Paper ID #40431

Auto Dispensing Cooler

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Dispensing Cooler

03/3/2023

Executive Summary

The purpose of this project is to design a cooler that can dispense drinks at any event, while remaining easy to use for everyone. To cool down, people need ice cold beverages kept in a cooler where they are hanging out, but all too often they run into inconveniences with the standard cooler design, such as difficulty carrying it and having to dig through the ice to find their beverages. The motivation behind this engineering design capstone project is to design a cooler that solves these problems. In order to successfully do that, market research was needed which was performed in the shape of a survey. From the results found in the survey and other research, a governing list of constraints and evaluation metrics was generated which heavily influenced the design generation and evaluation. Paired with the market research, research into the background and the current state of the art was conducted on the coolers that exist currently. The generated designs were evaluated within a weighted Pugh's method structure to determine the most viable solution.

From the evaluation, a design was selected and has been expanded upon. This project has been developed into a backpack style cooler that uses electrical components to dispense the beverages. By implementing the backpack option, transportation of the cooler and the beverages inside will be easier than it would be if it were the typical ice chest style cooler. This is achieved by being able to carry the bag on your back rather than in your hands, as well as the load of the bag being on your back rather than in your arms will reduce the strain.. The electrical components are used to implement an auto dispensing method for the dispersal of the drinks. Rather than taking the backpack off, opening the large top pocket, and rummaging around for the drink, one of three buttons will be pressed which will prompt the corresponding motor to rotate and drop the drink out onto the dispensing ramp. From the ramp the drink will roll down to a velcro pocket on the side of the bag where the user can simply reach back and open the pocket to retrieve their drink. This design will fill the customer's need for an easier method of transportation, as well as easier dispensing while also limiting the heat transfer into the cooler.

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Problem Definition

Scope

The purpose of this project is to design a cooler that can dispense drinks at any event, while remaining easy to use for anyone.

One of America's favorite things to do during the hot summer days is have big campfires and cookouts. To cool down, people need ice cold beverages kept in a cooler out where they are hanging out. For the 4th of July, the biggest day of cookouts for America, $1.6 billion is spent on beer and wine alone [1]. Camping also necessitates the use of coolers. In 2020, 47.94 million Americans went on some sort of camping trip [2]. These factors, as well as the many other events which would require coolers, brings the value of the cooler market to close to 5.8 billion dollars [3]. Which is projected to continue to increase another 5% until 2028. There is clearly a large market for coolers, and some of the competition can be seen in the state of the art section.

Background

Coolers work simply by reducing convection and conduction, which can be seen in Figure 1 [4].

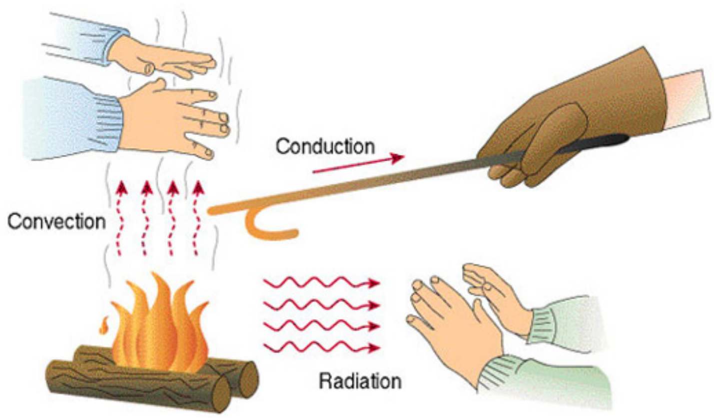

Figure 1: Modes of Heat Transfer

Convection is energy transferring from one medium to another, similar to the way you can put your hands near a fireplace and feel the warmth from the fire heating your hands through the air. Conduction is energy moving through a medium, the way that an entire metal bar gets hot if one end is left in the coals. Coolers do this by using insulation in the walls to lower the speed at which energy can pass, and maintaining a low temperature where the drinks are so the temperature difference is low.

Consideration was taken into potential stakeholders and they can be seen in Appendix A. Along with stakeholders the information applied to this project learned from previous courses is included in Appendix B.

State-of-the-Art

Many coolers currently exist on the market. Notable cooler brands such as Yeti, Igloo, Pelican, and Grizzly all offer adequate solutions but do not address the problem we seek to solve.

Yeti, for as good quality coolers as they are, all use the same open top design. However, Yeti is known for its especially effective insulation and high price. The Yeti Tundra Haul is a prime example of the Yeti coolers and can be seen in Figure 2 [5].

Figure 2: Yeti Tundra Haul Cooler

This cooler comes equipped with many features including wheels, a carrying handle, and their patented rubber latches used to keep the lid secured tightly shut. With all these successful features listed there is a lot to be learned from the Yeti cooler, although it still does not fully satisfy the scope of this problem.

Another notable potential competitor is the “King of the Cold Ones”, which is a small cooler that is able to be carried in one hand and can be seen in Figure 3 [6].

Figure 3: King of the Cold Ones Cooler

It’s notable feature is that it does in fact dispense cans for the user. Problems it runs into are that it is relatively small, especially when compared to the large trunk coolers like Yeti. Another disadvantage is that there is no ice or ice packs involved. This results in the bag necessitating the drinks be cooled before its use. The final potential disadvantage is the fact that it can only dispense standard 12 oz cans. This design provides a few potential approaches to the problem, but leaves much to be desired.

To summarize, there are few “dispensing” coolers and most follow the standard bag or trunk design, leaving room for a new cooler which can offer easy access to the drinks stored within.

Constraints

Various constraints exist for this project, many of which come from governmental regulations as well as from a public survey, the results from this survey can be seen in Appendix C. These constraints can be seen in Table 1.

Table 1: Design Constraints

Constraints	References
Final product cost <$175	Survey results
Holds 12 cans	Survey results
Maintain 41 degrees F or lower for 6 hours	Codes and Standards
Fully loaded weight < 35lbs.	OSHA lift limits [7]

These constraints frame the overall design of the cooler and must be met in order to satisfy the need and add value to the product.

Evaluation Metrics

There are many survey and research based evaluation metrics that accompany the design of this cooler. These metrics can be seen in Table 2

Table 2: Evaluation Metrics

Minimize weight
Maximize ease of manufacturing
Maximize ice retention
Maximize aesthetics
Minimize cost
Maximize number of cans
Maximize the variety of beverages

By aiming to achieve these evaluation metrics the quality of the product will be maximized.

Proposed Solution

There are multiple ways to go about developing a solution to the problem presented within this project. A representation of a few of the potential solutions and the analysis of the respective ideas can be seen in Appendix D.

In order to solve the problem a new cooler design was generated. This design consists of an insulated cooler backpack which can be seen in Figure 4 [8].

Figure 4: Insulated Backpack Style Cooler

In order to house the internal mechanisms necessary for the design the backpack will have to be extended. With the additional internal area the backpack is able to fit the internal mechanism. This mechanism is made out of ¼ inch thick polycarbonate and can be seen in Figure 5.

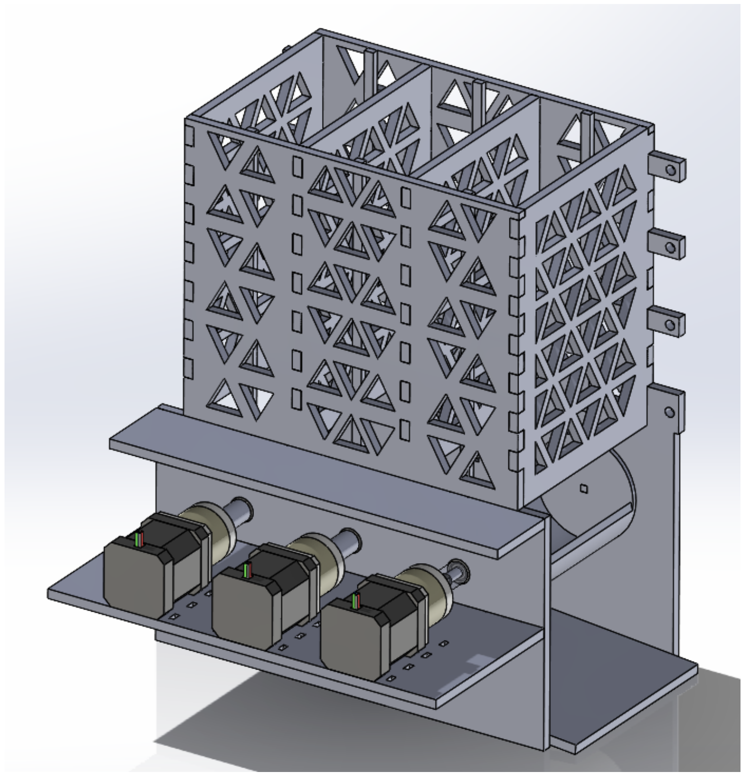

Figure 5: Isometric view of dispensing frame and mechanism.

The mechanism consists of front and back plates which are fixed together by four individual spacing walls which provide the three housing slots for the cans. Along with the plates and the spacing walls are the motor mounts which provide seating to the motors, which will be dispensing the beverages, and align their shafts with the circular dispensers; the alignment of these components can be seen better in the view provided by Figure 6.

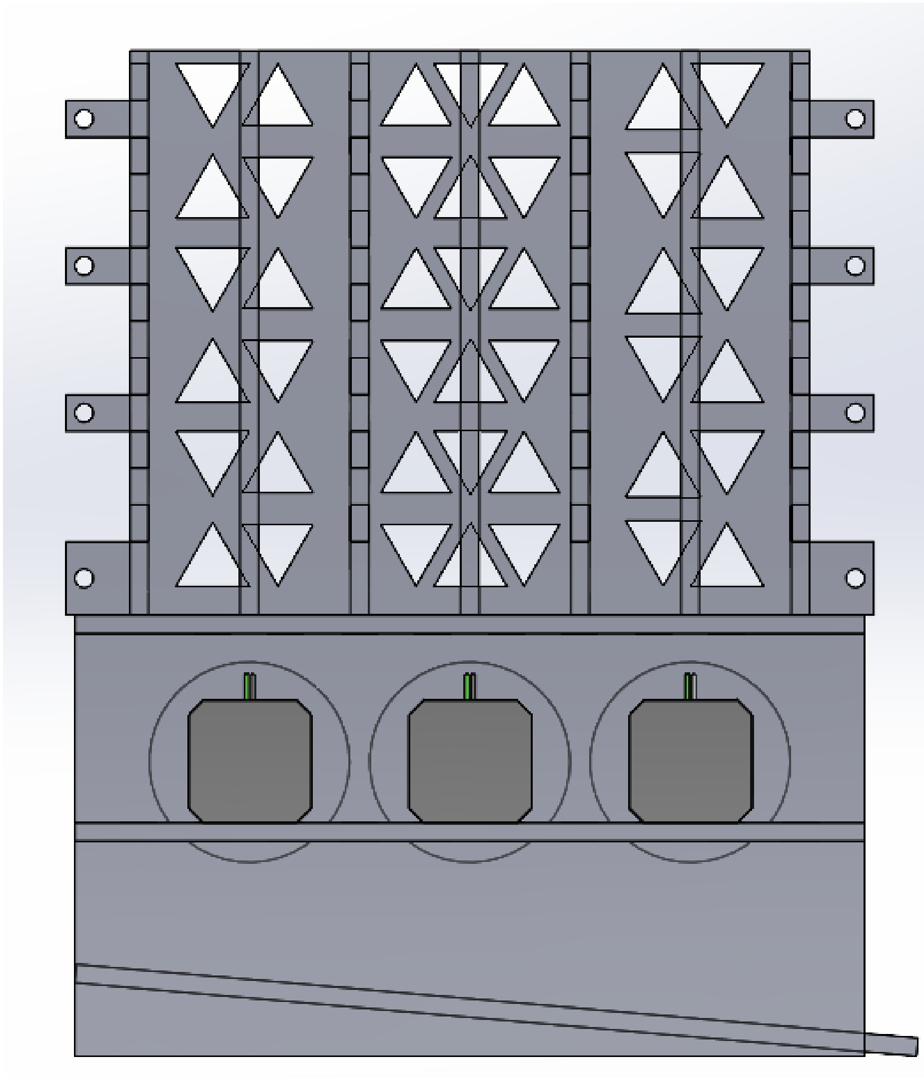

Figure 6: Front view of dispensing frame and mechanism.

The front wall was made transparent to better see the alignment of the motors with the circular dispensers and can slots. These rotating components will be operated by three planetary gearbox high torque Nema 17 stepper motors. The stepper motors will be responding to buttons which are programmed into an Arduino Mega controller. The programmable logic will be whenever one of the three buttons is pressed, which are connected to their respective motors, then that motor will perform one full revolution dispensing an individual can downward. When the can is dropped from the rotating housing it falls onto a dispensing ramp which the can then rolls down and out into the retrieval area on the side of the backpack. In order to keep the internal mechanism fixed in position, plastic bolts and nuts will be inserted through the bag itself and secured into the holes which are depicted in the previous two figures.

In order to make the interior mechanism as rigid as possible while still maintaining a relatively light weight, per the constraint to keep the unloaded bag under 10 pounds, the pattern of triangles was designed into the walls to maintain structural integrity while also removing a portion of the material to help reduce the weight. Along with that, considerations were taken when selecting the thickness of the polycarbonate to be used. The decision to use ¼ inch thick polycarbonate combined the desired strength of the material with weight considerations. The motor selected also needed to be able to handle the torque that was going to be applied to it. In order to calculate the torque the motor was going to be experiencing a few calculations were performed which can be seen in Appendix H. Those calculations showed that the motor would have to be able to handle $28.78\, oz * in > 18.35°$. With that value taken into consideration the planetary gearbox high torque Nema 17 stepper motor met all the needed forces.

This design meets many of the surveyed needs of users including quantity of drinks, ice retention, and the style of cooler. The cooler will be able to hold 12 cans throughout three sections, allowing the user to have multiple drink choices. To improve ice retention for those cans the cooler decreases energy transfer into the cooler by reducing the area exposing the internal cavity and the environment when retrieving beverages. Surveyed individuals wanted a backpack style cooler, so the dispensing and storing mechanisms are held within an insulated backpack, this reduces the difficulty of carrying the cooler greatly. Overall, the cooler provides a convenient carrying mechanism for the drinks, as well as providing a unique dispensing method.

Manufacturing

The manufacturing of this product will be completed in a couple of phases. The interior framework of the dispensing mechanism will be manufactured at the Ohio Northern Universities facilities. In order to do this the needed high density polycarbonate will have to be ordered and then machined in the machine shop of the Ohio Northern University Engineering building to meet the specifications and tolerances denoted in the design portion of the project. The CNC router will be programmed with the solidworks files that were generated in the design process. Nylon screws, nuts, and epoxy glues will be used in order to fasten the respective components with one another. This framework will include the frame walls, stepper motors, Arduino, dispensing ramp, and the rotating components needed to dispense the cans.

Another aspect of the manufacturing process is the modifications that will need to be made to the bag. These modifications will require cutting a new pocket at the end of the dispensing ramp to allow the user to reach the can. This is located on the side of the backpack near the bottom where there is a pocket to hold water bottles on most backpacks. There also will have to be holes made into the back portion of the bag to allow for the plastic bolts and nuts to be inserted through the backpack and into their holes in the internal mechanism. This portion of the process will have to be shopped out to an alterations shop that has the capability to perform the sewing tasks needed. Following a conversation, this task will be performed by Smiths Alterations based out of Kenton, OH.

Upon the completion of the interior framework and the necessary alterations being made to the bag itself the framework will be mounted within the bag. This will be done by the members of the capstone group using plastic bolts and nuts which will run through the portion of the bag that will be on the user's back. The bolts will run in and fasten to the anchor points on the internal mechanism and hold it securely in place there.

Conclusion

Along with the building of the product, a test plan and testing procedure will be developed in order to ensure that the product will meet all of the design constraints and evaluation metrics that have been laid forth in this report. T

References

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[6] “KING OF THE COLD ONE can dispensing cooler,” *Pinterest*, n.d. [Online]. Available:

https://www.pinterest.com/pin/200058408433091011/

[7] “Department of Labor Logo United Statesdepartment of Labor,” *OSHA procedures for safe weight limits when manually lifting | Occupational Safety and Health Administration*. [Online]. Available: https://www.osha.gov/laws-regs/standardinterpretations/2013-06-04-0#:~:text=The%20lifting%20equation%20establishes%20a,easy%20it%20is%20to%20hold. [Accessed: 23-Jan-2023].

[8] “Amazon.com : Insulated cooler backpack 58 cans large capacity backpack ...” [Online]. Available: https://www.amazon.com/Insulated-Backpack-Capacity-Leak-Proof-Waterproof/dp/B08ZN943WM. [Accessed: 14-Nov-2022].

Appendices

Appendix A- Stakeholders

- Investors
    - Impacted by the profitability of the cooler itself
- Consumers
    - Impacted by cost to purchase and quality of design
- Design Company
    - Impact quality of design, profit from productivity of the design
- Manufacturers
    - Impacted by ease of manufacturing, availability of materials, design constraints
- Advertising Agencies
    - Provided with business to promote the cooler

Appendix B- Tools and Information from Previous Courses

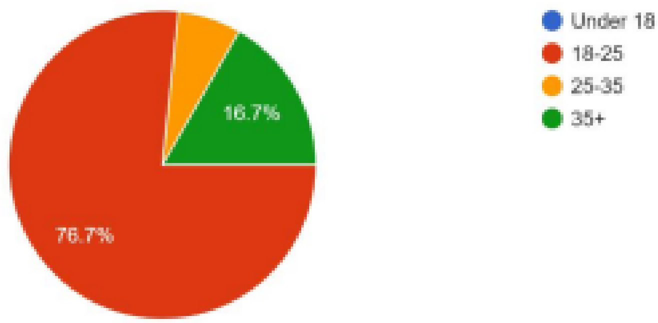
At this point in the process there have been many skills from prior courses that have had to be applied to the project. With that said there are still some to be mentioned including:

- Research tactics learned in Foundations of Design 1 and 2 have been applied in the information gathering
- Methods from Process of Design have been used in order to find applicable codes and standards for the project
- Information from Foundations of Design was used to determine constraints and evaluation metrics, as well as distinguishing stakeholders
- Material selection methods taught in mechanical design 1 and 2 were applied in choosing the materials
- Skills learned in Computer Applications were applied in the Autocad renderings of the mechanisms

Appendix C- Survey results

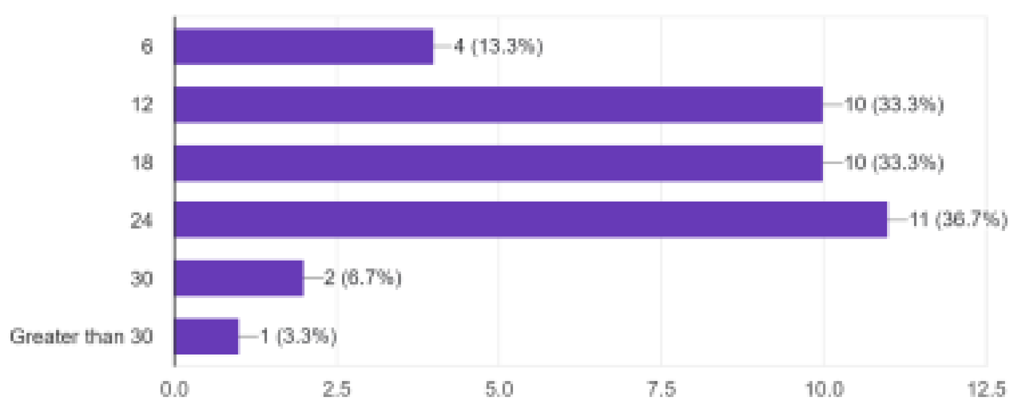
What is your age?

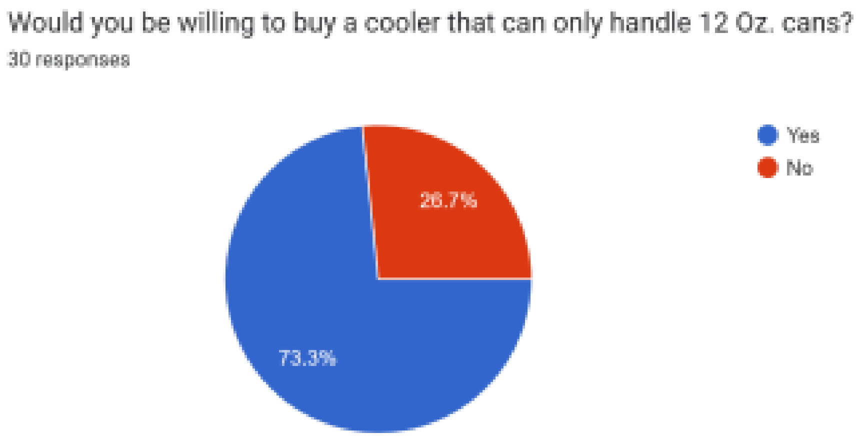
30 responses



How many drinks would you prefer to be able to fit into your cooler?

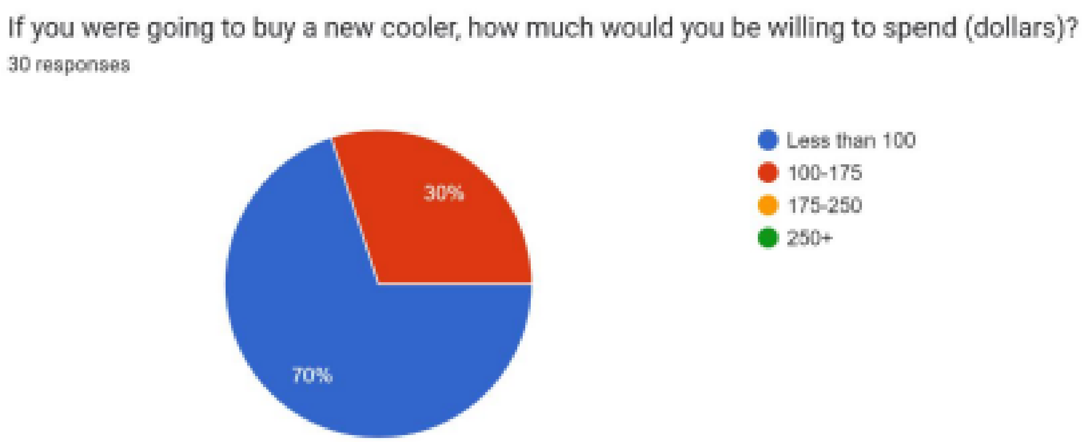
30 responses





Common reasonings for the above responses:

- Most common drink choice for yes responses.
- Want to keep larger drinks/food cool for no responses.

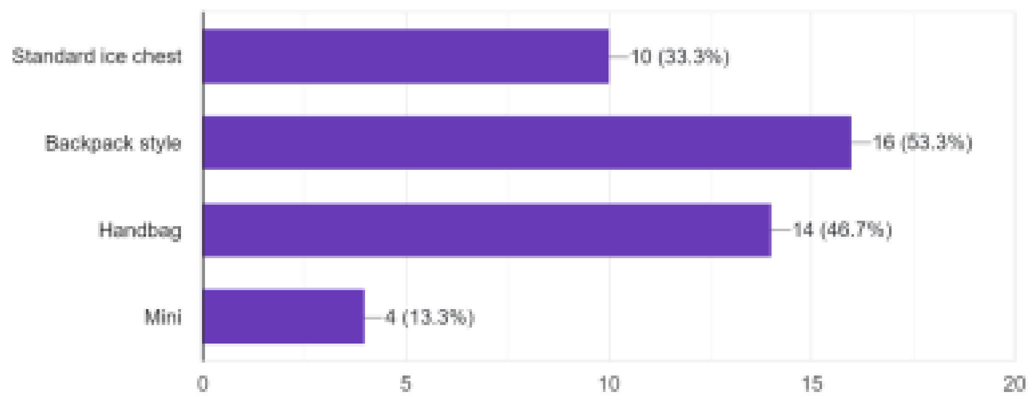


Common reasonings for the above responses:

- Not much extra disposable income.
- Can’t justify spending too much on a cooler.

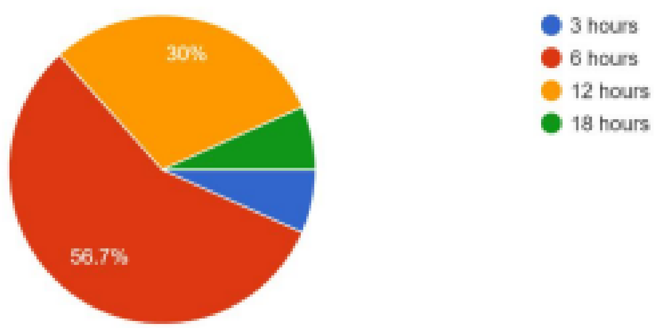
Which of the following coolers would you be interested in buying?

30 responses



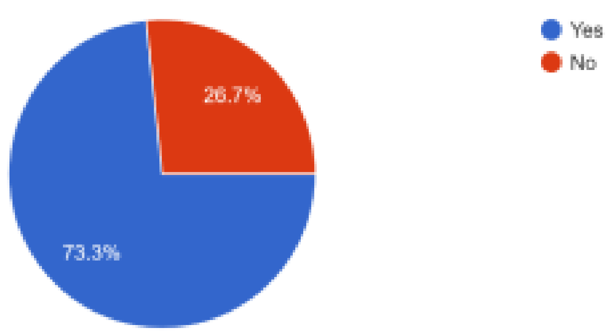
How often are you willing to replace the ice?

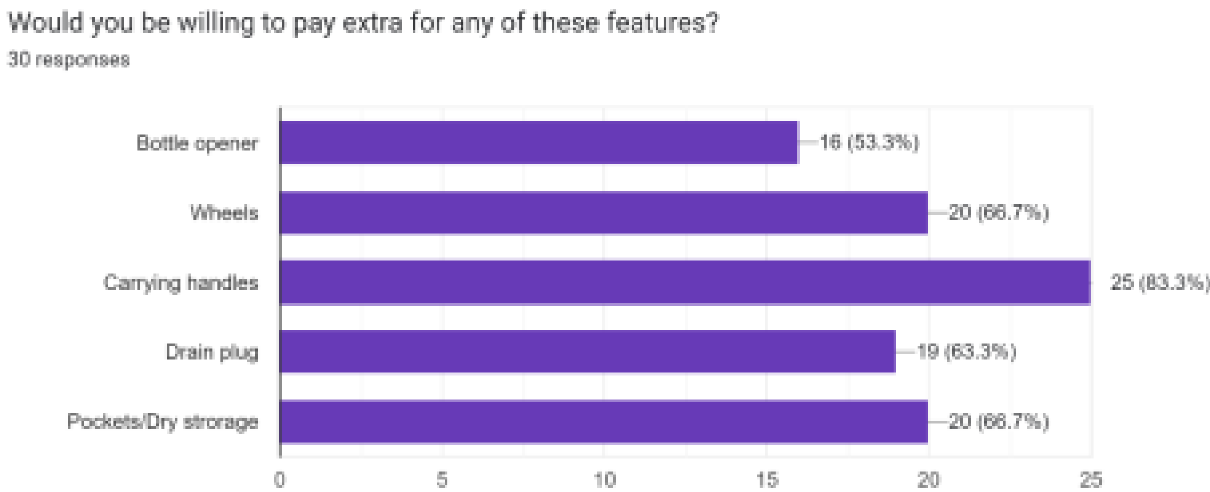
30 responses



Would you be interested in a cooler that dispenses from the side rather than open the lid on top?

30 responses





Likes or dislikes from prior coolers:

- Dislike heavy/difficult to carry coolers.
- Dislike ice retention too short.
- Like designs/colors.
- Like easily cleanable coolers.
- Like wheels.

Appendix D- Potential Solutions

The first design idea pushed the envelope on the idea of dispensing the drink and can be seen in Figure 1. In this design a hand bag style cooler is used and rather than carrying cans in it a bladder is used, similar to the style that a boxed wine employs. This method then allows the user to fill the bladder and use the accessible spigot to dispense the beverage. This method poses concerns with cooling, the liquid will have to be cooled by a form of ice pack, potentially designed to have the interior of the handbag be designed like a freezer pack to control the temperature.

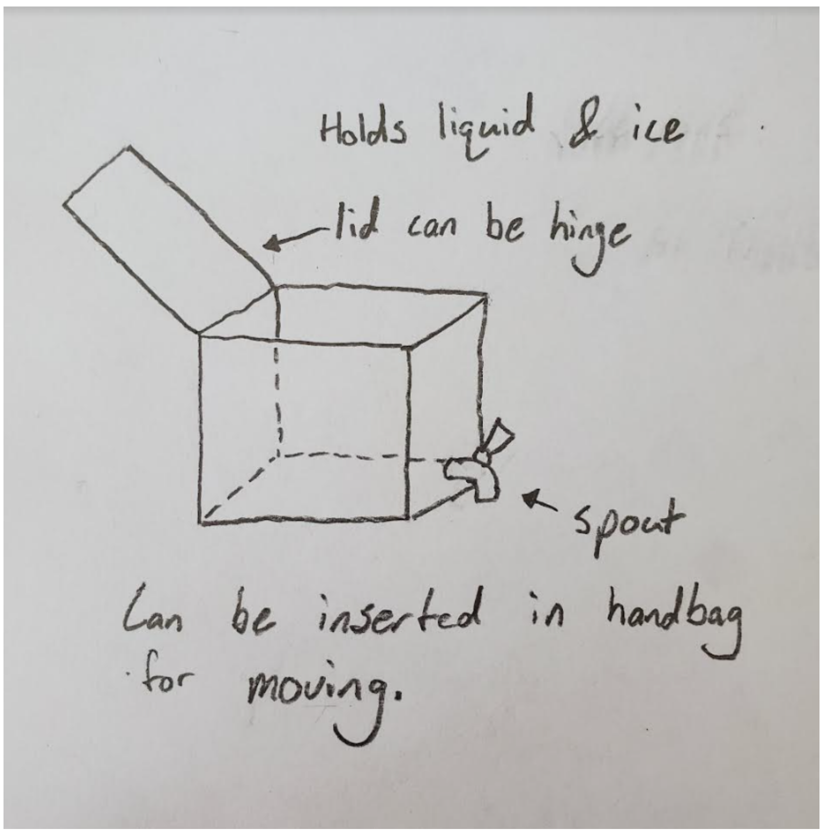


Figure 1: Drawing of the Bladder/Tank Inside Handbag Design

The second idea is based off of a standard ice chest cooler design. In this design shown in Figure 2 the ice chest has a tapered base that funnels the beverages into the desired area. The design of the base allows for the possibility of cooling with ice in the recesses that will not be used for the taper. The drinks are then able to be removed using a drawer style system allowing the user to slide the dispensing mechanism out and retrieve their drink.

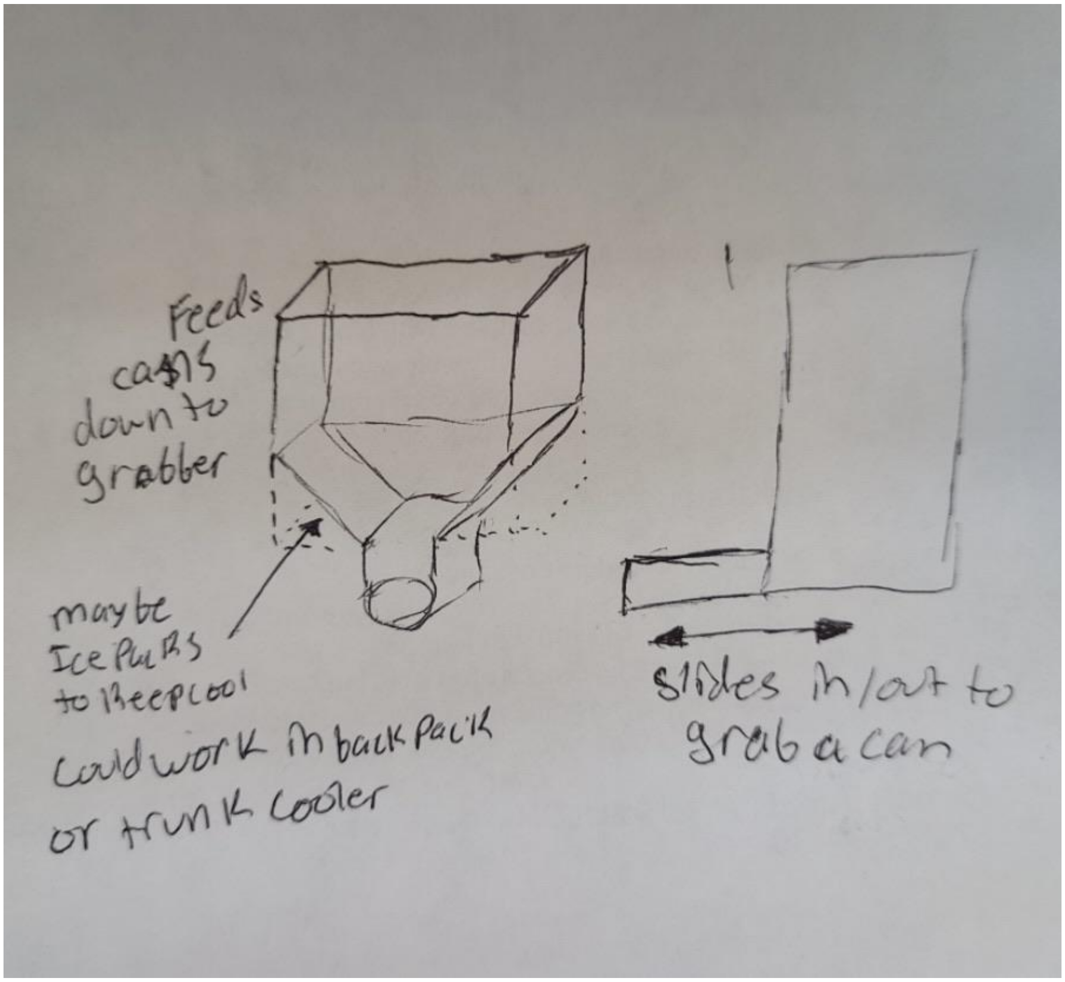


Figure 2: Drawing of the Standard Ice Chest Design

The third design that can be seen in Figure 3 is an idea for a backpack style cooler. For this design 3 tube style containers are inserted into a general style backpack. There is then a set of three circular dispensing tubes that the drinks funnel down into and are operated with steppers motors and buttons. The dispensing tube rotates when the button is pressed, dropping a can down onto a horizontal ramp that feeds the can out into a place where the user can access it.

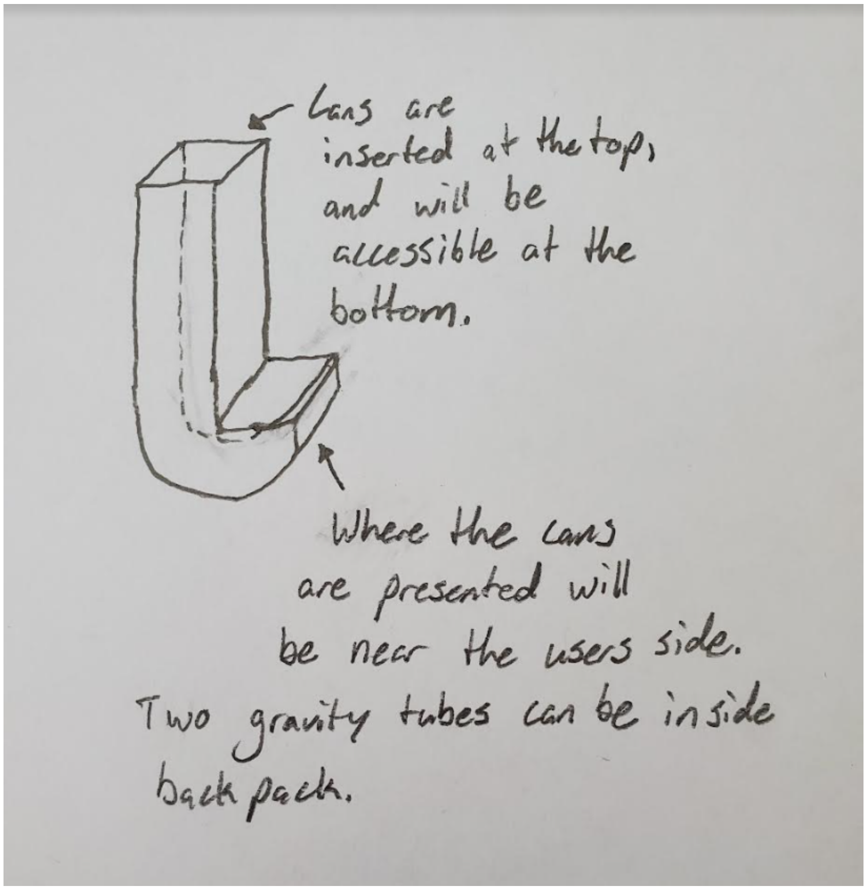


Figure 3: Drawing of the Gravity Feed Tube design.

With the three ideas generated they had to be evaluated against the necessary constraints and evaluation metrics and ranked against one another. A weighted Pugh's Method was used in order to do this, the cost, volume, weight, and temperature were the evaluation criteria. The evaluation itself can be seen in Figure 4.

			Scoring/Weighted Scoring					
Criteria/Constraint	Evaluation Metrics	Weighting	Tapered Shell		Gravity Tubes		Spout Dispenser	
Cost	$, <175	30	1+	30	1+	30	1+	30
Volume	Liters, 5>	30	1+	30	1-	-30	1-	-30
Weight (empty)	Lbs, 10<	25	1-	-25	1+	25	0	0
Temperature	Degs, <41 for 6 hours	15	1-	-15	1+	15	1+	15
	Total:	100		20		40		15

Figure 4: Weighted Pugh's Method Evaluation

Upon the completion of the evaluation method it was determined that the third idea, based on the gravity fed tubes was the best option. Due to this it will be the primary design evaluated moving forward.

Appendix E- Project Management

CaterGator	Front loading, holds trays instead of drinks,	$244.99		https://www.webstaurantstore.com/catergator-black-front-loading-insulated-food-pan-carrier-with-blue-ice-board-5-pan-capacity/215PC5KTC.html
Frigidaire EFMIS045-RED	See through front panel, button vending, refrigeration	$124.98		https://www.amazon.com/FRIGIDAIRE-EFMIS045-RED-Perfect-Vending-Machine/dp/B07N6XHB4R/ref=asc_df_B07N6XHB4R?tag=bingshoppinga-20&linkCode=df0&hvadid=80882879496932&hvnetw=o&hvqmt=e&hvbmt=be&hvdev=c&hvlocint=&hvlocphy=&hvtargid=pla-4584482458401822&psc=1

YETI TUNDRA HAUL	Wheels and carrying handle, rubber latches to hold lid down, rotomolding formed plastic shell	$400		https://www.yeti.com/coolers/hard-coolers/tundra/10060200000.html?country=US&currency=USD&utm_source=bing&utm_medium=cpc&utm_content=__iv_p_1_g_1265538800334101_c__w_pla-4582695777717752_n_o_d_c_v__l__t__r__x__y_63694_f_Online_o_10060200000_z_US_i_EN_j_4582695777717752_s__e__h__ii__vi__&gclid=8109189237ae173936f47b843fd4a5f3&gclsrc=3p.ds&msclkid=8109189237ae173936f47b843fd4a5f3&utm_campaign=Bing_US_English_Shopping_Smart_HardCoolers&utm_term=4582695777717752

Igloo Latitude	Wheels and carrying handle, cupholders, water drain,	$59.99		https://www.kohls.com/product/prd-4925855/igloo-latitude-60-qt-wheeled-cooler.jsp?skuid=65829249&ci_mcc=ci&utm_campaign=OUTDOOR%20RECREATION&utm_medium=CSE&utm_source=bing&CID=shopping20&utm_campaignid=401561977&utm_adgroupid=1235851302938522&gclid=e53c6ab721a71cd67fa409a128c344ba&gclsrc=3p.ds&msclkid=e53c6ab721a71cd67fa409a128c344ba
Woodworking	Autodispensing	N/A		https://www.instagram.com/tv/Ch43MzLJspj/?igshid=YmMyMTA2M2Y=
Kanga Kase Mate	Easy open top	$49.95		https://www.thewarmingstore.com/kanga-coolers-kase-mate-standard-30-pack-cooler.html
King of the Cold One	Can Dispensing	$42.95		https://themanregistry.com/gift/king-of-cold-one-personalized-can-dispensing-cooler/

Jockey Box	Taps for dispensing	$145.00		https://magicspecialevents.com/event-rentals/rental-item/jockey-box-for-beverage-dispensing
store n tote	can dispenser	16.98		https://www.amazon.com/Store-Tote-Stackable-Can-Dispenser/dp/B00CD5SWVE/ref=asc_df_B00CD5SWVE/?tag=hyprod-20&linkCode=df0&hvadid=198060101726&hvpos=&hvnetw=g&hvrand=6735246570604198240&hvpone=&hvptwo=&hvqmt=&hvdev=m&hvdvcmdl=&hvlocint=&hvlocphy=9015966&hvtargid=pla-351459427435&psc=1

Appendix F- Codes and standards

Auto-dispensing Cooler project. Our capstone group has been tasked with designing a solution to the common issue of sitting on a cooler at a party and having to get a new drink out which requires you to stand up and lift the lid which is inconvenient and results in a noted loss in cooling within the cooler.

- Drink coolers in sanitation facilities and vessels

21 CFR § 1250.85

- If cooler uses lithium batteries

UL 1642

- One from Dr. Mikesell, if we go with cooler that uses electrical plug

Y14.5-2009

- Another from Dr. Mikesell, Refrigerator codes & standards

10 CFR430

- Requirements for materials in contact with beverages, as well as design and construction

NSF/ANSI 18

- Maximum thickness of 10 inches shall be permitted in cooler walls

ALP 2603.4.1.2

- Establishes minimum food protection and sanitation requirements for the materials, design, construction and performance of dispensing freezers

NSF/ANSI 6

- establishes minimum food protection and sanitation requirements for the materials, design, construction and performance of equipment and devices that manually dispense food or beverages

CXC 62-2006 CCCF

- Code of practice for the prevention and reduction of Dioxin, Dioxins-like PCBs and non-Diozin-like PCBs in Food and Feed.

Toxic Substances Control Act 40 CRF part 751

- Regulates the manufacture and sale of certain toxic chemicals to protect the public.

Model Toxics in Packaging Legislation

- Applies to all packaging and components, wraps, bags, containers, boxes

California Proposition 65

- Imposes substance restrictions, particularly regarding plastic products

Appendix G- Calculations

45 degree ramp

3Nm of torque / 0.03683m = 81.46N force

Acting at 45 deg = 40.7N