Design Review 3

Arthritis Ziploc Assistive Device

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01.

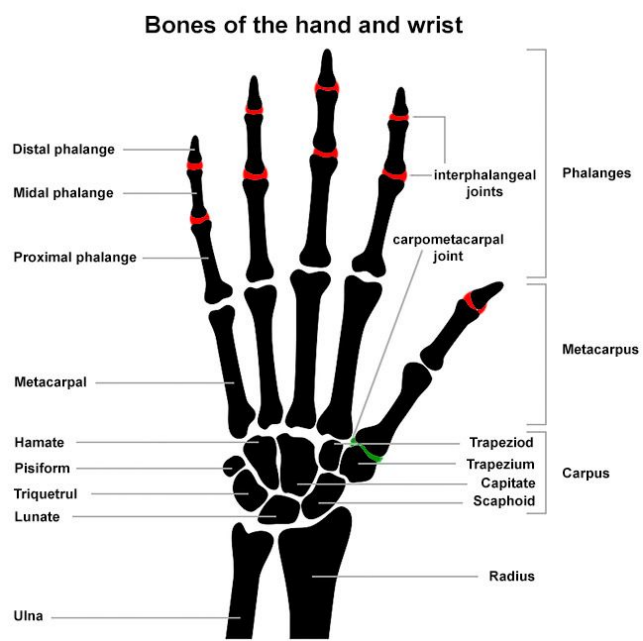
Background

Background and Customers

The Everyday Struggle

- **20%** of adults in the U.S. have arthritis
- Low motor strength, force, & precision in fingers
- Causes frustration, reliance on others, and a decreased quality of life

Arthritis' Impact on Joints



- **Osteo and rheumatoid arthritis**: affects interphalangeal joints **(RED)**
- **Basal thumb arthritis**: affects basal joint **(GREEN)**

Source: Hospital for Special Surgery (https://www.hss.edu/conditions_assistive-devices-for-the-hand-small-joint-protection.asp)

Arthritis Struggle & Solution

- One related difficulty is the opening and closing of Ziploc bags
  - Requires precision and outward force to open
  - Requires alignment and continuously applied pressure to close
- **Decided to address arthritis assistance for pinch-to-close resealable quart-size freezer bags**

Model Users Of This Product

Elenora DeBolle
(Maya's grandmother)

Arthritis diagnosis:
Basal thumb arthritis, both hands

Humera Bashir
(Zahir's mother)

Arthritis diagnosis:
Osteoarthritis, both hands and lower back

Rama Subramanian
(Vio's housemate's mother)

Arthritis diagnosis:
Basal thumb arthritis, right hand only (right-hand dominant)

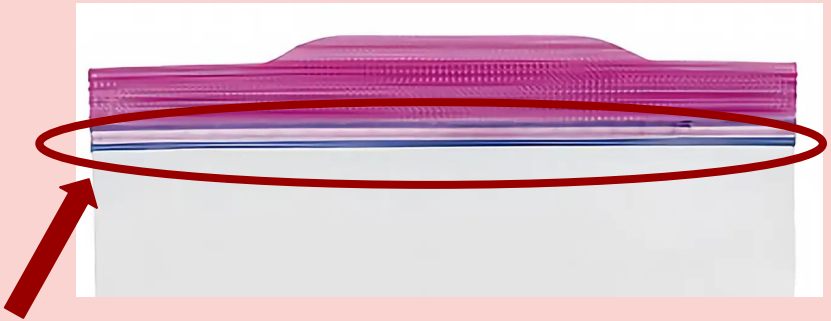
02.

Final Prototype

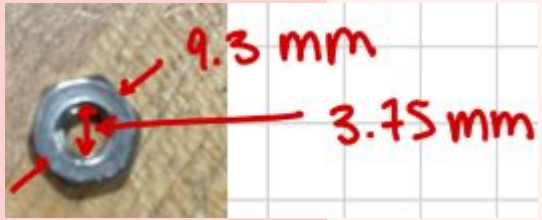
Definitions, Progress from DR 2, and Demonstrations

Definition of Parts

“Teeth”: the ridges on a resealable bag



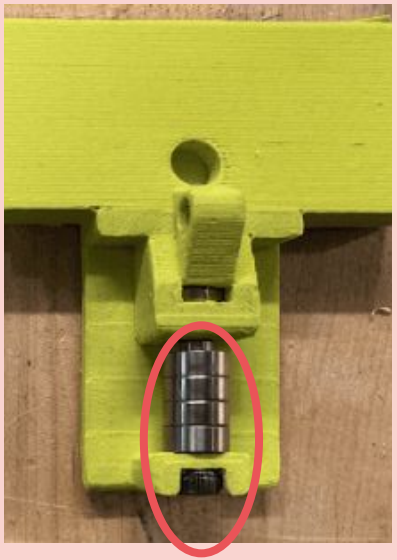
“Hardware”: any metal components

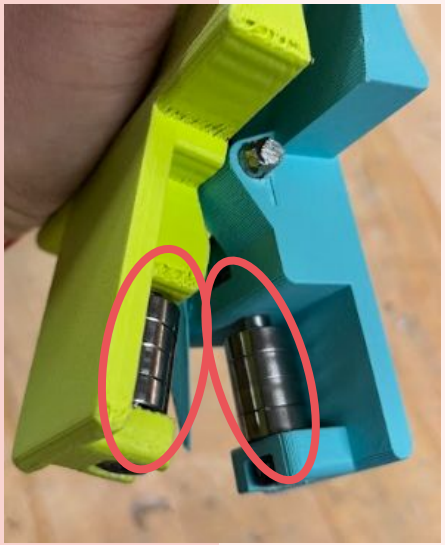


Definition of Parts

“Opening Mechanism” or “Wedge” : refers to the pointed tip

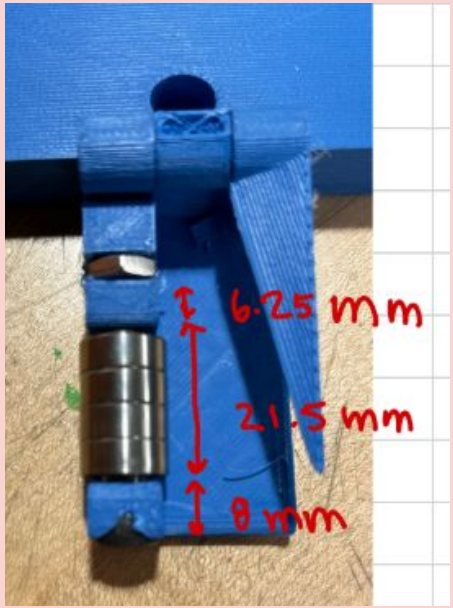
“Closing Mechanism”: refers to the rolling component (shoulder bolt and bearings)



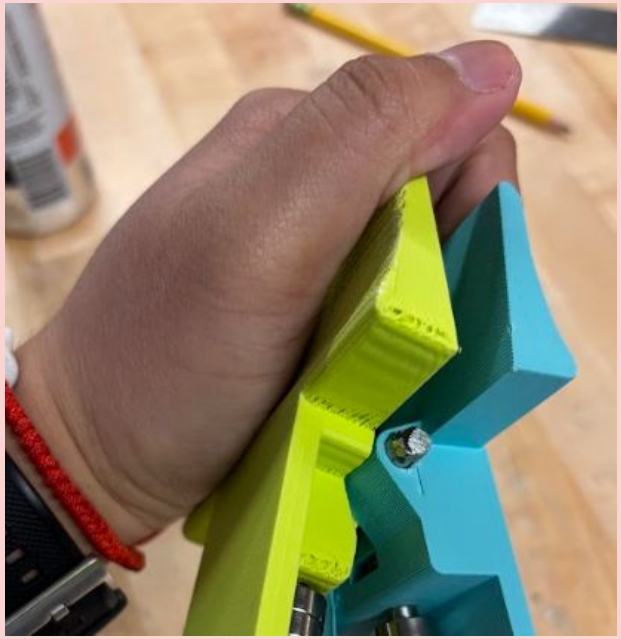


Definition of Parts

“Body”: the 3D printed part of the device where the hardware is attached



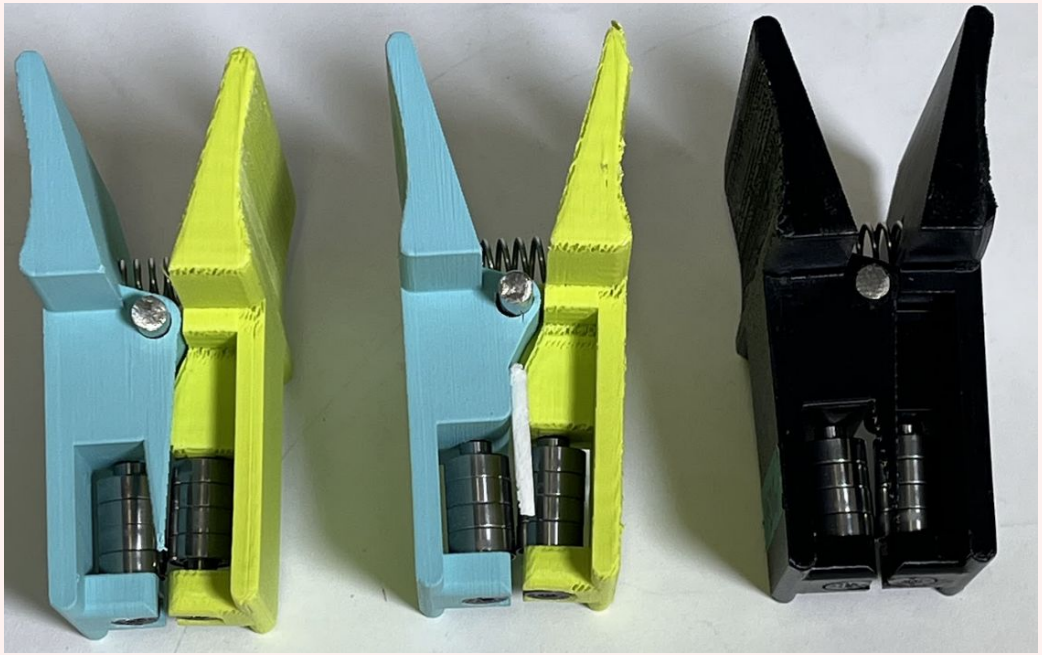
“Grip”: the 3D printed part of the device the user holds



Since Design Review 2

- Deviated from teeth alignment requirement
- Deviated from idea of opening mechanism “flipping down”
  - Safety concerns
  - Large enough surface area of bearings to close teeth
- Switch between open / close
  - Directionality
- Solved issue of opening mechanism blocking closing mechanism
- Clarified spring, hinge, and closing mechanisms
- Finalized risk analysis

Final Prototypes!



Entirely PLA

***PLA + Mold & Cast Opener

Entirely PETG

Prototype Demo: Opening the Bag

Prototype Demo: Closing the bag

Now you try!

(Please be gentle with the prototypes)

03.

Design Process

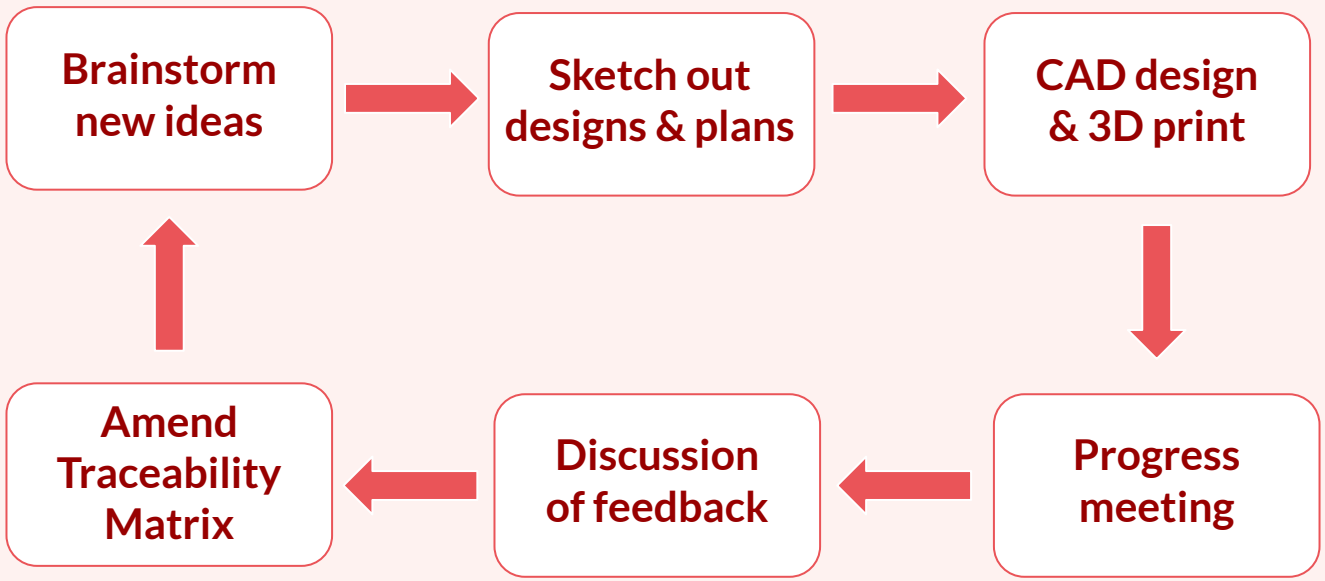
Considerations, Iterative Design Process, and Other Ideas Explored

Creating a portable, durable, and comfortable device

Design Considerations (TM - Design Inputs)

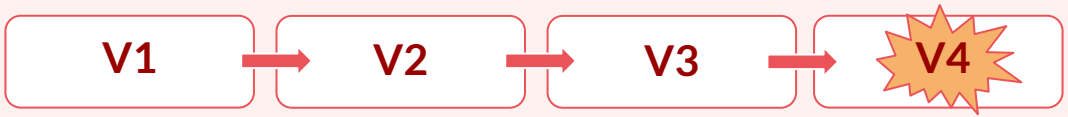
- Users can use the device without pain
- Must be safe for user (no sharps, toxics, materials)
- Device must be portable
- Clamp with enough force to lift a bag off a surface
- Device can withstand being dropped
- Device must function after submerged in soap and water
- Mainly 3D printed, with metal parts to enable rotation and clamping

Prototype Design Process

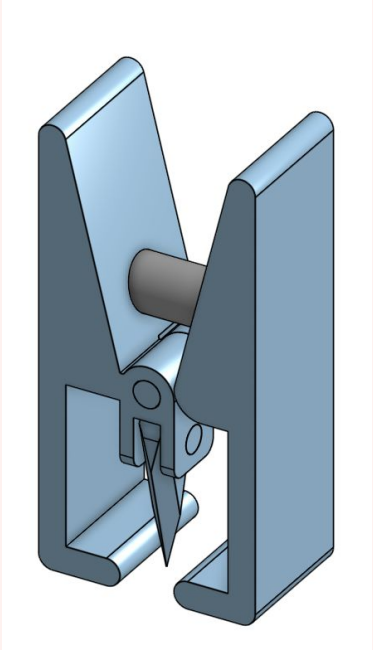


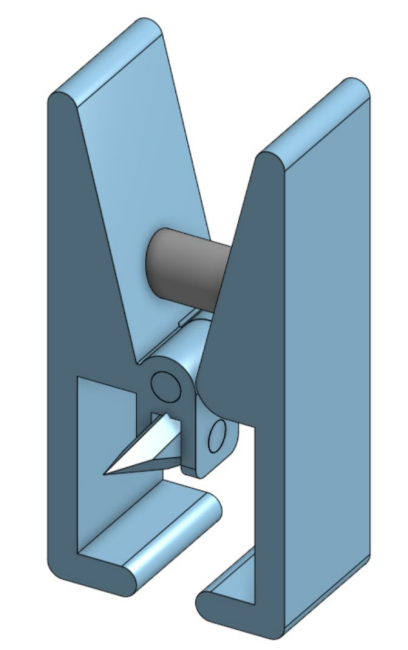
Prototype Timeline

All previous prototype designs and how each iteration improved to get us where we are now!



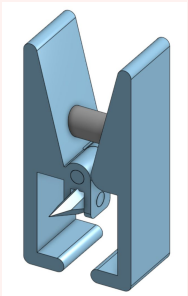
Prototype 1: Initial ideation



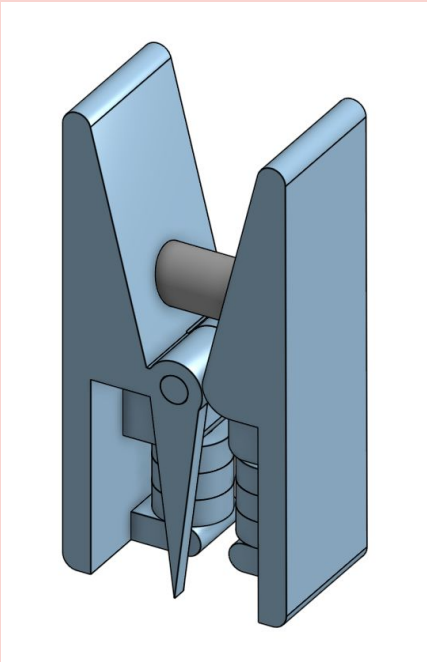


CAD model

Prototype 1 Faults & Solutions

Faults	Brainstormed Solutions
Closing mechanism relied on constant pinching	Use rollers so that you only need to pinch once and drag
Opening mechanism was free to rotate 	Fix the opening mechanism in place
No distinct directionality	Redesign so that the device only opens the bag in one direction and closes in the other

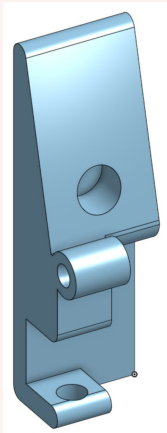
Prototype 2: Bearing holder



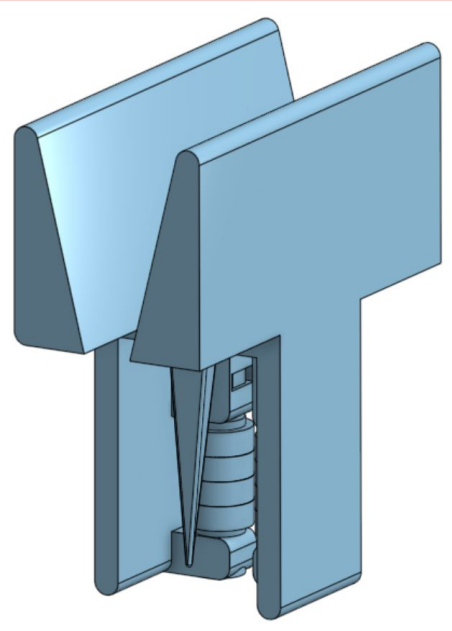
CAD model

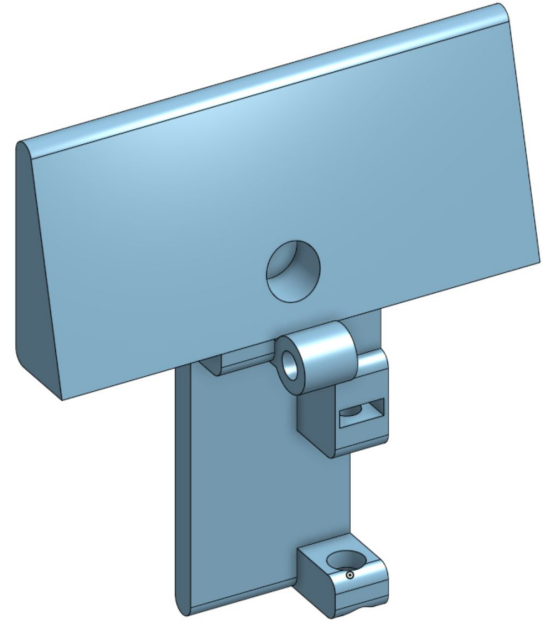
Physical model

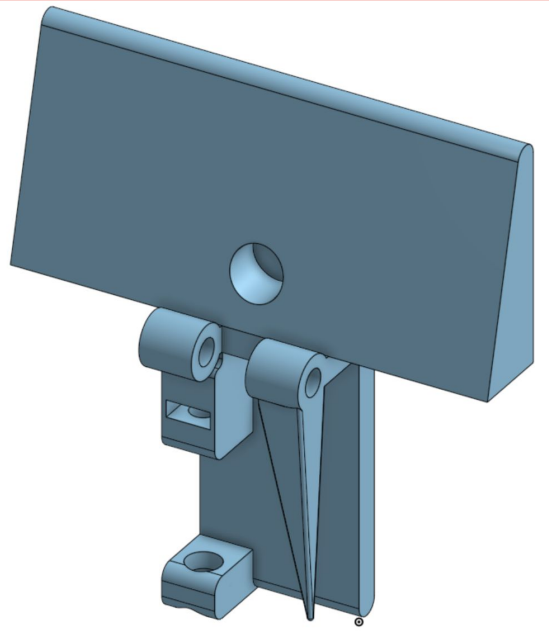
Prototype 2 Faults & Solutions

Faults	Brainstormed Solutions
2-Segment hinge was unstable 	A 3-segment hinge (limit range of motion normal to the rotation)
Roller bearings are not properly secured (friction fitting is no good)	• Have a threaded component inside of the 3D print • Utilize a shoulder bolt and hex nut to secure at the end

Prototype 3: Shoulder bolt

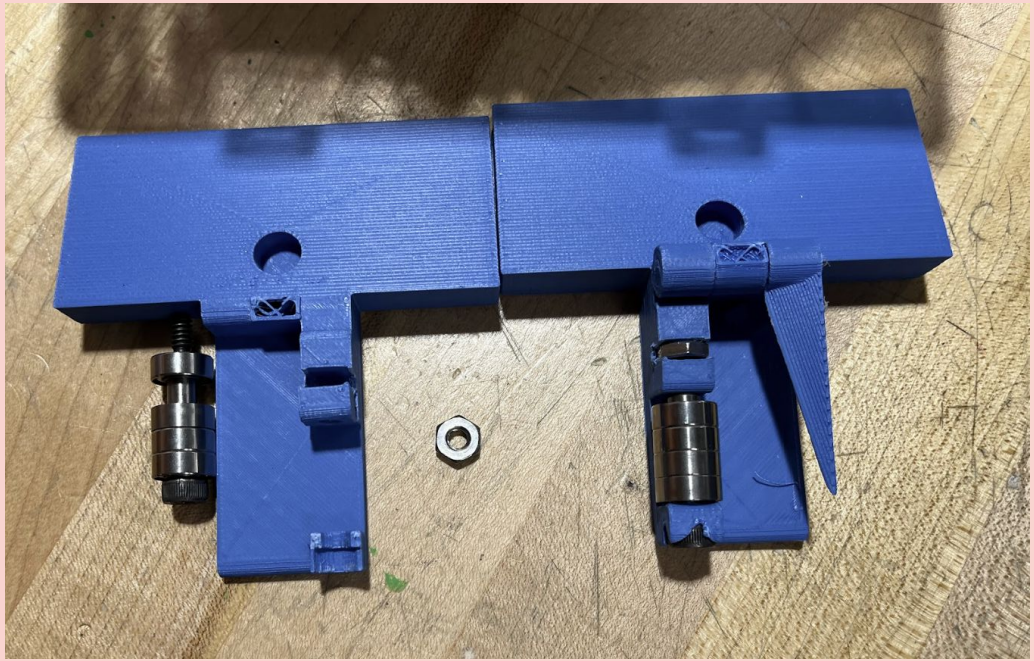






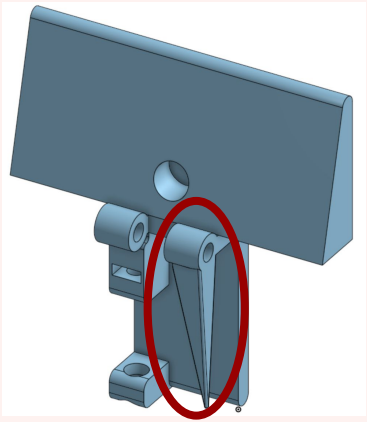
CAD model

Impact Testing

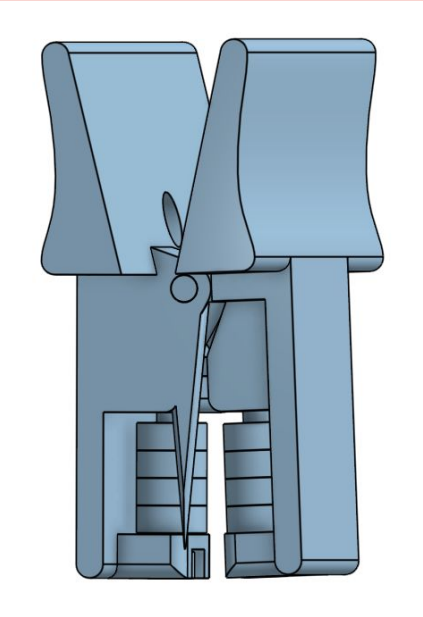


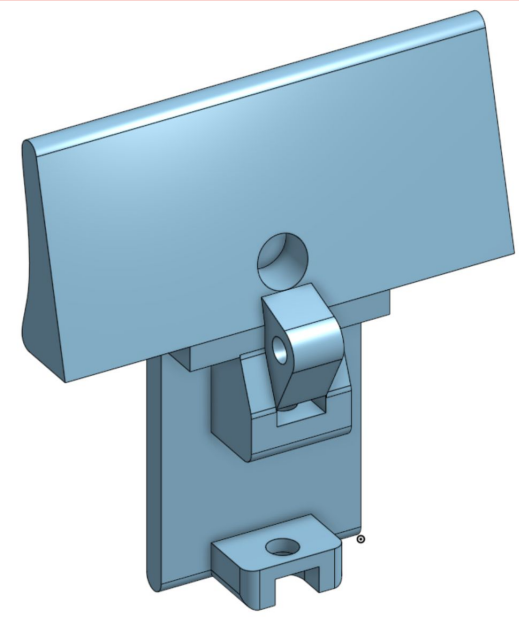
- Damaged bearing holders and middle hinge

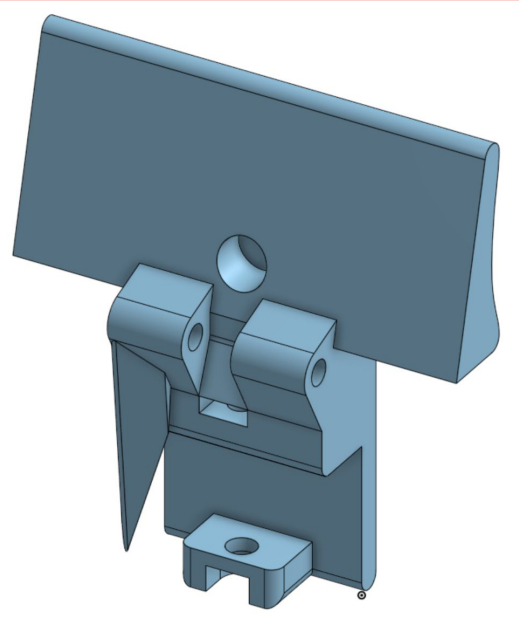
Prototype 3 Faults & Solutions

Faults	Brainstormed Solutions
Opening mechanism easily broken off 	Reinforcement (triangle shape) at base of mechanism
Opening mechanism tip can't withstand the shear stress as bag is opened	Mold and cast tip out of a more durable material (polyurethane)
Device weight is uneven	Move the closing mechanism to the center

Prototype 4: Final Product







CAD model

Prototype 4: Final Product

Physical model

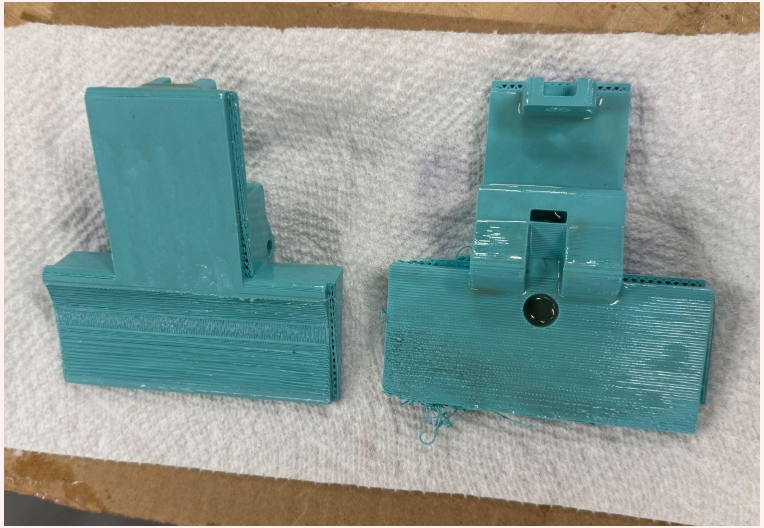
Other approaches we explored

Tested multiple materials and part replacements

1. Coating 3D print
2. Making prototype out of a different material
3. Molding and casting to reinforce parts
4. Different spring

1. Coating 3D Print

- **Concern being addressed:** PLA texture rough
- **Solution:** XTC-3D coating
- **Conclusions:**
  - Doesn't completely fill in gaps between ridges
  - Poor color

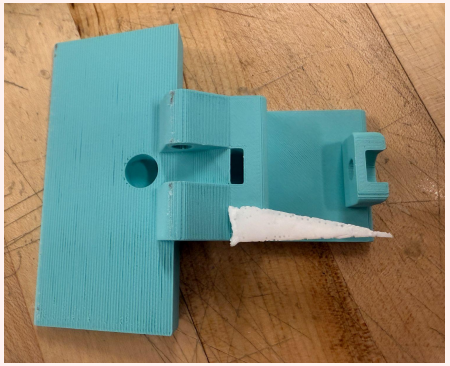


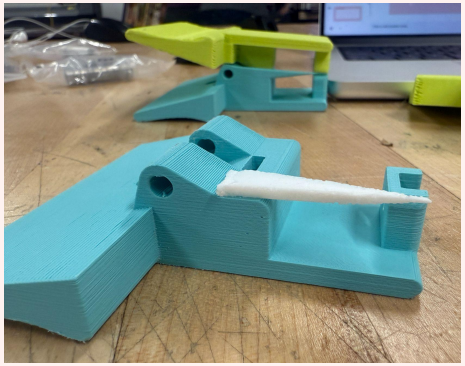
2. Another Material: PETG

- **Concern being addressed:** PLA is brittle
- **Solution:** Print with more flexible material
  - PETG is more ductile and strong
- **Conclusions:**
  - Incredibly durable print!

3. Molding & Casting the Wedge

- **Concern being addressed:** PLA is weak; wedge might snap with compressive force
- **Solution:** Mold and cast opener tip with polyurethane
- **Conclusions:**
  - Weaker than PLA
  - May break off of device body





4. Different spring mechanism

- **Concern being addressed:** Amount of outward force
- **Solution:** Chip clip spring
- **Conclusions:**
  - Nothing applying outward force
  - Size of the spring too small
  - Better alternatives available

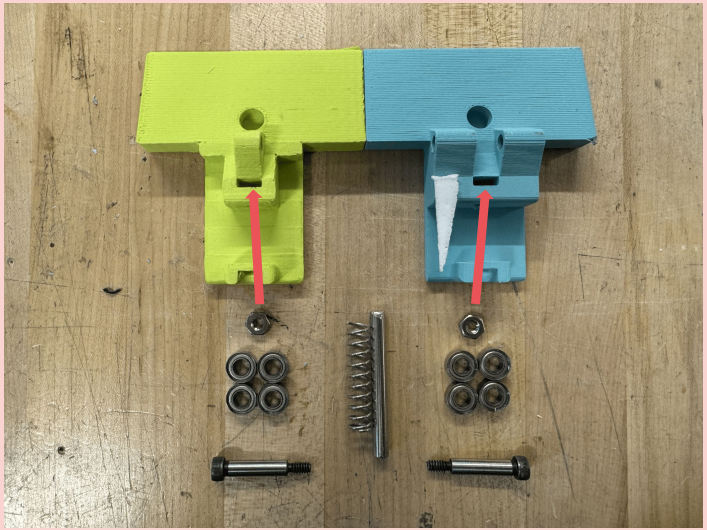
04.

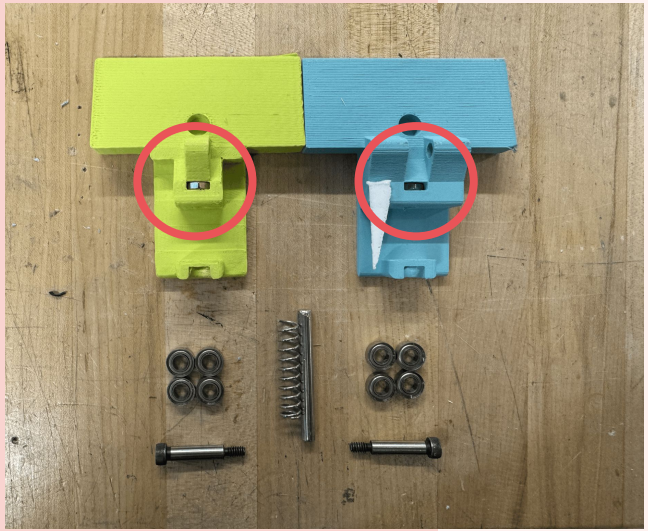
Closing Considerations

Manufacturing, V&V, Risk Analysis, and Limitations

Assembly Step 1

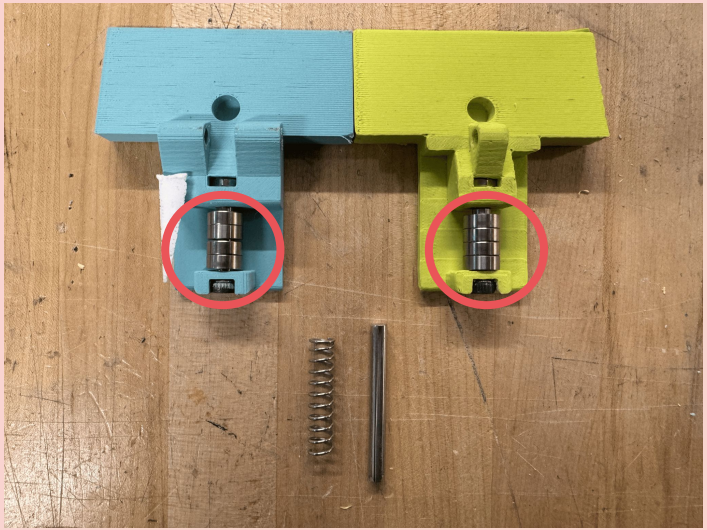
Step 1: Insert hex nut into slot



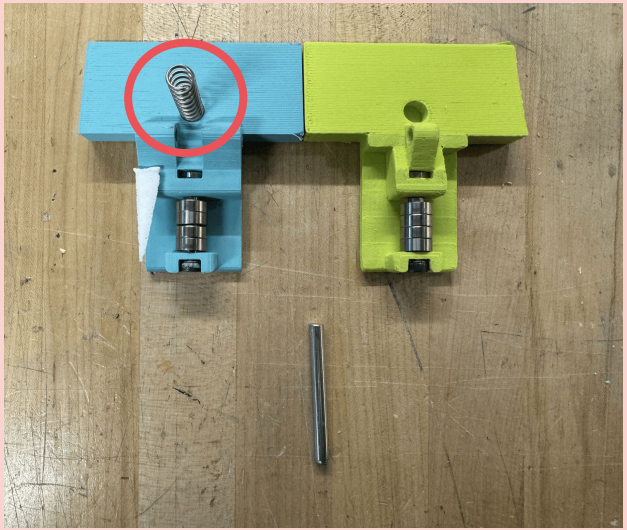


Assembly Steps 2 and 3

Step 2: Insert shoulder bolt into holes and mount bearings

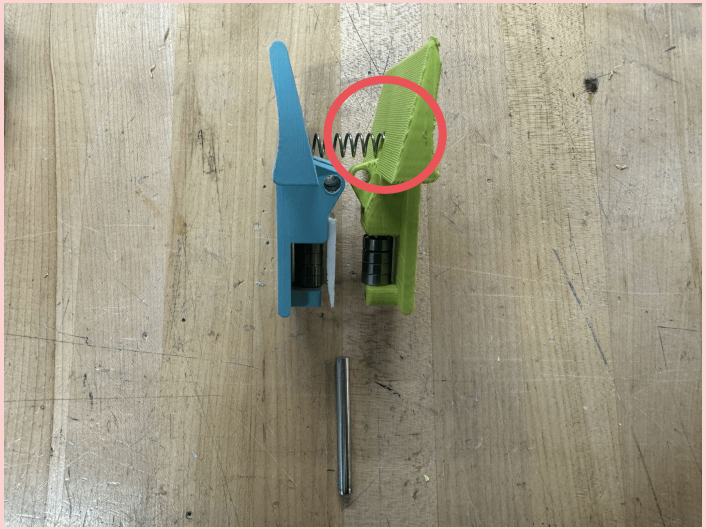


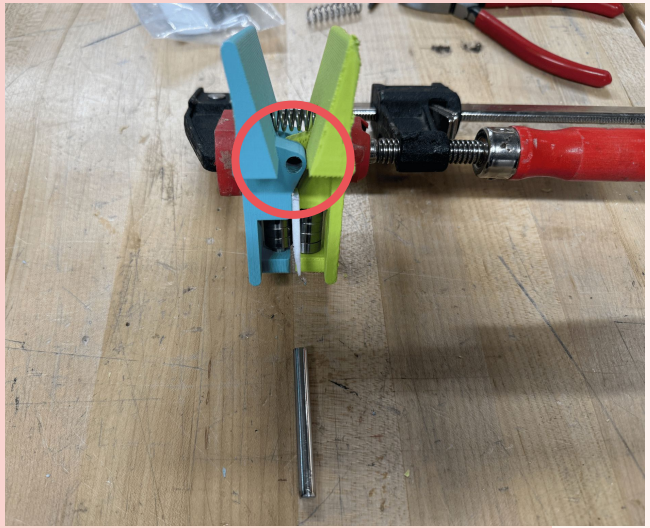
Step 3: Insert spring



Assembly Step 4

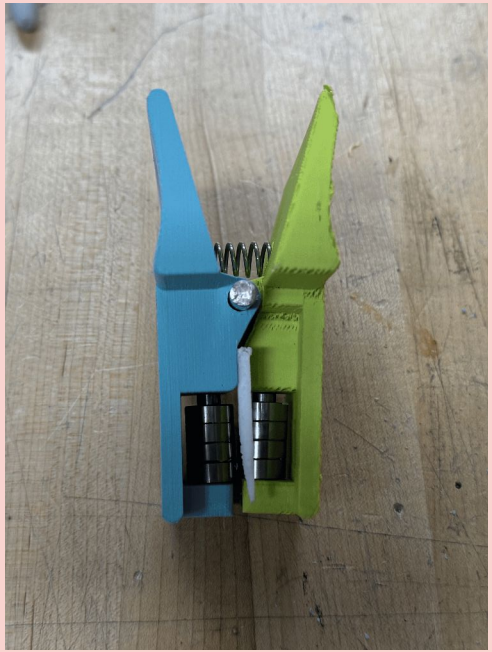
Step 4: Connect pieces and clamp





Assembly Step 5

Step 5: Insert metal dowel into middle



Final Risk Analysis

Item Number	Function	Risk Control	Unmet or Met
	Functional Output	Risk Mitigation	Final Prototype Risk Analysis
	Description	*The way by which the risk is reduced/ eliminated*	*How does the prototype mitigate risk and address hazards*
1	*Bag is not fully open*	*Extension tip is made more sharp, utilize angle of extension*	*Once bag seal is broken, opener can easily slide across*
2	*Bag is not fully closed*	*Add ridges to align bag, only release device from bag when closed*	*Rolling bearings apply pressure over large surface area*
3	*Sharp open mechanism*	*Extension has rounded tip*	***Fails: Pointed tip could break off and scratch user***
4	*Device too small*	*Device has large surface area for hands*	*Grip surface dimensions: 3.5 x 1.5 inches*
5	*Device too large*	*Optimize mechanism functions and weight*	*Prototype mass is:136 grams*
6	*Device not stable*	*Device weight is balanced and level*	*Prototype placed on any face will not tip*
7	*3D print shatters*	*Make 3D printing tolerances and interface with plastic smaller*	***Fails: Small hardware and shattered plastic parts pose choking hazard***
8	*Device cannot maintain open or closed conformation*	*Ensure that spring weight is small enough as to not cause major injury to user*	*Small spring force: 7.5 n/mm*

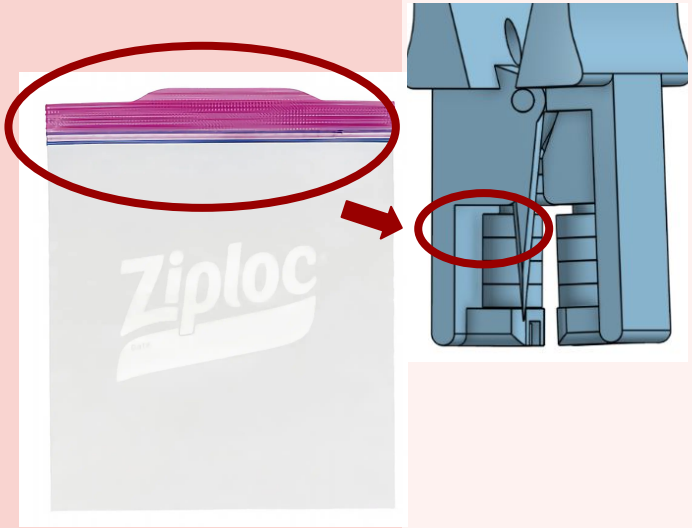
Limitations

Device Limitations from V&V:

- Device still hits the lip of bag
- Teeth are still very hard to pry open
  - Somewhat awkward angle
  - Might pierce lip of bag
- Size is not space efficient

Process Limitations:

- Lack of stakeholder feedback!
- Collective indecision
  - Late
  - Limited by delivery time



Verification: Design outputs to inputs

Inputs met:

- Small Size
- Washable
- Food-safe
- Low-cost production
- Full device weight: ~130 g
- Spring force ~ 15 N

Inputs unmet:

- 3D printed grip is rough and unfinished
  - Grip is not ergonomic
- Performance may differ with different bags

Validation: Successful Users

Ashley Wu (A’27)

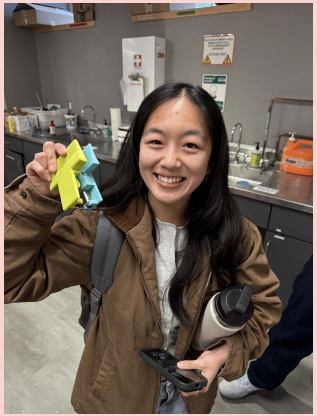
Addy Mock (E'26)

Lillian Tran (A’26)

Meghan Yi (E’26)

Eli Lipman (E’27)

Adda Hennessey (E’26)



Future Considerations

Materials

- Material diversity
- Mold and casting
- Increased research funding

Testing

- Stakeholder feedback
- Durability

Scaling up

- Mass-manufacturing
- Ordering and shipping

Thank you!

For more information, please visit
our website:
https://sites.tufts.edu/pinkteam/

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