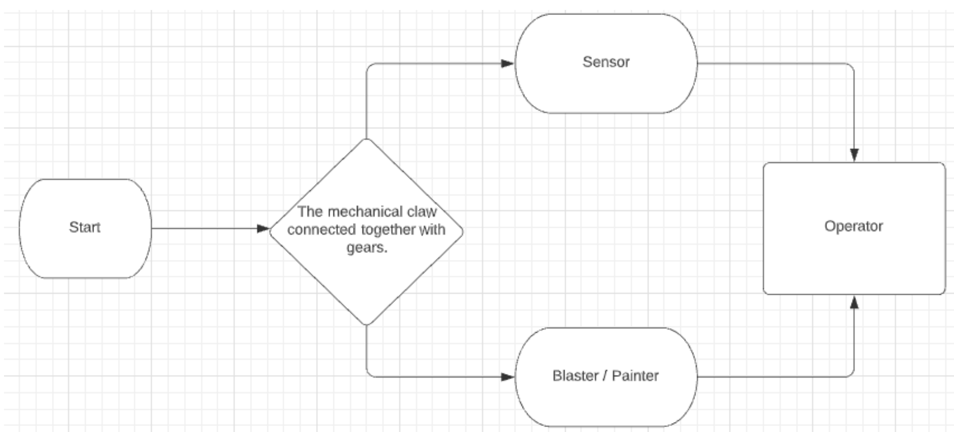


Figure 12. Subsystem 1: End Effector with the Gear Connection (Toby)

Subsystem 2

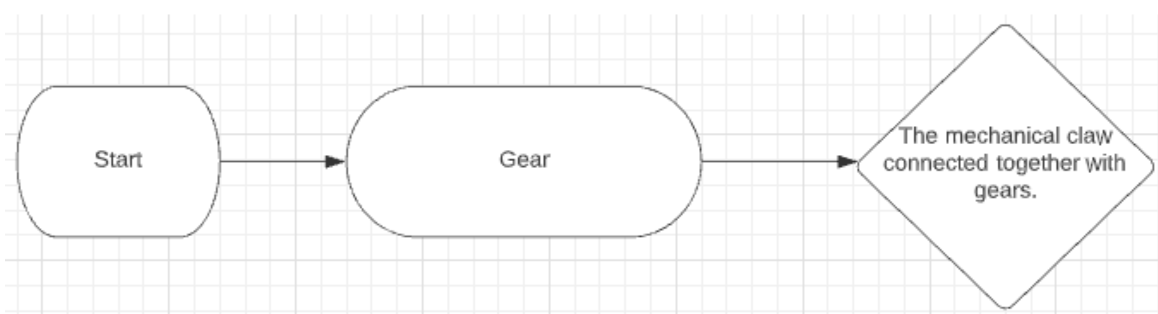


Figure 13. Subsystem 2: The Third Gear Connected to the Mechanical Claw (Toby)

For this subsystem, there will be a third gear which will contact the gear of one arm of the end effector. Once the third gear starts rotating, the gear of the arm connected with the third gear will perform as an idler as it also contacts with the gear of the other arm. It makes the claw work to handle or release an object.

Subsystem 3

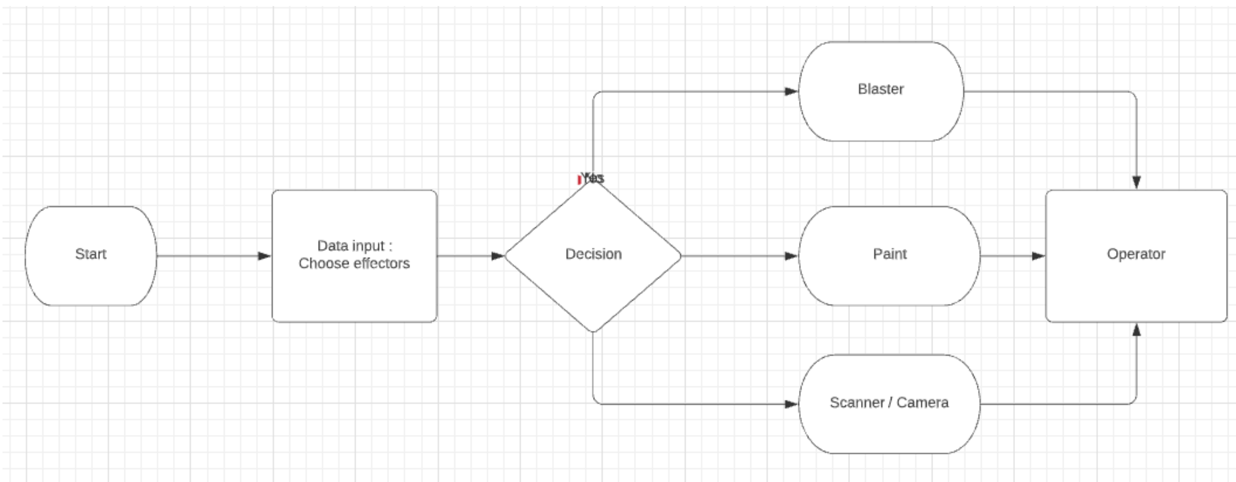


Figure 14. Subsystem 3: Coding Interface (Toby)

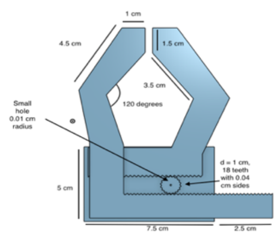
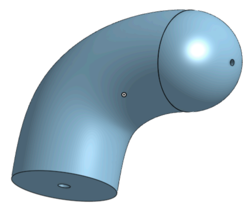
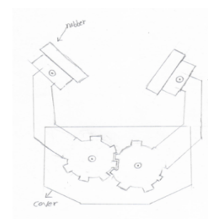
Comparison Between Selected Designs

Problem Statement

National Defence of Canada needs a robotic arm designed to use on Halifax Class steel ships in open and defined spaces. The arm should be safe, open source, straightforward to use and maintain. The arm needs to be able to scan the workspace, hold a tool to remove paint or corrosion, hold a painting tool, and paint with precision.

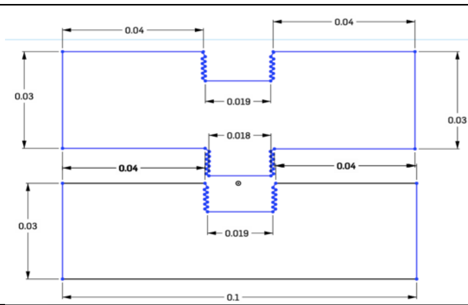
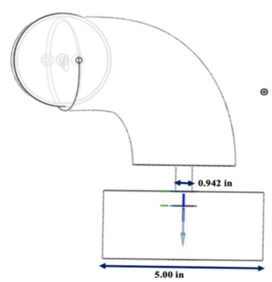
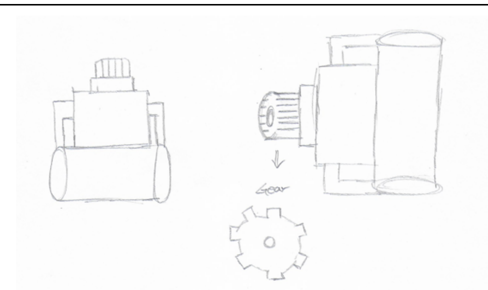
End Effector

Table 1. Selection Matrix for End Effector Design

Design Criteria	**A**	**B**	**C**
Image			
Effector Type	Claw	Nozzle	Claw
Capabilities	Grabbing/Holding	Spraying	Grabbing/Holding
Inner System	Rack and Pinion	Hollow Tubing/Ball	Gear System
Rotation	120°	360°	180°

Connection Component

Table 2. Selection Matrix for Connection Component Designs

Design	**A**	**B**	**C**
Image			
Installment	Screw Mechanism	Screw-In	Gear

Interface Coding

Table 3. Selection Matrix for Interface Coding Designs

Design	**A**	**B**	**C**
Image	Figure 11	Figure 6	Figure 3
Coding Language	Python	Python	Python
Open Source	YES	YES	YES
Uses	Booleans, Inverse Kinematics Equations	Booleans, Inverse Kinematics Equations	Booleans, Inverse Kinematics Equations

COMBINED SOLUTION

End Effector

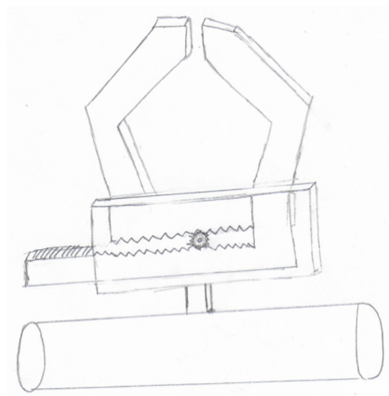


Figure 15. End Effector

Table 4. Combined Solution for End Effector Design	
Design	**A**
Effector Type	Claw
Capabilities	Grabbing, Holding
Inner System	Rack and Pinion
Rotation	360°

Connection Component

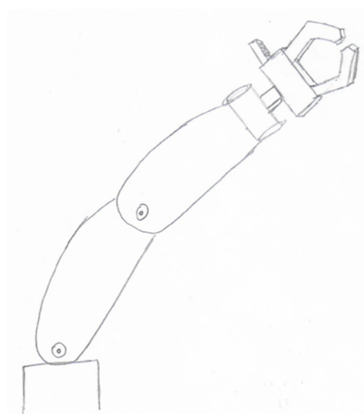


Figure 16. End Effector Connected to Arm

Table 5. Combined Solution for Connection Component Design	
Design	**B**
Installment	Screw

Interface Coding

Table 6. Combined Solution for Interface Coding Design	
Design	**B**
Coding Language	Python
Open Source	Yes
Uses	Booleans, Inverse Kinematics Equations

OTHER COMBINED SOLUTIONS

Table 7. Other Combined Solutions

Design Combination	End Effector **C** Connection **B** Coding **A**	End Effector **A** Connection **C** Coding **Toby**	End Effector C Connector **C** Coding **A**
Effector Type	Claw	Claw	Claw
Capabilities	Grabbing/Holding	Grabbing/Holding	Grabbing/Holding
Inner System	Gear System	Rack and Pinion	Gear System
Rotation	180°	120°	180°
Mechanism	Screw-In	Gear	Gear
Coding Language	Python	Python	Python
Open Source	Yes	Yes	Yes
Uses	Booleans, Inverse Kinematics Equations	Booleans, Inverse Kinematics Equations	Booleans, Inverse Kinematics Equations
Why Design was Not Chosen	End Effector didn't provide enough force to hold the payload.	Connection C was intricate and would cost more, while Toby's coding didn't include verification.	Connection C was intricate and would cost more, while the End Effector C could not provide enough force.

Written analysis

The final selection of subsystems was a combination of End Effector A, Connector B, and Coding Interface B.

The decision to include End Effector A came from the capabilities of the claw and the mechanical system being of better use. The Claw system has better capabilities than a nozzle, and can hold the paint blaster, sander, and sensor, while the nozzle system could only hold the painter, and add extra volume in hard-to-reach spaces. Furthermore, the rack and pinion system for the claw is more precise than the designed gear system, allowing each claw to move a smaller distance, and also has a perpendicular force rather than an angled force, achieving a higher payload.

The connector B was chosen due to its' simplicity and ease of use. It is only composed of a female screw-in mechanism to connect the end effector and potentially house a wrist motor. It also is simple and universal, allowing any end effector connection to be made as long as the male screw is a size that is compatible with the female counterpart.

Finally, as all coding was similar and Python being used a base, Code B was chosen due to its' detail and better-defined containers. The system is dependent on a series of Booleans which lead to the use of an inverse kinematics system that will position the end effector. The system also incorporates safety by verification and not needing to change parts while running the code.

Overall, the final solution, dubbed ABB, was chosen as it gave the most payload wise, cost wise, and interchangeability wise, which gave the most intuitive plan to follow.