ENGE 1216 - Spring 2024

UV Filtered Water Backpack

Team 2
Liam Ryan, Myriam Bajani, Lilly Underwood, Julia Effenberger, Benny Goodyear, Nassim Abou Habib

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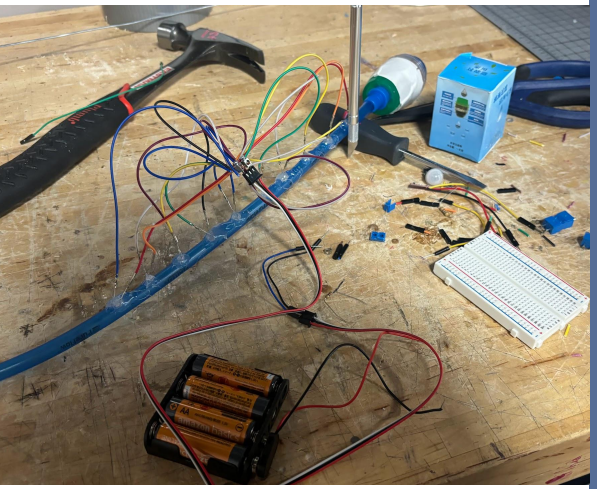
ABOUT THE PROJECT

Around two billion people in the world do not have access to clean water [1]. This is a major issue and something that our group has decided to focus on for our semester long project. Related to SDG 6, “Clean Water and Sanitation”, the unreliable access to clean water in many situations is a major problem in many areas of the world. Whether it is the lack of clean water in underdeveloped countries, during a natural disaster, or simply while outdoors, we want to create a sustainable, reliable, transportable, and easy-to-use device to provide those in need with a clean water source. With 40% of the world fighting water scarcity, such a device can leave a lasting, positive impact. [2]

SOLUTION OVERVIEW

This is the UV AquaPack prototype we have created with the initial carbon activated filter followed by the UV Lights Filter which can be activated by the lightswitch.



FEATURE HIGHLIGHTS

Activated Carbon Filter

- Acts as the first method of filtration.
- The water leaves the bag through a tube and immediately flows through the filter.
- Effectively removes chlorine, odor, chemicals and many other contaminants.

UV Light Filtration

- 21 UV lights line the tube transporting the water from the bag to the mouthpiece.
- The UV lights effectively filter out 99% of living organisms such as bacteria and fungi.
- Touch sensor turns on the UV lights for filtration.

Portable Filtration

- The filtration system is stored inside of a CamelBak Backpack allowing for portable filtration.
- The 4 lb backpack filters water in under 5 seconds allowing for fast filtration anywhere in the world.

LIMITATIONS

Limited Filtration Capacity

While our system is designed to provide clean drinking water for individual users, it may not be suitable for supplying water to larger groups or communities during emergencies or disasters.

WHY IS IT CHALLENGING?

Addressing the limited filtration capacity is challenging due to the balance between portability and filtration efficiency. Increasing the filtration capacity will require larger components, which could mess with the portability and easy use of the device.

OUR PLAN TO LOOK AHEAD

To address this issue, we will look into making our design modular, which means it can be adjusted to fit different needs and situations. Additionally, we will explore alternative filtration technologies and materials that offer better efficiency without significantly increasing the size and weight of our device.

Maintenance Requirements

Our design requires ongoing maintenance and replacement needs associated with the UV bulbs and active carbon filter. While these components are essential for water purification, they will wear out over time and require changing regularly, which could pose challenges in environments with limited resources or remote areas.

WHY IS IT CHALLENGING?

The challenging part in addressing this limitation is the access to replacement parts and the technical expertise required for proper installation. Moreover, the cost needed to purchase and replace these components may be an issue for some users.

OUR PLAN TO LOOK AHEAD

We will make our device user-friendly and design components that are easily accessible and replaceable without special tools. We could also add simple screens to show when different parts need to be replaced. Furthermore, we plan on working with NGOs to provide replacement parts and training on the device's sustainability.

02

PROJECT GOALS

PROJECT REACH

WHO

Our project is designed to reach a wide variety of people around the world. It is made to be convenient and portable to those in need of clean filtered water. Some key stakeholders are natural disasters victims, third world countries, college students, or even a hiker.

WHERE

This product can be used worldwide, but those near the gulf or in third world countries are the main targets of product.

WHAT

The purpose of our design is to give clean filtered water to those who do not have the resources to do so. Many people globally do not have access to clean water and suffer from dehydration. Our product also is a sustainable solution to minimize the long term effects on the environment.

CONSTRAINTS

EASY TO USE

The purification process should not require much attention. The user (such as: people in underdeveloped countries, natural disaster victims, hikers, college kids) will be able to fill the device with water in seconds. The user will drink from the mouthpiece while touching a sensor. This sensor will turn the filtration system on, filtering the water as it passes through the tube.

WATER STORAGE OVERTIME

The amount of liquid the product can hold is important for the longevity of the resource.
"The average male needs 3 Liters of water per day and the average female needs 2.2 Liters of water per day." [4]
The filter holds about 2 Liters of water per day, meaning this filter would last ⅔ a day for males and one day for females.

EFFECTIVE FILTER

Our design will hold 1-2 L of water and purify it effectively. Because this is not a brand new concept, our efficient filtration time (3 seconds) along with our effective filtration system will keep this product competitive with other filters.

ACCESSIBLE MATERIALS

Our design will use materials that can easily be found around most societies. If all materials are easy to access then those in underdeveloped countries will be able to use this product and have it for a long time. Overall, batteries, switch mechanisms, uv led lights, and backpacks can be found in most countries, therefore, this product can be mass produced and handed out to those in need.

TIME IT TAKES TO FILTER

Users will be less likely to enjoy and use the product if it takes too long to purify. It also eliminates the point of the product if it takes just as long for them to travel to a clean water source.
Our product will filter the water in about 3 seconds. The water will leave the bag and pass through the UV lights and then the carbon filter when the user drinks from the spout.

LIGHT WEIGHT

The device should be as lightweight as possible to allow for maximum water capacity. If the product is lightweight this can help in the long run with health problems. The weight should range between 4-5 lbs.

CRITERIA

COMPLEXITY OF PURIFICATION

This is an important criteria to follow because this is meant to be a simple, easy fix for those in need. Therefore, if it becomes too complex the product will lose demand making it useless. It will take about one minute to fill the backpack with water. The filter process will take a couple of seconds.

Grade: 5

COST OF MATERIALS

A main goal of our team is to make our product inexpensive, so anyone can use it. Including those in underdeveloped countries. The cost of material will be measured in dollars and will stay under the budget of $50.

Grade: $18.47

DURABLE

Our product is designed to go to underdeveloped countries that don't have access to purification or resources, so this product needs to last a long time to help with their lack of resources. It would be a waste of time and material that could potentially hurt the environment if the product is not durable.

Grade: 5

WEIGHT

Weight is an important criteria because this product will likely be carried long distances. If the product was lightweight this can help prevent long term health issues when carrying heavy items for long distances. Carrying heavy loads might lead to "changes in the mechanics of the spine, and it is also possible to cause scoliosis." [5]

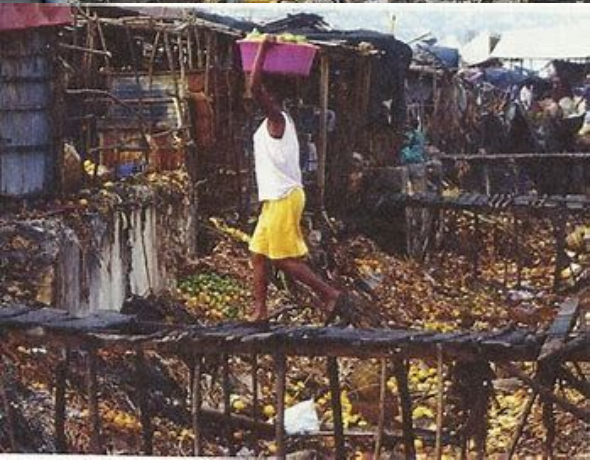
Grade: 4.2 lbs

SUSTAINABLE

We want our design to have a substantial, positive impact on lives. Yet, we do not want to harm the environment in the process. Our goal is to create a purification system that will leave minimal to no trace on the environment that it is used in. Thus, our design will be powered by sustainable, clean energy and created with products, such as: our carbon filter and led uv lights, that will leave minimal to no trace on the environment

Grade: 4

STAKEHOLDER PROFILE



WHO THEY ARE

People in developing countries and countries affected by natural disasters. These people can be anywhere around the world and can even happen to us here in the United States in the case of natural disasters.

WHAT THEY NEED

A human can only last three days without water; therefore, access to water is very important but what is even more important and essential is the access to clean water as people use it for multiple purposes such as drinking, cooking, bathing, etc...

HOW WE'RE HELPING

What we are doing is helping those who have lack of access to clean water by creating and providing a portable device able to purify dirty water and make this clean water accessible without the use of big industrial water purifiers or complex water filtration systems.

STAKEHOLDER PROFILE

WHO THEY ARE

College students who are located all over the world similar to the students at Virginia Tech and other local universities.

WHAT THEY NEED

Clean water is also essential for a healthy life and a life full of energy. College students are at the most active age of their lives. They need a lot of this clean water to continue their active lives as well as the access to this clean water while exercising.

HOW WE'RE HELPING

Given the location of Virginia Tech and the access to the hills, mountains, and valleys around us, many students resort to hiking and exploring these mountains. What we are providing is a portable bag which can be used to carry water in your backpack while making sure it is purified. Also, students who find small ponds of water on their hikes can fill up the bag to ensure that the water they are drinking is clean, thanks to the double water purification system in our device.

POTENTIAL CONCERNS

- Creating an affordable and accessible product for everyone.
- Create a water filter that is effective in removing contaminants, ensuring the consumer remains safe and healthy.
- Ensure the consumer is provided with an accurate and detailed description of our product.

OUR ETHICAL STANDARDS

NSPE Code of Ethics - “Engineers shall at all times strive to serve the public interest.” [6] (SDG 6)

- Our product serves anyone in situations where clean water is inaccessible.
- Our focus is to help the public good along with putting profits towards underdeveloped countries who would benefit from this product.
- Ensure clean water while also preserving the health of the consumer.

TECHNICAL INFORMATION

03

PROTOTYPE DETAILS

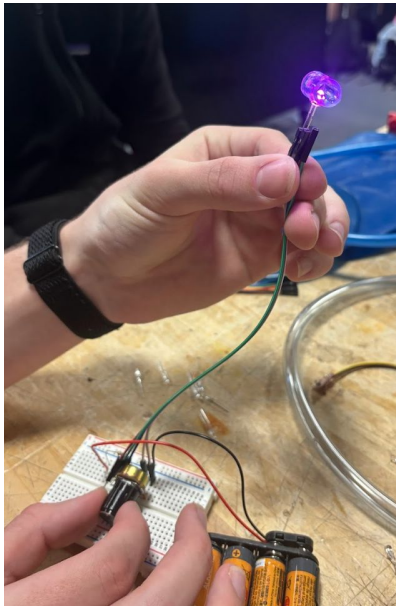
DESCRIPTION

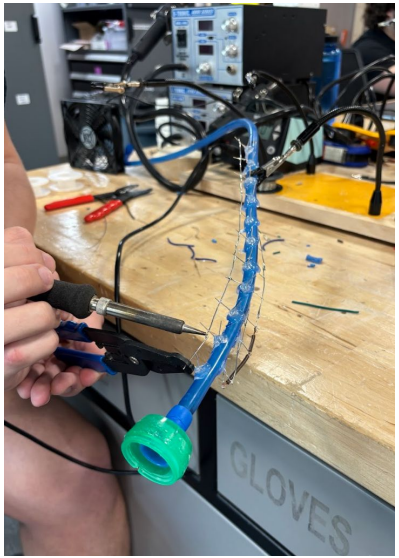
We built a portable water purification system in the form of a backpack. This backpack holds a water container and a tube where a person can drink through. Our prototyping part mainly involved the tube as we made two water purification systems before the water comes out of the tube. We have a carbon activated filter as well as UV led lights inside the tube to have direct contact with the water and purify it.

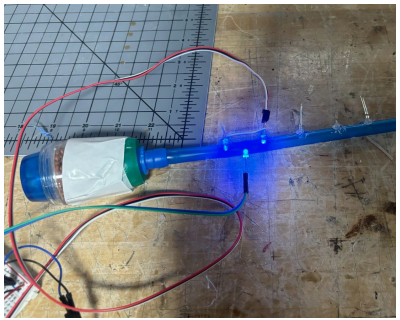
IMPORTANT DETAILS

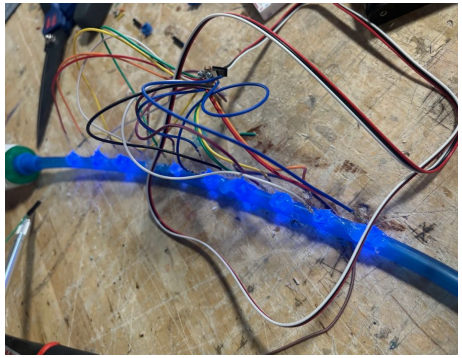
- 21 UV lights for Water Purification
- Carbon Activated Filter - Water leaves the bag and flows through the filter before entering the tube.
- The UV lights are attached to a battery pack and can be turned on and off. The UV lights line the tube on both sides for 10 inches.

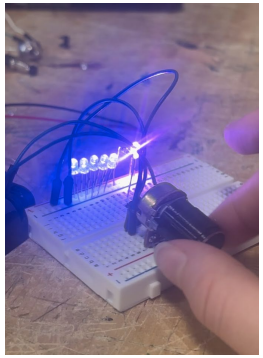
PROTOTYPE DETAILS











BILL OF PROTOTYPING MATERIALS

Description	Quantity/Units
LED Lights (Purple UV) color for water purification (Water Purification)	21
Breadboard (Circuit)	1
Wires (To attach to I+UV Lights)	20
CamelBak (Our main backpack with the water tube)	1
Carbon Activated Filter (First step of water purification)	3
Battery Pack (To power the UV lights)	1

PROGRAMMING SUMMARY

```python
import math

bulbs = input('Please input the amount of UV bulbs being used: ')
print()

while True:

    while bulbs.isdigit() == False or int(bulbs) == 0:
        print('Input Error: ' + "'" + bulbs + "'" ' is not a valid input.\nInput must be a whole, positive number.')
        bulbs = input('Please input the amount of UV bulbs being used: ')
        print()

    break

bulbs = int(bulbs)

length_of_tube = 10
# in inches^^
milliwats = bulbs * 64
watts = milliwats / 1000
diameter = 3/10
radius = (3/10)/2
# 1 inch to 2.54 cm

area = math.pi * ((3/10)/2)**2
# area of the circle made by the tube
volume = area * 10
uv_per_inch = length_of_tube / bulbs

if watts == 1:
    print('Total watt output:', round(watts, 2), 'watt')
else:
    print('Total watt output:', round(watts, 2), 'watts')
'''
if bulbs == 10:
    print('There is a UV bulb every', round(uv_per_inch, 2), 'inch.')
else:
    print('There is a UV bulb every', round(uv_per_inch, 2), 'inches.')
'''

uv_power_punit = milliwats / (length_of_tube * 2.54)
# mw/cm^
radius = radius * 2.54
base_e_absorption_coefficent = 0.135 * math.exp(1)

uv_intensity = (uv_power_punit/(2 * math.pi * radius)) * (math.exp(1) ** (-base_e_absorption_coefficent * radius))
# mw/cm^2

print('UV intensity:', round(uv_intensity, 2), 'mw/cm^2')

time = 2.7
uv_dose = uv_intensity * time
# time = the amount of time it takes for water to pass through the part of the tube with all the LEDS
# NOT COMPLETE - CURRENT TIME IS FOR THE PURPOSE OF TESTING AND IS NOT VALID

print()
if uv_dose >= 50 and uv_dose <= 60:
    print('The water meets the standard purification requirements.')
    print('The water is SAFE to drink.')
elif uv_dose > 60:
    print('The water is beyond the standard purifcation requirements.')
    print('The water is VERY SAFE to drink.')
else:
    print('The water does not meet the standard purification requirements.')
    print('The water is NOT SAFE to drink.')
```

DESCRIPTION

In our prototype, there are 21 UV bulbs over a length of 10 inches. Our program calculates the UV wattage and intensity over the given 10 inches depending on a user-inputted amount of UV bulbs. With the calculated UV intensity, it then calculates the UV dosage and compares it to the standards for what is safe to drink. The program will then output the UV wattage, UV intensity, and if the water is purified and safe for consumption.

HOW IT WORKS

1) User is prompted to input the amount of UV bulbs being used
2) Program calculates the area and volume of the tube over the given length and the UV wattage
3) Then uses a heavily researched UV intensity formula and does such calculations using previously determined variables
4) Calculates the UV dosage with the above intensity
5) Determines if the water is safe to drink depending on a range of UV dosages
6) Outputs to the user if the water is safe

PROGRAMMING SUMMARY

TEST RUNS

The following screenshots include test runs that includes results and input validation such as:

- Making user redo the input if:
  - They inputted anything other than a digit
  - Inputted a negative number, decimal, or zero

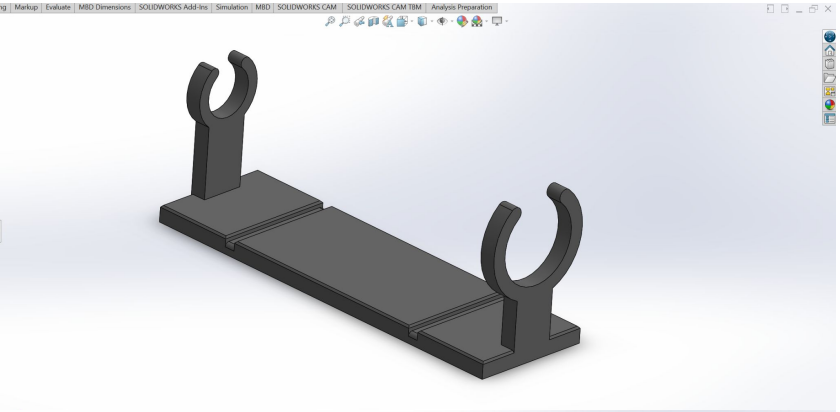
```
>>> %Run ENGE1216CODE.py
 Please input the amount of UV bulbs being used: 10

 Total watt output: 0.64 watts
 UV intensity: 9.15 mw/cm^2

 The water does not meet the standard purification requirements.
 The water is NOT SAFE to drink.
```

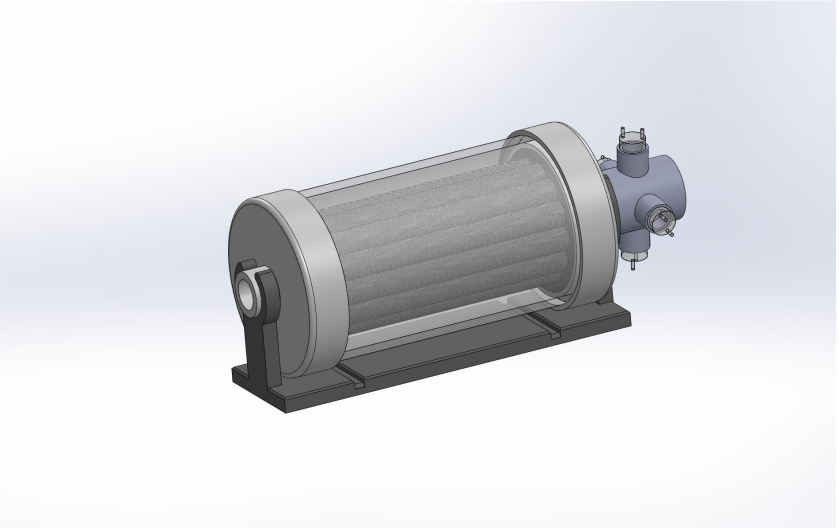
```
>>> %Run ENGE1216CODE.py
 Please input the amount of UV bulbs being used: 21

 Total watt output: 1.34 watts
 UV intensity: 19.22 mw/cm^2

 The water meets the standard purification requirements.
 The water is SAFE to drink.
```

```
>>> %Run ENGE1216CODE.py
 Please input the amount of UV bulbs being used: 50

 Total watt output: 3.2 watts
 UV intensity: 45.76 mw/cm^2

 The water is beyond the standard purifcation requirements.
 The water is VERY SAFE to drink.
```

```
Please input the amount of UV bulbs being used: abc

Input Error: 'abc' is not a valid input.
Input must be a whole, positive number.
Please input the amount of UV bulbs being used: 3.5

Input Error: '3.5' is not a valid input.
Input must be a whole, positive number.
Please input the amount of UV bulbs being used: -2

Input Error: '-2' is not a valid input.
Input must be a whole, positive number.
Please input the amount of UV bulbs being used: 0

Input Error: '0' is not a valid input.
Input must be a whole, positive number.
Please input the amount of UV bulbs being used: 30

Total watt output: 1.92 watts
UV intensity: 27.46 mw/cm^2

The water is beyond the standard purifcation requirements.
The water is VERY SAFE to drink.
```

CAD MODEL





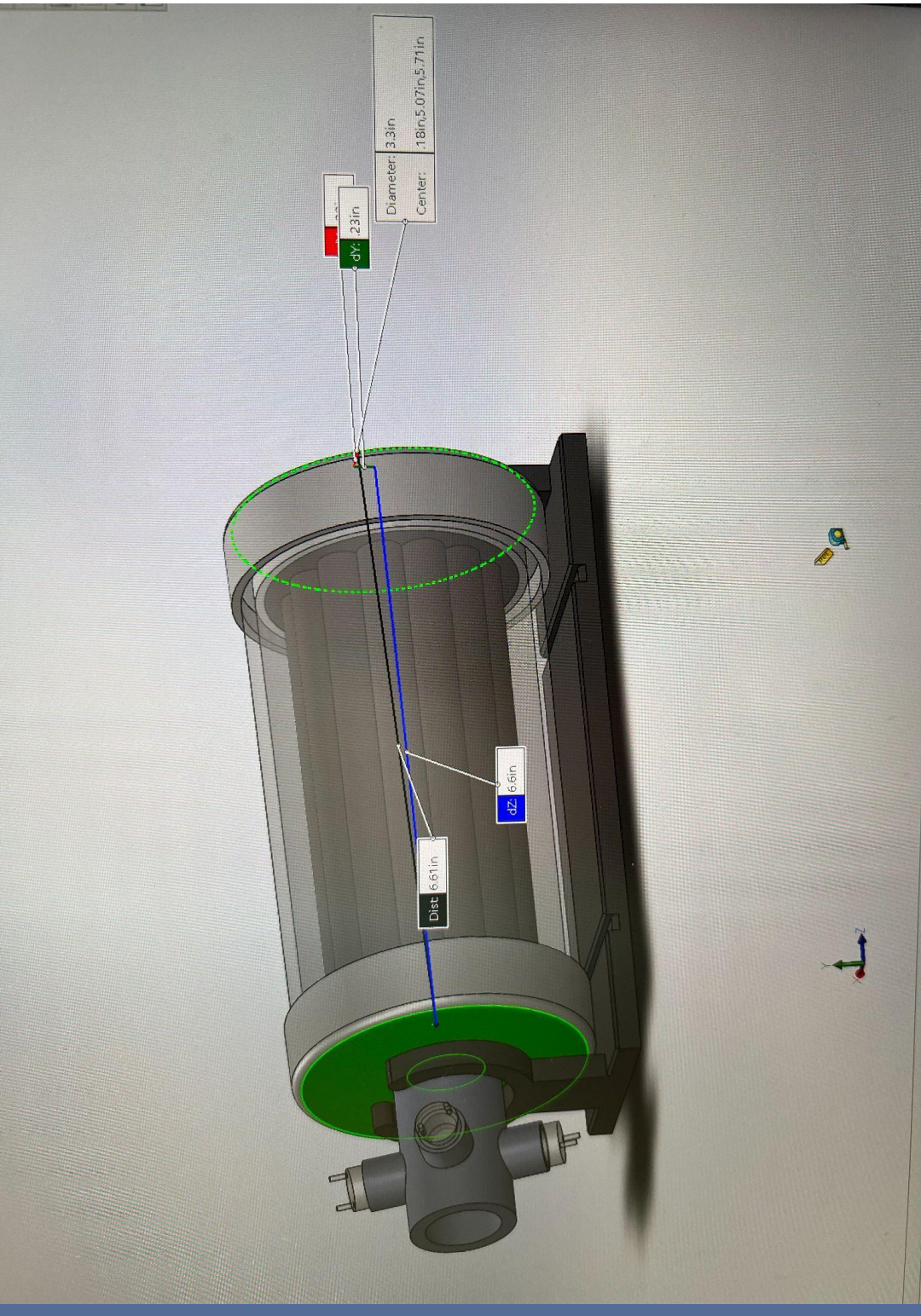
DESCRIPTION

In our model we designed the carbon activated filter that is going to be within the backpack. It will be attached near the pouch where the water will be stored. As well as, a holder designed to be put in the backpack and keep the filter secure and in place.

IMPORTANT DETAILS

- Carbon activated filter (water flows through)
- UV Lights are on the interior where the water enters
- It has holder for the UV lights
- It is easily changeable due to quick pop in and out of the holder

DIMENSIONS


Diameter: 3.3in
Center: .18in,5.07in,5.71in
dY: 2.3in
dZ: 6.6in
Dist: 6.61in

REFERENCES

— [1] S. Bayram, “Billions of people lack access to clean drinking water, U.N. report finds,” NPR, NPR, 22-Mar-2023. [Online]. Available: https://www.npr.org/2023/03/22/1165464857/billions-of-people-lack-access-to-clean-drinking-water-u-n-report-finds [Accessed: 31-Jan-2024]

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— [6] National Society of Professional Engineers, “NSPE Code of Ethics for Engineers,” National Society of Professional Engineers, Jul. 2019. https://www.nspe.org/resources/ethics/code-ethics