MEMS 411: Compact Sewing Pin Dispenser

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Compact Sewing Pin Dispenser

Sewing pins are small and hard to handle, and managing the pins can be very distracting (or painful) for a sewist. Our goal was to design a simple and easy sewing pin dispenser for a home sewist that can dispense small headed dressmaker pins. For our design to be a viable product, it would have to dispense pins very quickly, accurately, and safely. Additionally, it has to handle many pins at the same time so it does not have to be reloaded during use.

Based on the design of a toothpick dispenser, our prototype small, lightweight, and portable device that manually dispenses pins quickly and easily. The pins are loaded onto a ramp with the head of the pin placed into a rut that guides the pin as it rolls down the ramp. The pins sit at the bottom of the ramp until the user presses down on the lifting mechanism. The lifting mechanism is held up by a spring, but when pressed it drops down to the ramp and allows exactly one pin to roll into a pin-sized slot. The spring then raises the lifter back up for easy selection of the pin by the user.

Loading the pins is somewhat slow and occasionally difficult, but this can be done ahead of time and the dispenser can continuously handle over 50 pins, making pre-loading a reasonable strategy. Our design allows a sewist to maximize efficiency while sewing: a pin can be dispensed in under 3 seconds and easily picked up from the lifter, and with a single digit failure rate the dispenser can be relied on to give you a pin when you need it.

ARMANINO, Nick
LU, Eric
WEINSTEIN, Jacob
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1 Introduction

The goal of our project is to create a sewing pin dispenser that is capable of accepting small headed dressmaker’s pins in any orientation. As one of the main struggles for a sewist lies in being able to grab pins head up without being pricked or dropping those pins, a main priority is that the dispenser is expected to be able to dispense the dressmaker pins head up for easy access. It is also important to the user that the inputted pins are still in good condition (in that they are not bent or dull) by the time that they are dispensed. One of the final priority considerations would be to dispense pins at a reasonable rate, so that work is not stalled by the speed of the dispenser.

2 Problem Understanding

2.1 Existing Devices

2.1.1 Existing Device #1: Pintastic Automatic Pin Dispenser

![Figure 1: Pintastic Automatic Pin Dispenser](https://www.junetailor.com/notions-pintastic-and-pins)

Link: [https://www.junetailor.com/notions-pintastic-and-pins](https://www.junetailor.com/notions-pintastic-and-pins)

Description: The Pintastic Automatic Pin Dispenser is a plastic pin dispenser that can supply the user with a single, large-headed sewing pin by pressing on the plastic tab oriented at the front of
the machine. The device can only be used with sewing pins with a sufficiently large head, and has been on the market for 8 years without a significant impact on the sewing community, due to the machine’s tendency to jam or break.

2.1.2 Existing Device #2: Wawak Magnetic Pin Holder

![Wawak Magnetic Pin Holder](https://www.wawak.com/Cutting-Measuring/Pins/magnetic-pin-holder/?sku=MPC1)

**Description:** There are very few direct competitors to a sewing pin dispenser, but one similarly purposed device is the Wawak Magnetic Pin Holder. This device is a simple concave button shaped device with magnets to hold the metal sewing pins. This device is cheap ($5.99) and can hold pins in a set orientation with a divot that makes them easier to pick up. However, this device is small (about 4” by 4”) and thus can only hold a small amount of pins, and it also cannot reorient the pins for the user.
2.1.3 Existing Device #3: Dritz Magnetic Pin Dispenser

![Figure 3: Dritz Pin Dispenser with a few pins inside](image)


Description: Dritz, who also makes the small headed pins our client uses, also makes a magnetic pin dispenser that claims it can even be used for tacks and paper clips. This device, also more simplistic than the Pintastic, does not orient the pins for easy pickup. This device has a magnetic wheel to get the pins into the tray in an orderly fashion, and has a flip up lid to access the pins. This device also has a limited capacity of around 50 pins, has poor reviews, and does not appear to be actively made by Dritz anymore.

2.2 Patents

2.2.1 Pin Dispensing System and Method

(US20120181299A1)

This patent is for a machine comprised of a spinning drum which sewing pins are poured into, which in turn carries pins onto a storage chute by utilizing a bowtie-shaped "lug" attached to the interior of the drum to collect pins into a specific orientation that will release pins at a point directly above the chute. These pins are stored on the chute until the user presses down on a tab at the end of the storage chute which allows the last pin on the chute to rest on the tab and get lifted upward by the spring underneath the aforementioned tab, allowing easy access to the pin by the user.
2.2.2 Sewing Pin Dispensing Device  
(US006427867B1)

This device utilizes a special housing that allows for the insertion of pins into the device, which fall down a chute into a pathway that leads into a larger cavity containing a specially crafted wheel with notches that can collect the pins. The wheel is moved by an actuator driven by a button at the top of the device. The actuator spins the wheel while also lowering a plate that presses down on the end of the topmost pin, which in turn tilts it upward through a small opening in the top of the casing which allows for easy access to the head of the pin by the user.
2.3 Codes & Standards

2.3.1 EnergyStar - Energy Conservation Guidelines
(10 CFR 430.32(w))

This EnergyStar standards sets specifications for the power consumption of our device in the case that it is plugged into an AC power source. In the case of our estimated 10-50W power range, we adhere to the Nameplate Output Power guideline of $1W < P_{out} < 49W$ where $P_{out}$ is output power. Minimum average efficiency while active is said to be calculated as $\geq 0.071 \times ln(P_{out}) - 0.0014 \times P_{out} + 0.67$. The maximum power in no load mode through the initial nameplate output power guideline is set to be $W \leq 0.100$. As we want our products to be energy efficient household products for both retail and regular use, adhering to Energystar standards provides an extra incentive for customers to try our products.

2.3.2 Standard for Safety for Motor Operated Household Preparing Machines
(UL 982c26.12)

This code for household appliances with rotational, potentially grinding, and electrical components states that the malfunction or breakdown of any single electronic component, located in any circuit of the product, shall not result in increased risk of injury to persons, such as a loss of OFF control or unexpected operation. As we want to make sure that the malfunction of one of our electrical components does not cause a failure in our other control systems, or subsequent catastrophic failure and dangerous destruction of our product, it is important to follow this code.
2.4 User Needs

Sed ut perspiciatis unde omnis iste natus error sit voluptatem accusantium doloremque laudantium, totam rem aperiam, eaque ipsa quae ab illo inventore veritatis et quasi architecto beatae vitae dicta sunt explicabo.

2.4.1 Customer Interview

Interviewee: Mrs. Melanie Heckman  
Location: Zoom Meeting, Washington University in St. Louis, Danforth Campus  
Date: February 2nd, 2021

Setting: We interviewed Mrs. Heckman over a virtual zoom call and asked various questions about her needs for a pin dispenser. We were allowed to see how much space, the size of the pins in question, and more through video call and discussed ideas and concerns. The whole interview was conducted virtually and took 30 mins.

Interview Notes:

How rapidly should the product need to dispense the pins?
- The fastest or most ideal would be around 1 pin per second.
- The slowest acceptable speed would be around 1 pin per 2-3 seconds.

How versatile does the pin dispenser need to be in terms of pin size?
- Pins vary in size
- The most common pins used will be "dressmaker’s pins" which are approximately 1.25 inches long and have a very small head.
- Dispenser should be able to accommodate different lengths and head sizes
- Pin brand is from Dritz-Joann fabrics

What should the dispenser primarily accomplish?
- Pins need to be dispensed head up so that they can be grabbed between the thumb and forefinger with ease
- Pins could also be dispensed sideways but easily accessible
- Pins should be able to be sorted in any orientation, but this is a lower priority than the one listed above.

What is the acceptable wear and tear on the pins?
- Pins bend easily, so the dispenser cannot warp or dull the pins
- If the pins dull or are bent, they are not effective or cannot pierce the fabric

What type of power source is acceptable for the product?
- Either battery power or direct connection is fine

What is the ideal pin capacity of the machine?
- Ideally it can take a standard box of pins, or 350 pins at once.
– The machine should also be able to distinguish between extraneous material

What is the ideal size of the product?
– Needs to be small enough to fit on a table
– Maximum size should not exceed 18 inches by 10 inches surface area
– Pickup height should not be too tall

What are the concerns about noise for this machine?
– Since a sewing machine is often pretty noisy, there are not many noise concerns for this product

How should the product be stored?
– Ideally the dispenser comes equipped with a case to protect from dust
– The sewing machine could also benefit from rubber feet to prevent excess vibration

What is the acceptable failure rate for the pin sorter?
– Keep it minimum, ideally less than 1

How complicated (mechanically) should the machine be?
– Can be more mechanical/less layman friendly given that diagrams are included

Are there any outstanding concerns about the product that have not been covered?
– Make sure that the product does not generate too much heat or be capable of damaging the table
– Pins are magnetic (nickel plated brass)
– Slightly bent pins could be mixed into the input
– Fluff and other material will likely be thrown in and the machine should be able to withstand non ideal conditions.
2.4.2 Interpreted User Needs

Table 1: Interpreted Customer Needs

<table>
<thead>
<tr>
<th>Need Number</th>
<th>Need</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pin is easy to pick up from the dispenser</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Size of dispenser</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Mechanical complexity of device</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Speed of dispensing pins</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Speed of accepting pins</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Noise of dispenser</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Failure rate of pins (dispenses head up is success)</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>Can handle fuzz/thread mixed in with pins</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>Dispenser does not dull or bend pins</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Portability</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>Power source</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>Can be covered for storage</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>Pins can be easily inserted</td>
<td>4</td>
</tr>
<tr>
<td>14</td>
<td>Dispenser can handle slightly varied pins</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td>Handles sharp pins safely</td>
<td>4</td>
</tr>
</tbody>
</table>

Per our client interview, the most important need is that the pin is easy to pick up from the dispenser. The only other need as important as this is that the dispenser does not dull or bend the pins, as this would make the pins unusable over time. Other lower priority needs, like size, power, or noise, are less important to the design, and may have to be compromised on to achieve the top needs.

2.5 Design Metrics

The most important need for this project, that the pins are easy to pick up, is somewhat subjective and not easy to quantify. However, part of the specifications for how easy a pin is to pick up is that it is dispensed head up. The rate of pins that fail to meet this standard can then be measured. Many other needs can also be quantified, as seen in Table 2 below.
Table 2: Target Specifications

<table>
<thead>
<tr>
<th>Metric Number</th>
<th>Associated Needs</th>
<th>Metric</th>
<th>Units</th>
<th>Acceptable</th>
<th>Ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,7</td>
<td>Rate of pins dispensed upside down</td>
<td>avg. fraction</td>
<td>1/100</td>
<td>1/300</td>
</tr>
<tr>
<td>2</td>
<td>2,10</td>
<td>Total volume</td>
<td>ft³</td>
<td>&lt; 5</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>Time between dispensing of pins</td>
<td>seconds</td>
<td>&gt; 10</td>
<td>&gt; 4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>Time between accepting of pins</td>
<td>seconds</td>
<td>&gt; 4</td>
<td>&gt; 2</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>Noise</td>
<td>decibels</td>
<td>&gt; 65</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>Number of uses before pin breaks/-</td>
<td>avg. integer</td>
<td>&lt; 150</td>
<td>&lt; 300</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>No load power</td>
<td>W</td>
<td>none</td>
<td>&lt; .1</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>Rotational/electrical components whose</td>
<td>integer</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>breakdown could be dangerous</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2.6 Project Management

The Gantt chart in Figure 6 gives an overview of the project schedule.
**Design Report**

- Problem Understanding
- Concept Generation
- Concept Selection
- Concept Embodiment
- Design Refinement
- Peer Report Grading

**Prototypes**

- Mockup
- Proofs of Concept
- Initial Prototype
- Initial Prototype Demo
- Final Prototype
- Final Prototype Demo
- Prototype Expo

**Presentations**

- Class Presentation
- Final Presentation

<table>
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<tr>
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<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
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<tr>
<td>25</td>
<td>1</td>
<td>8</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>15</td>
<td>22</td>
<td>29</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>19</td>
<td>26</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 6: Gantt chart for design project
3 Concept Generation

3.1 Mockup Prototype

Our mockup was designed to test some basic principles of the pin sorter. Fastened out of cardboard and tape, our simple design featured a funnel on top that functioned as a well for mass addition of sewing pins. The box below the funnel has a slit roughly the size a single pin oriented sideways, and then a ramp below the box to dispense the pins. This concept is somewhat lacking in a dispenser mechanism, as this proved too difficult for a quick mockup.

The prototype works, but in a limited capacity. By gently shaking the device, pins will slowly orient themselves in a way where they can slide through the slit in the box, and then slide down the ramp into the plastic container. The shaking allows the pins to get through the slit, but can also disrupt the orientation of the pins, so they do not always get into the box in a standard orientation. Additionally, the device is very slow. More complex mechanisms for the pin sorting should be examined.

Figure 7: Top view of Mockup
Figure 8: Side view of Mockup

Figure 9: Front view of Mockup
3.2 Functional Decomposition

This chart breaks down the necessary pieces of dispensing a pin successfully.

Figure 10: Function tree for Sewing Pin Dispenser
3.3 Morphological Chart

This morphological chart sorts out several different solutions for the problems associated with making the sewing pin dispenser.

![Morphological Chart](image)

Figure 11: Morphological Chart for Sewing Pin Dispenser

3.4 Alternative Design Concepts

3.4.1 Plinko Machine (xxx)

Description: The point of the plinko machine is to sort out the needles in the way that a plinko machine usually wins against players by sorting out most of the coins by pushing them to the side. Pins that are not oriented correctly (sideways) will be stopped before entering and shaken by the rotating funnel until oriented correctly. Those in the wrong head/tail orientation will be corrected either by placing foam under the apparatus and allowing only the needle down pins to stick or a dispensable magnet that allows pins to be grabbed from the head easily.
3.4.2 V-Funnel

Description: The V-funnel machine allows for continuous sorting of the pins through a system that will result in the pins landing in a v-shaped funnel that will orient the pins such that each pinhead will face one of the two ends of the funnel. The funnel will rock back and forth, sliding the pins so that one end will collect pins by having the pinheads catch the lip of the funnel, locking them in place, while the other end dispenses into a collection tub where pins are sent through a
transportation system to be re-dispensed into the V-funnel, with the process repeating indefinitely until no pins are left uncaught.

Figure 14: Preliminary sketches of V-funnel concept
3.4.3 Wheel-Slide concept (xxx)

Description: The pin goes through the Wheel-Slide concept through the funnel at the top. In order to sort the pins by proper orientation, the wheel underneath the funnel has a slot for the pinhead that will only allow pins with their head to the front of the wheel to go into the slide. The pins travel through the slide to a transitional piece below. This piece rotates the pins from horizontal to vertical so they can go into the conveyor belt, point down. The conveyor belt rotates the pin to
the front, where it can be picked up by the head. A motion sensor at the end stops the conveyor belt when a pin reaches the end, much like a grocery store checkout conveyor.

Figure 16: Sketches of Wheel-Slide Mechanisms
Figure 17: Wheel-Slide Mechanism Concept
4 Concept Selection

4.1 Selection Criteria

We chose our selection criteria based on the needs of the customer. As the main concerns were that the dispenser dispenses quickly and accurately, we were sure to include those criteria in the AHP. In addition, the customer was sure to mention that the dispenser could not damage the work space and that it be as easy to input needles as possible. Although ease of operation was not a primary concern, it would be better if the dispenser was easy to understand and use. Therefore, we are left with the 5 criterion seen below.

![Figure 18: Analytic Hierarchy Process (AHP) to determine scoring matrix weights](image)
4.2 Concept Evaluation

<table>
<thead>
<tr>
<th>Alternative Design Concepts</th>
<th>Plinko Machine</th>
<th>V-Funnel</th>
<th>Wheel-Slide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection Criterion</td>
<td>Weight (%)</td>
<td>Rating</td>
<td>Weighted</td>
</tr>
<tr>
<td>Dispenses Quickly</td>
<td>23.94</td>
<td>4</td>
<td>0.96</td>
</tr>
<tr>
<td>Dispenses Accurately</td>
<td>30.62</td>
<td>2</td>
<td>0.61</td>
</tr>
<tr>
<td>Easy to Operate</td>
<td>2.67</td>
<td>3</td>
<td>0.08</td>
</tr>
<tr>
<td>Safety Insulated</td>
<td>28.39</td>
<td>4</td>
<td>1.14</td>
</tr>
<tr>
<td>Input in Any Orientation</td>
<td>14.39</td>
<td>3</td>
<td>0.43</td>
</tr>
<tr>
<td>Total score</td>
<td>3.217</td>
<td></td>
<td>2.098</td>
</tr>
<tr>
<td>Rank</td>
<td>1</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 19: Weighted Scoring Matrix (WSM) for choosing between alternative concepts

4.3 Evaluation Results

The plinko machine was selected as the best concept by the scoring matrix, but we have already identified universal weaknesses in our designs and continued to iterate through the design process. The plinko machine won because it scored well for speed, safety and simplicity, with a weakness in the dispensing mechanism. However, we came to a new dispensing mechanism modeled after an automatic no-touch manual toothpick dispenser. This dispensing mechanism is more practical and simple than most of our designs, and is designed to effectively dispense small rods one at a time. This mechanism would allow us to separate the processes of dispensing and sorting the pins, which was not as easily possible before because the design of our dispensing mechanisms was heavily dependent on the orientation of the pin from the sorting process. With this new concept in mind, we can work on creating a mechanism to manually sort the pins effectively and quickly, while continuing to develop the new dispensing mechanism.

4.4 Engineering Models/Relationships

The following engineering models were chosen in relation to the alternative concepts provided. As our alternative concepts included a multitude of electrical, magnetic, and mechanical components, we decided to use the following models as consideration for our future design.
This magnetic force diagram clearly shows the forces that would be exerted on the pins if two magnets were set up in an effort to dispense the pins with correct orientation. In the diagram above, B represents the magnetic field, F represents the Force, v represents the velocity by the object, q represents the charge of the pins moving through the field.
For the designs that involve a rack and pinion to raise a sewing pin up from a container to be collected by a user, the torque that must be produced by the motor attached to the gear in order to lift a pin up can be modeled as $\tau = r \times F$, where $\tau$ is the torque, $r$ is the radius of the gear, and $F$ is equivalent to the combined weight of the pin and the lifting mechanism.
Creep, which is deformation under consistent stresses, can occur under repeated cycles of stress lower than the yield strength of the material. As shown in the figure above, creep has three stages: primary, where the rate of creep decelerates, secondary, when the rate of creep plateaus, and tertiary, when the rate of creep accelerates. The equation for creep is \( \epsilon_{\text{creep}} = A\sigma^n e^{-Q/RT} \), where \( \epsilon_{\text{creep}} \) is the rate of creep strain, A is a constant, n is the stress exponent, Q is the activation energy, R is the universal gas constant, and T is the temperature. In a device like ours that will continually undergo cycles to sort and dispense pins, creating a device that will last long and survive creep is important.

5 Concept Embodiment

5.1 Initial Embodiment

The prototype has the following three prototype performance goals:
- Prototype can handle 50 pins at once
- Sorting mechanism can successfully sort 9 out of 10 pins
- Dispenser can dispense at least 1 pin every 3 seconds

5.2 Proofs-of-Concept

Initially we believed that we could create a sorter-dispenser combo in which pins could be inputted in any orientation into a V-shaped funnel and allowed to fall down a ramp to the dispensing area. However, we soon found that dispensing and sorting such small pins would be extremely difficult. The pins were so small that they were very liable to dull, bend, and break while in the sorting mechanisms hypothesized - even when sorted correctly, the precision needed to have the small pin fall into a rut to roll down a ramp was too unrealistic. Pins also had difficult time rolling down smooth and rough ramps without the help of a precise rut (incidentally included in our current design shown below, but at the sacrifice of mass sorting capabilities) without rotating or displacing other pins once it hit the bottom. Therefore, our prototypical design was modified to fit only a few dozen pins and inputted one at a time to ensure accurate dispensing. Our future prototypes are expected to handle more pins, sort and dispense more accurately, and allow bulk input loading.

Our selected concept was the "Plinko Machine" as seen in section 4 of this report. Similar to the final design, the Plinko Machine idea used ruts to sort out pins vertically before placing them into the dispensing area. However, after proof of concept testing, we realized that rolling or sliding pins down both smooth and rough ramps were notoriously unreliable. Therefore, we modified the design to have one rut for single loading purposes in the dispensing area only (after removing the sorting mechanism to be reworked for future prototypical designs). Preliminary testing also revealed the infeasibility of a rotating funnel to sort the pins, as the small and easily tangled nature of the pins ensured that pins would bend, break, and jam the sorter if designed the way that the Plinko concept had indicated. In addition, since the pins themselves are so small, the pin holes needed would be within tolerance expectations for most 3D printing machines; larger holes would ensure that the pins would fall at different angles and become unsorted as soon as they exit the sorting mechanism. Preliminary testing also revealed the unreliability of a large magnet to keep pins oriented before they were dispensed. Despite the deficit of making the pins harder to pick up than if they were laid out on a smooth surface, the pins were often unpredictable in what orientation they stuck to the magnet. Overall, the design was almost wholly reworked in favor of a mechanically simpler and user friendly design.
Figure 23: Assembled projected views with overall dimensions
Figure 24: Assembled isometric view with bill of materials (BOM)
Figure 25: Exploded view with callout to BOM
6 Design Refinement

6.1 Model-Based Design Decisions

The most obvious engineering model that we will be using with our design is most likely a spring model. In order to make our pins accessible for the user without two handed operation, we incorporated a spring with the dispensing mechanism so that our dispenser would be normally in the upright position until pressed. The dispenser would catch a pin and then raise back up with the help of a spring once the lever is no longer pressed. In order to do this, we needed a kinematic model, mechanical spring model, and oscillating spring model to ensure that pins did not fly off the dispenser once the spring became fully extended, springs had the right k constant, and that the dispenser did not oscillate significantly once the springs had reached its end point.

\[
F_{spring} = -kx
\]

Figure 26: Mechanical Spring Engineering Model: Hooke’s Law

F\text{ spring} \text{ represents the force of the spring, } k \text{ represents the spring constant, and } x \text{ represents the displacement of the spring from its resting point. From this model, we can both figure out the forces on our pin as it is dispensed. We want to make sure that the normal force exerted upwards as a result of the force of the spring on the dispenser (and subsequently on the pin itself) is not larger than the weight of the pin itself.}
Therefore, the effective spring constant must be below the value calculated above. This can be achieved with a system of springs if a spring with this specific constant or below is unavailable.

We can also consider a separate model for our spring dispenser mechanism, which would be to ensure the spring does not oscillate at a frequency that would disrupt our dispensing mechanism. Therefore, it would also be important to consider the oscillation of a spring once the lever has been depressed then released.

\[ \omega = \sqrt{\frac{k}{M}} \quad \text{where} \quad \omega = 2 \pi f. \]

\( \omega \) represents the angular frequency, \( k \) represents the spring constant, and \( M \) represents the mass.
of the load at the end of a spring. From this model, we can figure out what spring to use so that our oscillating frequency is at an acceptable level that will not disrupt the operation of our sewing pin dispenser. A calculation for our mechanism is shown below.

![Figure 29: Oscillating Spring Engineering Model Calculations](image)

\[ \omega = \sqrt{\frac{k}{M}} \text{ where } \omega = 2 \pi f. \]

Figure 29: Oscillating Spring Engineering Model Calculations

From these calculations, we can see that spring value of 0.01 or lower would be acceptable in managing the oscillating frequency of the spring so that it would not disrupt the whole mechanism. Note that certain assumptions are made in that we are treating the pin as a fixed, non-moving mass at the end of the spring. In addition, we are also assuming that the spring is perfect and that the displacement will be steady at 0.02m every time. We are also assuming that the lever is released from the bottom and that the user will not apply negative work on the lever during operation.

### 6.2 Design for Safety

Sed ut perspiciatis unde omnis iste natus error sit voluptatem accusantium doloremque laudantium, totam rem aperiam, eaque ipsa quae ab illo inventore veritatis et quasi architecto beatae vitae dicta sunt explicabo.

#### 6.2.1 Risk #1: Launched Pins

**Description:** Since springs are not usually sold at such small spring constants, it is possible that the pin will be launched with a sufficient spring.

**Severity:** Marginal

**Probability:** Occasional

**Mitigating Steps:** A system of springs will be designed with the necessary equivalent spring constant in order to ensure the pins are not launched, as per the engineering models above.
6.2.2 Risk #2: Finger Injury

Description: Due to the nature of the pins themselves, the user may prick their finger when picking up the pin.
Severity: Marginal
Probability: Seldom
Mitigating Steps: Steps have been taken to design the dispenser so that it is unlikely to prick your finger while picking up the pins from it. As the dispenser is designed so that users will pick up the pins from the middle and then transition to the head, while the pointy end is covered by plastic, the user will be unlikely to injure themselves.

6.2.3 Risk #3: Dispenser Jam

Description: In the event that a pin or something otherwise gets lodged in the device and the dispenser jams.
Severity: Critical
Probability: Seldom
Mitigating Steps: The dispenser section has been designed to fit with tight tolerances to the rest of the parts. Therefore, it’s very unlikely that a pin will get lodged and break the whole device.

6.2.4 Risk #4: Pins stack and are placed out of orientation

Description: Pins rolling down the ramp at sufficient speed will skip the groove and settle over other pins, causing the dispensing mechanism to malfunction from time to time if the pins are not correctly oriented.
Severity: Marginal
Probability: Likely
Mitigating Steps: As more pins are added to the dispenser, this becomes more likely. The groove that was designed on our ramp to hold pin heads as they slide down was a countermeasure to pins roughly stacking on top of one another.

6.2.5 Risk #5: Lever break

Description: Too much force applied to a 3D printed lever would cause the lever to snap and break, rendering our dispensing mechanism useless.
Severity: Catastrophic
Probability: Unlikely
Mitigating Steps: It is unlikely that a user exerts enough force to snap the lever off of our device unless the action is intentional. The lever and anchoring point have been made extra thick, however, as a countermeasure against excessive force and breaking.
The heat map seems to suggest that four of our five concerns be treated with equal weight, which would be in the circumstances of a lever break, an orientation issue, launched pins, and dispenser jams. Our fifth concern, a finger injury as a result of the dispenser, is recommended to be a second priority. As most of these concerns have already been mitigated and the design has been changed as a result of these concerns, the heat map seems representative of what remaining problems we should focus on. This way, we can choose to work on our spring, orientation, and material problems that would cause the first priority of risks.

### 6.3 Design for Manufacturing

This design has 6 3D printed components, 4 suction cups, and a spring, for a total of 11 components excluding fasteners. There are 4 fasteners for the design. For TNCs, there is the main base with ramp, lifter, spring, and the suction cups. The lifter must be separate from the ramp so it can move. The spring and suction cups must be made of different materials than the rest of the assembly. There are a few unnecessary pieces beyond our TNCs in our assembly, these being 3 rods
and the walls. The rods were printed separately for flexibility: these are a newer design element and we are not sure if they are necessary, so printing them separately gives flexibility to test with and without them. The ramp and walls were made to be separate components for prototyping functioning: by printing the ramp with its flat side on the print bed, the ramp comes out much smoother and makes it much easier for the pins to roll down the ramp. In a proper manufacturing process, these pieces could be combined, and this would also eliminate the need for the 4 fasteners. If the rods are necessary for the final design, they too could be attached to the main ramp, and remove these 3 as extra components beyond the TNCs.

6.4 Design for Usability

At the moment, we have no color coded mechanisms in our device that could cause a decrease in the usability of our device. We will most likely paint our lever to be a different color than the rest of our device in order to clearly signal to our users where the lever will be, but as long as we don’t use a red-green type of coloring we believe usability should not be decreased. As our dispensing idea will most likely have the pin presented sideways and on a dispenser, it is important to have the dispenser be a drastically different color than the metallic pin, and unlikely to encounter colorblindness concerns as well.

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If the person using the dispenser suffers from ticks, muscle weakness, or something such as Parkinson’s, it is unlikely that they will be using the dispenser because they would not have the motor function to sew or tailor as needed. However, our design will implement a wide dispensing area so that any dispensed pins can be easily picked up.

We will make sure that the dispensing area and the mode of operation for our dispensing machine is an easy press lever mechanism and provide for easy pickup from the middle of the pin. From that position, a user can transfer their grip to the head of the pin with no issues. That way, any control impairment will not result in a user giving themselves small injuries.

7 Final Prototype

7.1 Overview

Our final prototype ended up being different than our initial designs laid out in earlier sections in a number of ways. First, we pivoted away from our initial idea to use a motor-driven system as the mechanism to lift the sewing pin off of the ramp, opting instead for a manual, spring-driven design. This led to some drastic redesigns being necessary for the piece that actually holds and lifts the pins, as well as the front half of the ramp piece in order to support such a mechanism. Our resulting prototype was made up of five primary parts. The main body of the prototype is the ramp, which hasn’t changed significantly in it’s design except for adjusting the front end to fit the newly modified lifter. This lifter collects the pin at the bottom of the ramp via a manual, user-driven process. Initially the lifter is held in a raised position by a spring located underneath the lifter that is held in place by a rod that goes through the center of the spring and fits snugly in a hole in the center of the lifter. The front of the lifter is flat and holds flush against the ramp so that pins are braced against the lifter’s front when it is on standby in the upright position. The
wall (which also hasn’t changed significantly from previous iterations save for a hole in the front that that lifter handle goes through) holds everything together, and also serves to constrain the upward displacement of the lifter by the spring. When the user wishes to dispense a pin, the user may grab the ergonomically designed handle that is attached to the lifter (see the images below for reference) and press down, compressing the spring and allowing the small notch at the top front edge of the lifter to collect a single pin. Once a pin falls into the notch, no other pins can fit due to the intentionally small size of the notch. By releasing pressure on the handle the lifter is pushed into its upright standby position, raising the pin a couple inches above the top surface of the dispenser to allow for easy collection.

7.2 Documentation

Our final prototype is shown as follows in a front view, side view, and top view.

![Final Prototype Front View](image)
Figure 32: Final Prototype Side View
As seen above, our prototype followed the prototype design goals that were established for this project and were able to mostly meet each expectation. However, it should be noted that the word "quickly" in our third prototype goal, which states that "the device should quickly accept 50 pins at once," was not entirely met. Our pin loading mechanism remained slow and without a sorter, but remains useful in a setting where the sewist is willing to invest some time for future efficiency.

The following final prototype exploded view is added for further reference, so that the construction of our final concept sewing pin dispenser can be viewed in greater detail.
It should be noted that some of the major differences between our proposed prototype and the final prototype shown above lies in the spring mechanism used to activate the dispenser, as well as the suction cups that were added to the design to mitigate any unwanted forces on the dispenser as a result of a mechanical method of dispensing. Another noteworthy point lies in the design of the lever itself - once switching to a mechanical loading method (as opposed to motion sensor or motor generated), an ergonomic grip was installed on the lever in order to ensure an easier grip. Pieces fit comfortably together and the design is made to be easy to install. As only four screws need to be placed into the setup in order to ensure success, assembly is far from difficult.

7.3 Conclusion

We believe that our sewing pin dispenser is a success and performs all of the feats that were asked by our client. Although a more automated process was initially proposed, we believe that the complexity required for automated sorting and dispensing was far too much considering the restrictions of the project. Our dispenser works as intended and can be used for practical purposes. To compare to a current counterpart, a pincushion would be able to hold a significantly lower amount of pins and require a larger amount of focus in order for operations during sewing. With our mechanical dispensing and minimal focus method of dispensing, we believe our prototype is superior to traditional, currently available "dispensers."