



Our solution to the issue of bikes being so vulnerable to having different components being removed and stolen, is a customizable combination lock that replaces the standard hex nut on the axle of a bike wheel. This lock rotates freely about its center and around the axle itself. It will provide absolutely no leverage to be unscrewed until it is locked in place once the correct combination is entered. Thus, the tire can only be removed by the bike's owner, no one else.

BIKE BOLT

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Problem Statement

A serious problem is posed for anyone that owns a bike and uses it to commute. Since the 1920's, when modern road bikes were popularized, consumers have been forced to deal with bike theft. People are at risk of losing the different components of their bike, such as their tires, seat posts, and handlebars. Since these parts are simply screwed onto the bicycle, they are vulnerable to any common thief with an Allen wrench. This problem is especially prevalent in dense cities and college campuses.

Justification

College students are 53% more likely to have their bicycles stolen, especially on UC campuses. Additionally, according to the FBI, "1.5 million bikes are stolen every year" and 76% of those thefts are of just its components, costing people "worth some \$50 million" dollars annually. This is a significant issue communities face since it costs people so much money, hurts the bike industry by discouraging people to invest any further, and eliminates an eco-friendly method of transportation.

Similar Solutions

- Specialized Keys
 - Nutlock
 - Pro: deterrent to thieves
 - Con: wrench can be jammed into grooves
 - Delta Cycle KnoxNut
 - Pro: no key needed
 - Con: parts jam easily
- Mobile Locking Parts
 - Kryptonite Gravity Line
 - Pro: no key needed
 - Con: parts jam easily



Attack Points

- Ensure it spins freely initially
- Ensure it locks successfully on combo
- Prevent jamming
- Ensure indestructibility as protection from thieves

Final Prototype



FIGURE 1: Exploded view of the final prototype; total of 3 pieces that will be glued together.

- Combination Lock Cap
- Rotating Inner Shell
- Threading Insert



FIGURE 2: Frontside view of bike bolt on an actual bike wheel.



Build Documentation

MATERIALS

- Combination Cam Lock
- Presta Tire Valve Adapter
- Drill Press
- Lathe
- Hacksaw

PROCEDURE

- Remove excess parts (latch and screws)
- Saw lock housing to fit tire axle
- Glue insert to inner shell
- Reverse shape of locking pins underneath dials



Testing Procedure

FIRST TEST

- Set a timer for 3 minutes
- Within that time, attempt to break the lock and remove the wheel
- Repeat the procedure for 3 trials but use different tools
 - First Trial: Allen Wrench
 - Second Trial: Bolt Cutters/Pliers
 - Third Trial: Hammer

SECOND TEST

- Scramble the combination
- Enter correct combination and unscrew bolt
- Repeat for 3 trials

Sketches/CAD File



FIGURE 3: Initial sketch of possible prototypes

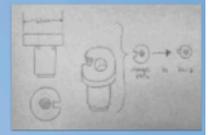


FIGURE 3.1: Sketch of locking pin shape reversal



FIGURE 4: CAD File of outer shell

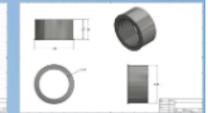


FIGURE 4.1: CAD File of threading insert

Modifications

- Make the tire axle's diameter adjustable
- Find a threading insert that will fit more smoothly into the rotating inner shell

Expert Credentials

Throughout this project we consulted...

- J. Lucas Elrath
 - Bike Component Manufacturer w/ Trek
- Eric Renick
 - Helen's Cycles employee
- Mike Davis
 - Helen's Cycles store manager

Conclusion

After testing different theft methods it is clear that the adhesive between the threaded core and outer shell must be stronger. The locking mechanism of our device is consistent and need not be changed. Our initial user feedback demonstrates that vast majority of people have confidence in our device. Meaning we will likely have a strong customer base to appeal to. Additionally, we were pricing our BikeBolt at \$35 but after user feedback will lower it to \$30.

Test Results/Stakeholder Feedback

FIRST TEST RESULTS:

- Allen wrench failed to remove threaded lock from tire axle
- Bolt cutters damaged lock shell but did not remove lock from axle
- Hammer broke lock but threaded core remained affixed to bolt keeping tire in place

SECOND TEST RESULTS:

- Combination consistently worked on lock even after scrambling



FIGURE 5: 74% of 58 surveyed were mid to highly confident in BikeBolt's ability to secure their bike



FIGURE 5.1: Around 70% of those surveyed believe \$20-\$30 dollars is a reasonable price



BikeBolt

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CONSEQUENCES OF THE PROBLEM



JUSTIFYING THE VICTIMS

- Anyone With a Bike
 - “1.5 million bikes are stolen every year”⁵ - **FBI**
 - 76% of thefts are of just the COMPONENTS⁷
 - Commuters, professional cyclists, and kids
- Theft Varies Between Areas
 - Small cities and college campuses (UC)
 - College students have a 53% of theft (greatest chances)⁷
- Its Significance
 - Bike Industry is hurt b/c of risk factors¹
 - Bikes “worth some \$50 million”¹ lost by riders annually - **Bicycle Law**
 - Only method of transportation for some people
 - “It can wipeout a livelihood”⁷ - **LA Times**

COMMON SOLUTION

- Cyclists may use multiple locks to secure all parts
- Creates the major inconvenience of carrying more weight
- Companies profit from this problem b/c of a high demand for locks
- KRYPTONITE even encourages purchasing more than one⁶

FRAME REAR AND FRONT WHEEL TWO U-LOCK METHOD:

This method is highly effective and uses two, typically primary locks, either chains, u-locks, or a combination of the two. One of the locks secures the rear wheel and the frame to the immovable object, while the other lock secures the front wheel to the frame.



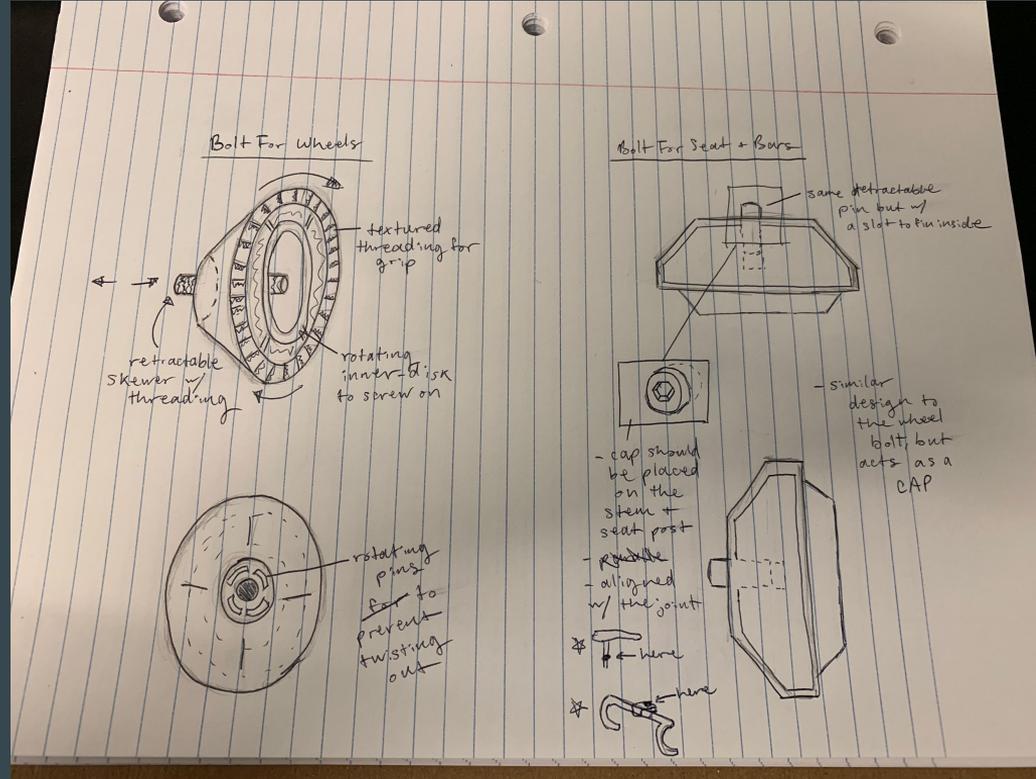
UNCOMMON SOLUTIONS

- Specialized Nuts
 - Only unlocked by a specific key
 - NUTLOCK
 - DELTA CYCLE KNOXNUT³
- Mobile Locking Components
 - Interior pins that slide up and down
 - Pins prevent the nut from being untightened when upright
 - KRYPTONITE GRAVITY LINE⁴



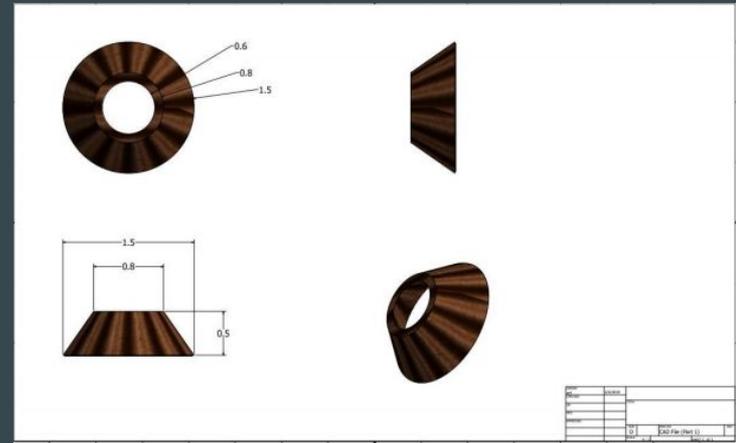
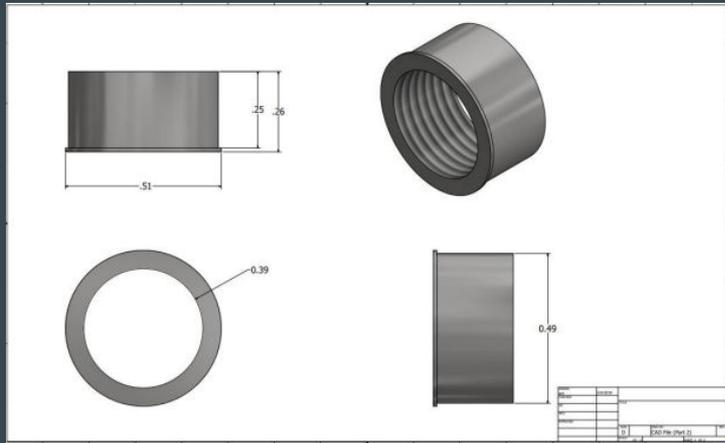
OUR SOLUTION

As our initial solution, we plan to construct a specific type of bolt that will be able to fit onto the wheel axles and handlebar stems. The wheel bolt is unscrewed by an axle that retracts and becomes somewhat flush (inaccessible) when locked. The joint bolt will be the same design but in a smaller size that fits onto the bike stem.



Implementation:

The first step is to use autodesk inventor to create a 3D model of our sketch, and we'll dimension it to fit bike parts (Wheels, Seats, Handlebars, etc.). From this point we hope to use the 3D printer to carefully test the prototype before we transition into a more expensive metal material. We'll most likely use steel parts for its high tensile strength and low cost. If we decide to keep steel as our material, we will consult our mentors and probably go to a machining shop to make the final product.



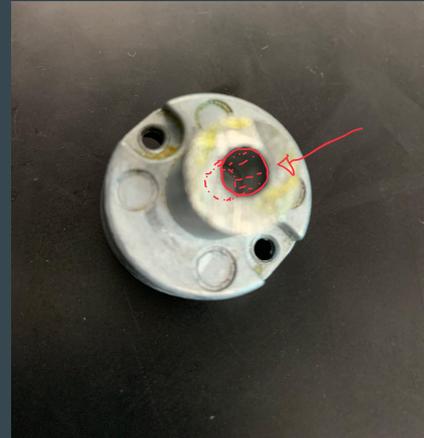
Prototype Construction: Materials

- Combination CAM Lock
 - Number dials, springs, axle, and metal housing component
- Threading Insert for Lock
- Hacksaw
- Soldering Iron
- Lathe or 3D Metal Printer



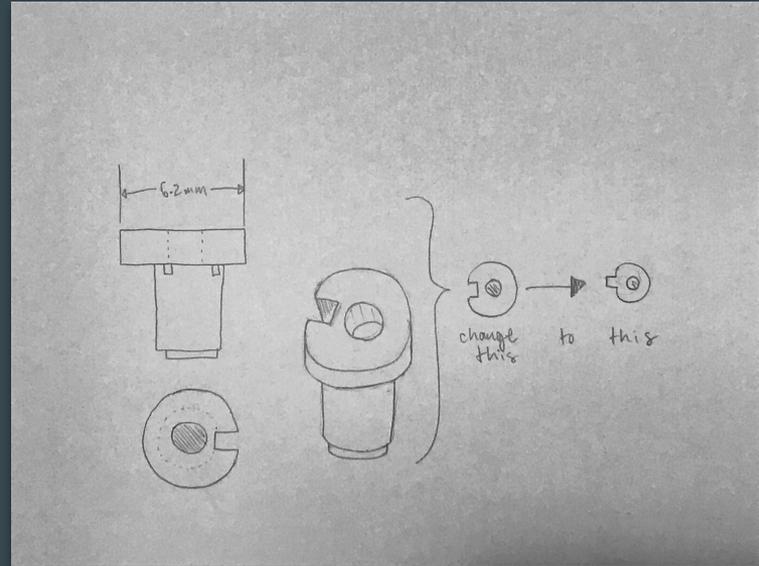
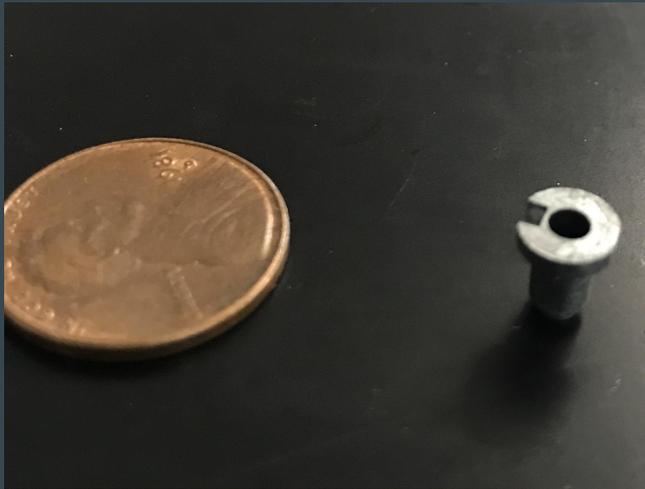
Prototype Construction: Repurposing

- CAM Lock provides a combination piece that has its only way of being unscrewed rotate around its center
- The housing of the lock slips right onto the axle of a tire hub
 - Thus, it isn't a problem to fit it onto a bike



Prototype Construction: Procedure

- Use a hacksaw to cut off about 1 cm of the lock housing's shaft
 - Done to ensure it fits the tire hub axle
- Recut pins inside number dials with a lathe to yield one tooth
 - Done to make it lock everywhere but the correct combination
- Glue in the threading insert on the inside of the shaft
 - Done to ensure it screws on to axle





Testing Plan

- Purpose:
 - Make sure lock can't be broken, and to ensure wheel can't be stolen when lock is secure on the wheel
- We'll test durability and steps of locking process
- Consulting
 - Helen's Cycles and Robson forensic will critique us



Testing Plan

- Goal of Tests
 - Ensure indestructibility of lock, prevent lock jamming, and that it locks successfully
- Procedure
 - Run 3 trials of using different tools to try and break into the lock for a maximum of 3 minutes.

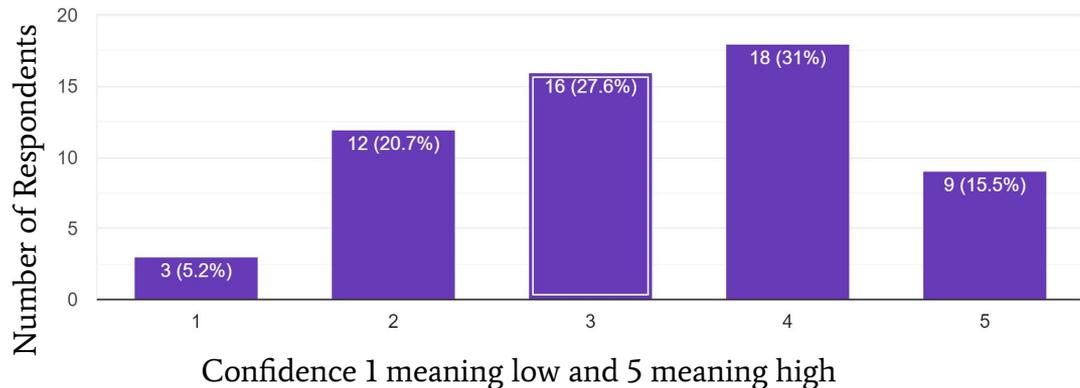


- Avoid using too many moveable parts during assembly, and apply grease.
- Scramble the combination, check that the wheel is locked, enter correct combination, open, repeat for 3 trials.

Testing Results

How confident are you in BikeBolt's ability to secure your bike?

58 responses

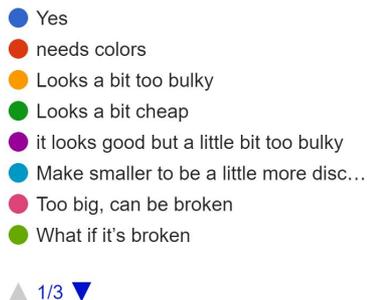
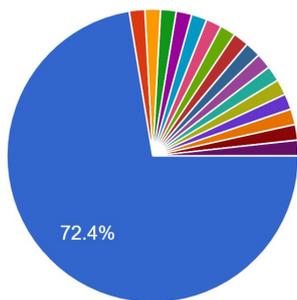


As a security device it is a good sign of user trust that almost half of those surveyed are extremely confident in BikeBolt's ability to secure their bike.

Testing Results

Do you like look of the BikeBolt design? If no please add a modification.

58 responses

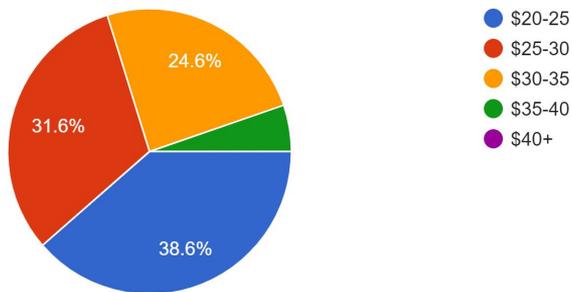


- “Studies have proven that creating good aesthetics in a product leads to better usability and user experience.” [Link](#)
- With 72% of respondents liking the look of our prototype we expect higher user satisfaction
- People like the aesthetics

Testing results continued

What price range seems most reasonable to purchase 1 BikeBolt

57 responses



We were originally pricing our BikeBolt at around 35\$ a unit. However, after gathering the opinions of our survey takers, we might lower it to \$25 or \$30 since that's the price at which the most people are willing to purchase one at.

Testing results continued continued

- Run 3 trials of using different tools to try and break into the lock for a maximum of 3 minutes.
 - We have not threaded the inside of our lock to affix to a bike axle yet. However, we have tested the durability of the lock's aluminum shell. The shell is resistant to blunt force and prying techniques. Additionally, the lock's screws are found on the underside of the lock which makes them accessible when flush against the bike axle.
- Avoid using too many moveable parts during assembly, and apply grease.
 - Have not added any additional moving parts only removed those unnecessary like the cabinet latch and coordinating bolt found below.



Testing Results Continued Continued

- Scramble the combination, check that the wheel is locked, enter correct combination, open, repeat for 3 trials.

→ The combination has been tested on all three locks, then changed and tested again multiple times. Once the combination is known there is no problem entering it and opening the lock.



REFERENCE

- 1.) *“About Bike Theft.” BicycleLaw.com, www.bicyclelaw.com/bicycle-safety/about-bike-theft/.*
- 2.) *“Anti-Theft KnoxNut Security Skewers.” Delta Cycle, deltacycle.com/KnoxNut-Security-Skewer.*
- 3.) *“Delta Cycle KnoxNut Skewer Set with Key.” Amazon, Amazon, www.amazon.com/Delta-Cycle-KnoxNut-Skewer-Set*
- 4.) *Kryptonite Locks. “Introduction to the Kryptonite Gravity Line.” YouTube, YouTube, 19 Oct. 2015, www.youtube.com/watch?v=Hu5CqtJlbHw.*
- 5.) *National Bike Registry - Prevent Theft: Register Your Bike in the NBR Database!, www.nationalbikeregistry.com/theft.html. Nutlock. “Nutlock.” Nutlock, nutlock.co/*
- 6.) *“Proper Lockup Bicycle.” Home, Kryptonite, www.kryptonitelock.com/en/proper-lockup-landing/bicycle-lock-up-bike.html*
- 7.) *“Why Are Cities Allowing Bicycle Theft to Go Virtually Unpunished?” Los Angeles Times, Los Angeles Times, 21 Apr. 2017, www.latimes.com/opinion/livable-city/la-ol-bicycle-theft-20170421-story.html.*

ABSTRACT: A serious problem is posed for anyone that owns a bike and uses it to commute. Since the 1920's, when modern road bikes were popularized, consumers have been forced to deal with bike theft. People are at risk of not only having their entire bike being stolen, but also of losing the different components of their bike, such as their tires, seat posts, and handlebars. Since these parts are simply screwed onto the bicycle, they are vulnerable to any common thief with an allen wrench. This problem is especially prevalent in dense cities and college campuses. College students are 53% more likely to have their bicycles stolen, especially on UC campuses. Additionally, according to the FBI, "1.5 million bikes are stolen every year" and 76% of those thefts are of just its components, costing people "worth some \$50 million" dollars of property annually. This is a significant issue communities face since it costs people so much money, hurts the bike industry by discouraging people to invest in it any further, and eliminates an eco-friendly method of transportation. Our solution is a combination lock that acts as a replacement for a standard bolt on a wheel axle. This lock rotates freely until the correct combination is entered and then it locks in place. This will provide leverage to unscrew the bolt to only the owner of the lock with the customized combination in mind, and therefore allows for total personalized security. After testing its durability and functional consistency, the bolt has proven to be secure for consumer use. Some next steps might include making the size of the bolt somehow adjustable to fit different types of bikes (road, mountain, hybrid, etc.).



PROTOTYPE CONSTRUCTION: In constructing the prototype we took a cabinet combination lock and removed excess parts(latch and screws). We then hack sawed the lock housing to allow the lock to fit to the wheel axle. We then used a powerful adhesive to affix a threaded insert into the outer shell of the lock, allowing the outer shell of the lock to snugly screw onto the bike axle. Lastly, we reverse engineered the pins inside the lock to make the lock housing spin freely unless combination is inputted.



| <u>Factors Tested For</u> | <u>Results</u> |
|------------------------------------|--|
| People's attraction to the product | People were confident in the Bike Bolt's ability to secure the bike |
| Durability | When a hammer, hacksaw, and allen wrench were used to try and disable the bolt, it maintained its structural integrity |
| Consistency | Bike bolt locked and unlocked 3 times in a row without any issues |