Retractable Grabber Tool

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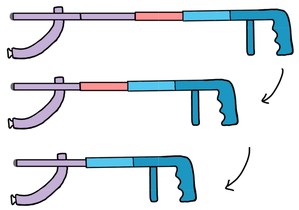


Color coded view of retractability. Blue doesn't retract, purple is connected to the claw and retracts partially into pink, and pink retracts into blue.

This grabber tool is designed for elderly people who may have knee or back pain and experience difficulties bending down to pick objects up. They require a device that can reach the ground and clasp down on an object without the user exerting too much force. The tool will be needed in everyday life so it needs to be portable, and therefore has a retractable design. To prevent the user from needing multiple devices, this design focuses on having multiple functionalities incorporated into one tool.

Early Design and Technical Requirements

Table 1 Normative Grip Force (in Pounds)

Age	Hand	Men n	Men M	Men SD	Women n	Women M	Women SD
65–69		19			33		
	right		91.5	15.5		54.9	10.1
	left		88.2	14.4		51.5	9.5
70–74		19			37		
	right		84.2	17.2		52.5	9.5
	left		81.4	18.4		48.3	10.5
75–79		17			39		
	right		81.9	9.94		48.2	10.3
	left		77.3	10.2		43.6	10.7
80–84		15			17		
	right		70.6	14.6		44.5	11.1
	left		63.1	16.2		41.0	9.3
85+		14			14		
	right		54.2	14.2		40.4	11.6
	left		50.3	13.8		37.7	8.6

Maximum grip force of elderly [1]. Device should only require a light force.

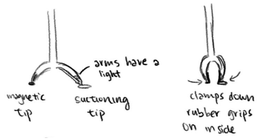
Since the main user is the elderly, the required force was one of the most important factors considered to ensure easy and comfortable use.

Foldable arm in the early design

Requirements	How It's Addressed
Required force of ~20 lbs (loose grip, even for 85+ women) [1] to operate the device	Distance between the jaws and trigger respectively will be adjusted to minimize force
Weight of the device must be light enough for an elderly person	Weight is minimized during analysis and lightweight aluminum is used
Device should be portable and easily stowed	Retractable arm that minimizes the size of the tool
Handle must be comfortable for arthritic fingers	Handle designed with an ergonomic handle and padded
Must pick up differently sized and shaped objects easily	Magnet and suction cup attached to the claws in addition to grabbing

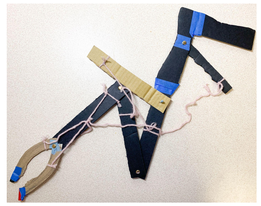
Initial Prototyping and Evaluation

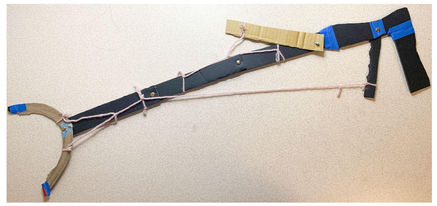
The initial prototype modeled the rough size and shape of the device. It tested the two main mechanisms, the foldable arm and the claw. Through the prototyping, it became apparent a foldable arm was difficult to implement without an additional trigger and also increased the bulkiness when folded. The design evolved to include a retractable arm instead. The shape of the claw made it difficult to add features to the tip while retaining its clamping abilities, so this and the method of closure was further developed in CAD.



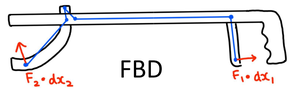
Initial planned shape for the claw, as reflected in the prototype below.

Folding mechanism is triggered by the brown handle on the side. Arm folds outwards.





Analysis



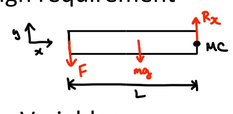
Using $\boldsymbol{F_1 \bullet dx_1 = F_2 \bullet dx_2}$, F_1 = 12lbs * 7cm / 10cm **F_1=17.14lbs**, which is less than 20lbs and fulfills the design requirement

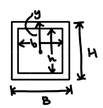
moment_of_inertia = (outer_w * outer_h^3) / 12 - (inner_w * inner_h^3) / 12 **= 1.42e-08 m^4**

moment = F * length + mass * 9.8m/s^2 * length / 2 **= 41.3 Nm**

$\boldsymbol{\sigma_{bending}}$ = moment * radius / moment_of_inertia = **4.37e+07 Pa**

safety_factor = $\sigma_{yield} / \sigma_{bending}$ = **6.31**





FBD & cross section variables

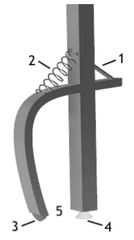
Variables:

outer_w (B) = 0.025 m	length = 0.75 m
inner_w (b) = 0.023 m	radius (y) = B/2
outer_h (H) = 0.03 m	mass = 0.34 kg
inner_h (h) = 0.028 m	F = 53.38 N (F_2)
σ_{yield} (aluminum 6061-T6) = 2.76MPa [2]	

Force analysis was conducted to determine the distance for the trigger and claw while meeting the force requirement for the elderly. Beam analysis was used to find an appropriate width, height, thickness, and length of the arm while assuming a certain mass using aluminum. A safety factor greater than 2 was the analysis goal. Values used in analysis reference averages of current models [3].

Updated Model

The arm features three hollow segments with dimensions corresponding to the analysis and decreases by 0.2cm each time. Each segment can be fitted into each other and is 25 cm long (0.75m/3 from analysis). The rightmost segment is attached to the handle (not pictured) and does not retract.



1. Connects to the end and pulls the claw close
2. Spring that pulls the claw back into the open position after release
3. Magnet for small metal objects
4. Suction cup for flat objects
5. Distance between claw determined through analysis (12 cm)

Conclusions and Future Work

I learned the fundamental steps of engineering design, from developing design requirements and visualizing sketches with prototyping to using calculations to create the final CAD model. While analyzing the arm, I finally understood the applicability of the beam analysis we learned during class. For future work, I would like to conduct further analysis by treating each segment as its own beam to understand how the tool might fail in the connections and considering friction in the claws. Also, my initial goal was to have the grabber tool be retractable while in use, so my next step after this would be to create another prototype using the updated designs and incorporating more sophisticated elements (ex. actual magnet and suction cup instead of representations) to test out the functionalities.

References

[1] https://doi.org/10.1123/japa.16.1.24
[2] https://asm.matweb.com/search/SpecificMaterial.asp?bassnum=ma6061t6
[3] https://www.bobvila.com/articles/best-grabber-tool/