M.I.C.E
Medical Innovation Creativity & Entrepreneurship Lab

Research Document – Week 1

Portable Container for Blood and Vaccine

Team 1

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Members –

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Problem at a Glance

Need Statement:

To develop a Portable Container for the Transportation of Blood Samples and Vaccines.

Description:

Cold Chain - The term **cold chain** or **cool chain** denotes the series of actions and equipment applied to maintain a product within a specified low-temperature range from harvest/production to consumption. [1]

BLOOD

WHO Defines it as -

> "The blood cold chain is a systematic process for the safe storage and transportation of blood from its collection from the donor to its administration to a patient who requires transfusion. It is referred to as a cold chain' because blood, being a biological substance, must be kept cold in order to reduce bacterial contamination and to prolong its life." [2]

A Blood Cooler is a device which keeps the blood sample within the required temperature range so that it reaches fresh to the required location.

Blood coolers are used to maintain & store blood. Maintenance of storage temp is essential to retain the oxygen carrying ability of blood. The upper limit of 6 degrees C is essential to minimize the growth of any bacterial contamination in the unit of blood. Below 2 degrees the red cells become haemolysed.

As we all are well aware that usually blood samples are transported in Thermocol boxes with ice packs. But this is a really hazardous practice, due to which our country is not able to meet the blood requirements. These boxes have no control over temperature, neither are they environmentally friendly.

Blood transport within a hospital is not an isolated component or routine action. It is a very important link in a larger logistic chain. Transportation of blood samples to the laboratory is an essential function within the patient diagnosis journey. When the transport is just in time, the lowest possible waiting time for the patient can be achieved.

VACCINES

Immunization is one of the best efforts that India is putting forward currently to fight against various vaccine preventable diseases. India had started its Universal Immunization Program (UIP) in 1985 focusing more on infants and pregnant mothers. The country spends a lot of money every year on immunization.

The success of this program depends highly on the level of cold chain maintenance of the vaccines right from the site of manufacturing up to its administration. Urban Health Centers (UHCs), set up under various Municipal Corporations, have been the backbone for delivering services related to immunization in urban areas in India.

It is thereby important that cold chain system be adequately maintained at these centers. It is repeatedly found that cold chain is not maintained properly in India. [3]

Vaccine storage equipment should be selected carefully, used properly, maintained regularly (including profession-ally serviced when needed), and monitored consistently to ensure the recommended temperatures are maintained.[4]

This is a Major Issue at remote areas where accessibility is the most difficult challenge. Proper Vaccination does not reach to children who belong to these remote places.

Insights:

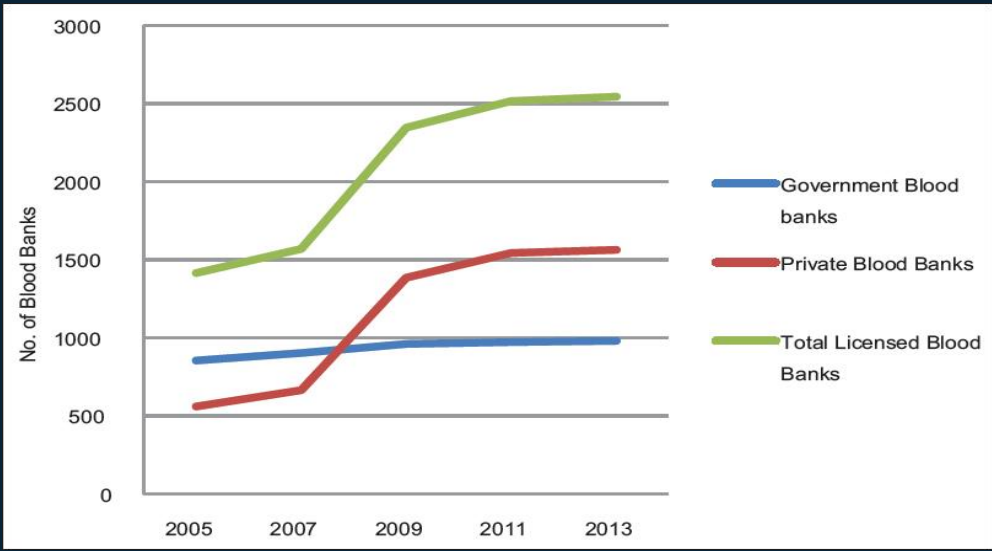
- The Cold Chain System in India is unorganized and fragmented.
- Most cold chains avoid investing in sophisticated equipment's for transport due to economic crisis.
- The most commonly used containers are Thermocol Boxes which are not just harmful for the Blood sample and Vaccine but also hazardous for Environment.
- For transporting small quantities, non-medical staff (patient's relatives) usually do it and discard it after use.

Primary Research:

- There are several products existing in the market.
- After looking closely into each and every product we listed the drawbacks in the existing products-
    - Lack of space
    - Cost
    - Different requirements for Blood, FFP (Fresh Frozen Plasma), Platelet, RBCs
    - Quality Issues
    - Compliance Issues
    - Temperature range

"Despite the current advances in technology in health-care delivery, access to safe blood and blood products and their judicious use remains a big challenge for the world. While the demand for blood is increasing in the developed nations resulting in longevity of life, country-specific blood stocks are barely adequate to meet basic requirements in developing nations."

- "Current status of blood banks in India" by Vikas Bhatia, Babita Raghuwanshi, Jyotiranjan Sahoo [5]



Statistics of Indian Subcontinent

According to Economic Times (2019 Report) [6] -

- WHO estimates that blood donation by 1% of the population is generally the minimum to meet a nation's most basic need for blood.
- In India's case, as per the data of 2016-17, there was a shortage of 1.9 million vis-à-vis the WHO norm.
- The blood transfusion service in India is unorganized and fragmented, as a result of which there is limited or almost negligible connectivity or communication between blood banks, and each operates in near isolation.

- While states like Maharashtra and Delhi are nearly self-sufficient in blood, most of the other states, especially those in the western belt, still face dire life-threatening shortages.

AIIMS Bhubaneswar also had some similar views over this matter [7] -

- Indian blood transfusion network is plagued by factors like inadequacy of blood storage centers, lack of proper facilities, storage & quality of services, etc.
- The total recorded blood collection in India is four million units, which meet only 40% of need against a minimum requirement of 10 million units.

Similarly, for Vaccines -

> "Childhood immunization is one of the most cost-effective health interventions. Since most vaccines are sensitive to heat, an adequate cold-chain system often has to be created and maintained to preserve the quality of a vaccine before it is administered. The World Health Organization (WHO) recommends that all childhood vaccines except the oral polio vaccine be kept at **2–8 °C** during their in-country distribution."
>
> - "Frequent exposure to suboptimal temperatures in vaccine cold-chain system in India: results of temperature monitoring in 10 states" – A WHO Report [8]

The Economist studied and reported how the vaccines are exposed to temperature below the lower limit. [9]

Science & technology

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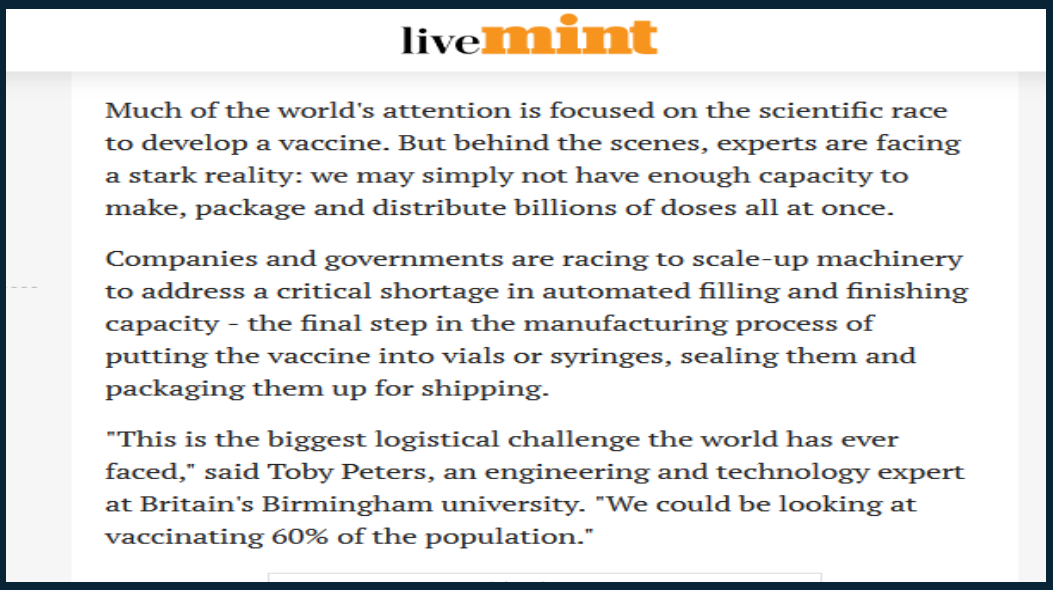
Taking stock

Managing supplies of vaccines is a huge problem

New research asks how often vaccines are exposed to temperatures below the lower limit

Much of the world's attention is focused on the scientific race to develop a vaccine. But behind the scenes, experts are facing a stark reality: we may simply not have enough capacity to make, package and distribute billions of doses all at once.[10]



livemint

Much of the world's attention is focused on the scientific race to develop a vaccine. But behind the scenes, experts are facing a stark reality: we may simply not have enough capacity to make, package and distribute billions of doses all at once.

Companies and governments are racing to scale-up machinery to address a critical shortage in automated filling and finishing capacity - the final step in the manufacturing process of putting the vaccine into vials or syringes, sealing them and packaging them up for shipping.

"This is the biggest logistical challenge the world has ever faced," said Toby Peters, an engineering and technology expert at Britain's Birmingham university. "We could be looking at vaccinating 60% of the population."

Secondary Research:

The stakeholders for our project -

- Doctors
- Blood Bank staff
- Paramedic staff

We created a form to enquire upon the following aspects (Guided by our Mentor)-

1. Finding problems in Blood storage
2. Finding problems in the current methods of blood storage
3. What according to them should be an ideal blood cooler?
4. How might we make the cooler more user friendly and user specific?

Our secondary research was conducted in two ways as follows-

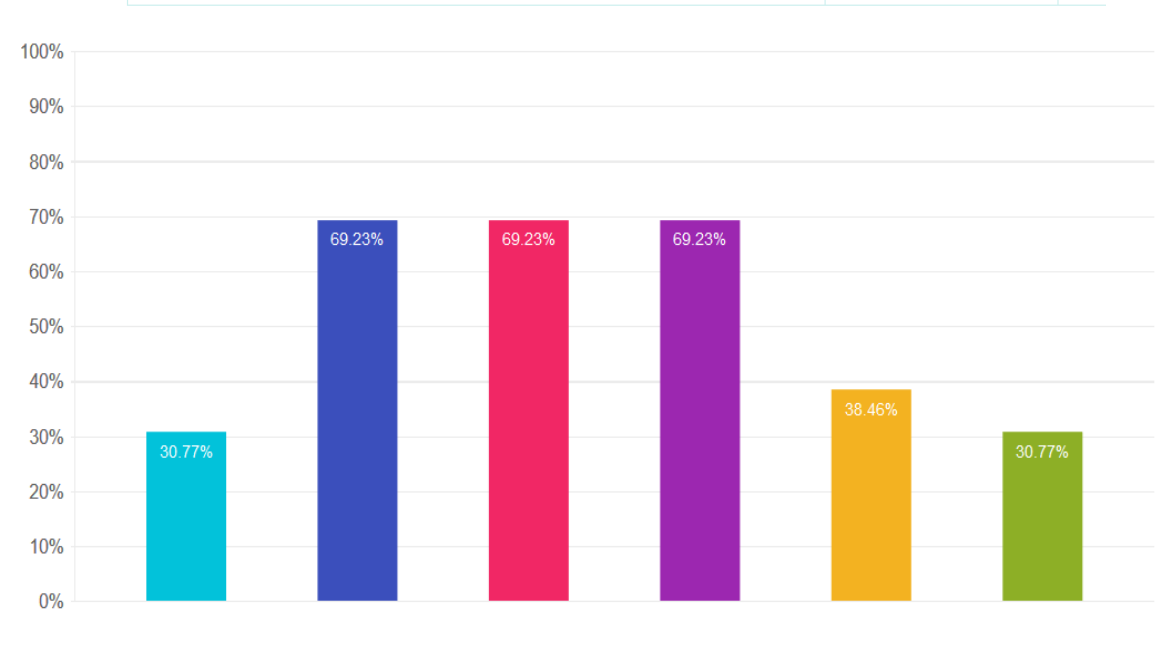
1. **ONLINE SURVEY**

The form for Online Survey was circulated to amongst the professionals. Questions were concerned with their current used product and what are the problems faced in it. They were also asked about the features they require in an ideal container and their suggestions.

The graphs and statistics from the survey is given below –

Q.1) What do you think are the major problems currently faced in transportation of blood in India?

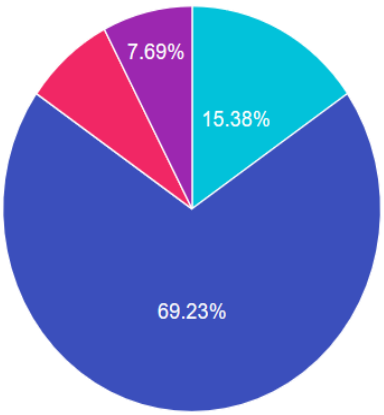
Choices	Response percent
Lack of enough boxes for transport/Boxes having low capacity	30.77%
Boxes not able to maintain temperature for long/Not well insulated	69.23%
No way of knowing the temperature at which blood is kept in the box	69.23%
Hospitals not being able to afford quality boxes (or not willing to)	69.23%
Paramedic staff unable to transport it properly	38.46%
Other (Please specify) Show 4 responses	30.77%



Q.2) Which of the boxes do you think is most commonly used?

Image choice	Response percent
 Thermocol box with ice packs	15.38%
 Insulated Plastic box with ice packs	69.23%
 Insulated bag with ice packs	7.69%
 Refrigerated box with temperature regulation	7.69%
 Refrigerated box with temperature regulation, but with wheels	0.00%

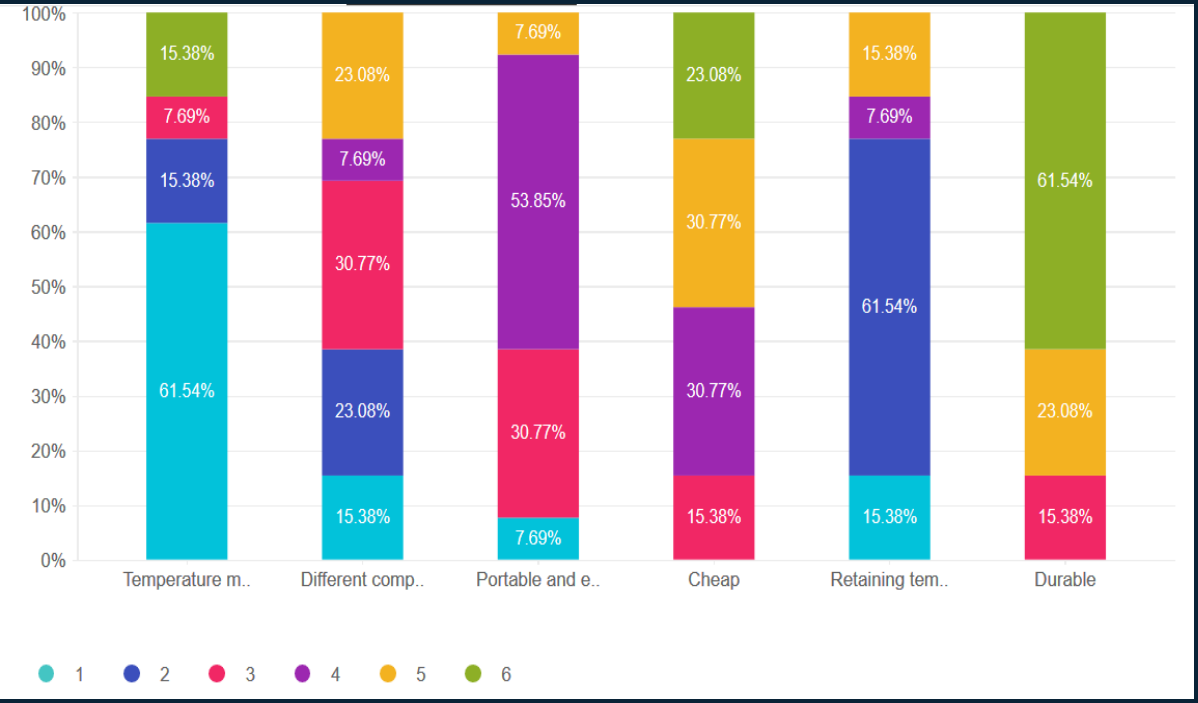
Any other? Please specify. Show 1 response



Thermocol box with ice packs
Insulated Plastic box with ice packs
Insulated bag with ice packs
Refrigerated box with temperature regulation
Refrigerated box with temperature regulation, but with wheels

*Although most of the respondents believed that 'Insulated Plastic Boxes' were the most commonly used products, but this is not true. In reality, thermocol boxes are used the most.

Q.3) What according to you is required the most in a blood cooler? (1 means it's extremely important and 6 means it's not very important)

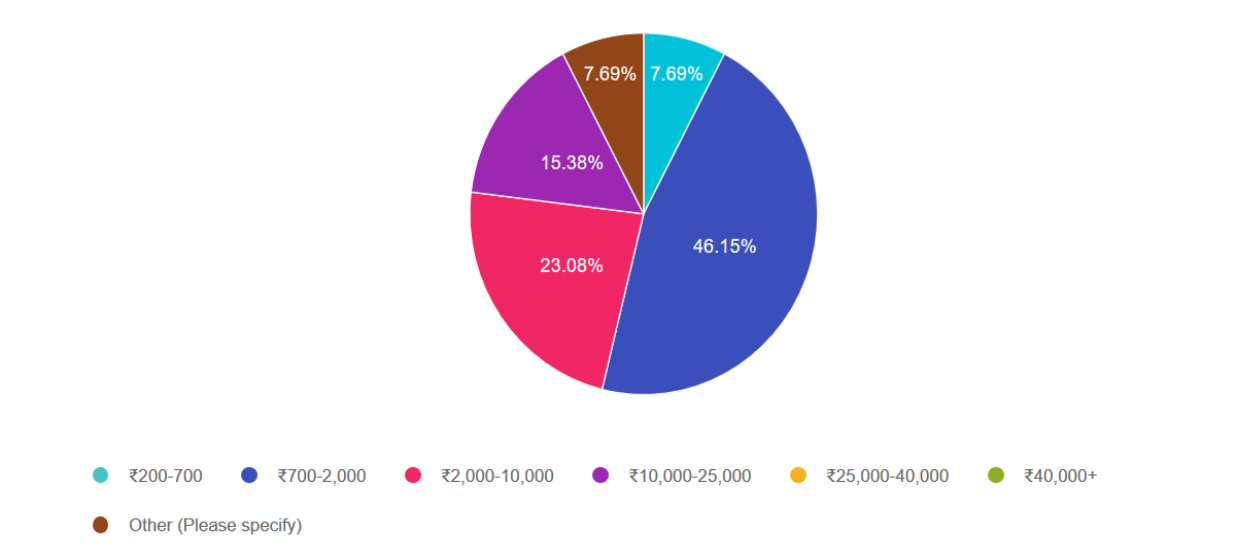


Ranking of the features most desirable –

1. Temperature Monitoring and Display
2. Retaining Temperature for long
3. Different compartments for different samples
4. Portable and Easy to carry
5. Cheap
6. Durable

Q.4) How much do you think would be a reasonable cost for a Blood transport container?

Choices	Response percent
₹200-700	7.69%
₹700-2,000	46.15%
₹2,000-10,000	23.08%
₹10,000-25,000	15.38%
₹25,000-40,000	0.00%
₹40,000+	0.00%
Other (Please specify) Show 1 response	7.69%



In this survey form, the professionals emphasized on including Vaccines as well in our study. Team had plans to include the same. This survey made it clearer.

2. TELEPHONIC INTERVIEW

We interviewed around 11 people including doctors, surgeons & paramedic staffs telephonically.

Followings are the answers to some of the questions-

Q1. What are the major issues faced during transportation of blood?

(i) Lack of enough boxes.

(ii) Lack of proper temperature maintenance

(iii) Lack of durable materials which maintains temperature for long.

Q2. Which materials are used?

A. Mainly thermocol boxes are only used for transportation of blood from top blood banks to hospitals.

Q3. Why are thermocol boxes used instead of other blood coolers available?

A. Usually the blood is given from blood banks to the relatives of the patients and not every time a paramedic staff transports the blood to hospitals/patients. Hence, thermocol boxes are preferred because of its cost-effective and handy not special training is required to handle thermocol boxes.

Also, relatives do not care much to return the boxes to blood banks and leave the boxes in hospitals itself where they are discarded and not reused.

Q4. What are major drawbacks of thermocol boxes?

A. (i) Non-biodegradable hence, harmful for environment
(ii) Temperatures cannot be maintained over a range hence, only a specific blood component can be transported at a time.
(iii) only can be used for a smaller duration for transportation to small distances.

Q5. Other issues apart from blood that needs a portable cooler?

A. Many of them answered that transportation of Vaccines to remote areas, villages, etc. is a major issue as vaccines also need a proper temperature in which it can be stored and transported. If temperature is not maintained vaccines lose its viability and cannot be given to children. Also, if these things are not taken into consideration it can create major health problems.

Current Progress:

- Problem Statement Defined.
- Discovery Phase successfully completed with Primary and Secondary Research over the topic.

Next Step:

- Creating a prototype design that fulfils the requirements.
- Making it economical, portable and user friendly.

References :

[1] Cold Chain Definition –

https://en.wikipedia.org/wiki/Cold_chain

[2] Blood Cold Chain -
https://www.who.int/bloodsafety/testing_processing/components/en/BloodColdChain.pdf?ua=1

[3] Vaccine Cold Chain Case Study -

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3898445/

[4] Vaccine Handbook –

https://www.paho.org/immunization/toolkit/resources/partner-pubs/ebook/Chapter5-Vaccine-Storage-and-Handling.pdf?ua=1

[5] & [7] Current status of blood banks in India

http://www.gjtmonline.com/article.asp?issn=2455-8893;year=2016;volume=1;issue=2;spage=72;epage=74;aulast=Bhatia

[6] Economic Times Report 2019 –

https://health.economictimes.indiatimes.com/news/policy/blood-transfusion-service-in-india-continues-to-be-unorganized-and-fragmented-suryaprabha-sadasivan/69780706

[8] WHO Report –

https://www.who.int/bulletin/volumes/91/12/13-119974/en/

[9] Economist Report

https://www.economist.com/science-and-technology/2017/04/01/managing-supplies-of-vaccines-is-a-huge-problem

[10] Livemint Report –

https://www.livemint.com/news/india/if-a-coronavirus-vaccine-is-developed-what-will-be-the-next-challenges-11593150035999.html

Design and Solution

After completing research, team defined problem statement as –

"Portable Container for Blood and Vaccines"

From the research, it was found out that the temperature range for Vaccine and Whole Blood Samples is similar. The aim of this week was designing the prototype.

Following are the components used in temperature control system-

1. ***Thermoelectric Peltier Module*** –

   A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current.[11]

   Thermoelectric coolers operate according to the Peltier effect. The effect creates a temperature difference by transferring heat between two electrical junctions. A voltage is applied across joined conductors to create an electric current. When the current flows through the junctions of the two conductors, heat is removed at one junction and cooling occurs. Heat is deposited at the other junction.[12]

   While they're useful for those purposes, they're not very efficient. Only around 5% of the electrical energy used to power them gets used for cooling. [13]

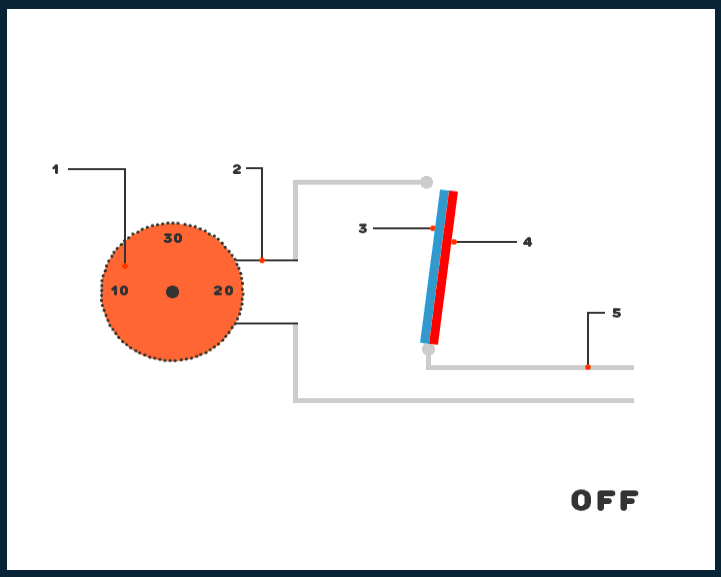
   Now this problem was solved by designing the circuits in a manner that Peltier module brings down the temperature, it stops using power and then temperature is maintained for as long as possible. Again, when the

temperature rises above a certain point, the Peltier module is switched on till the temperature is brought down to a marked point.

2. *Thermostat –*

Thermostat is a heat-activated switch that comes with a temperature sensor. This switch opens or closes, causing the electrical circuit that is responsible for the heating and cooling to get completed or interrupted.
Thermostats work on the principle of thermal expansion. This principle governs the switching off or on of the electric circuit.[14]

This would control the Peltier Module and switch it off and on when the temperature reached a certain point.



Mechanical Device

Electrical Device

3. ***Rechargeable Battery***

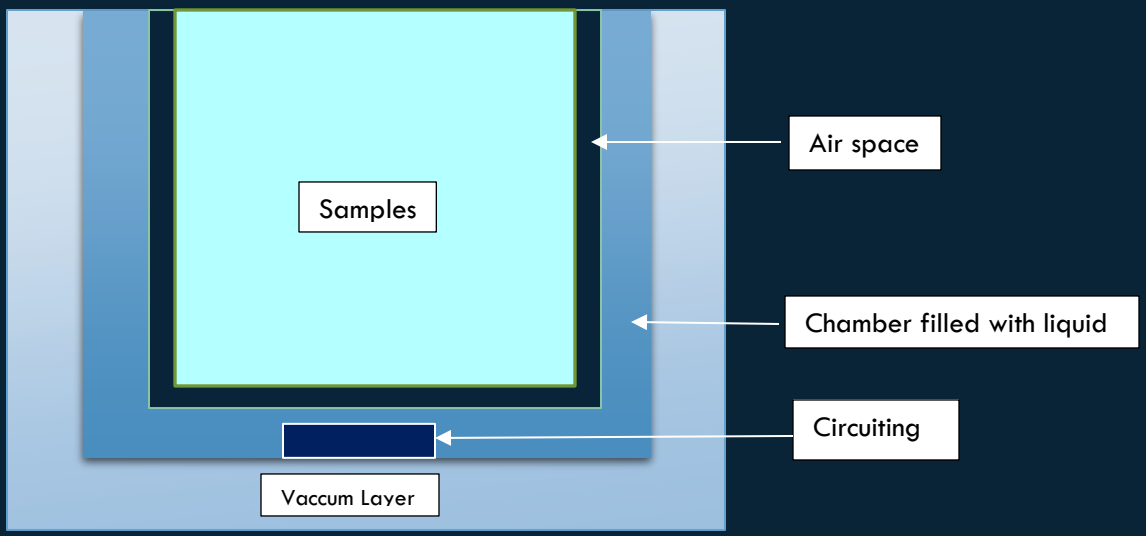
   Battery would be rechargeable so that it lasts long.

4. ***Vaccum Layer***

   Adding a Vaccum Layer would help the device retain temperature for a longer period of time. This would ensure that Peltier module is turned on for a lesser amount of time, hence using less battery for the same.

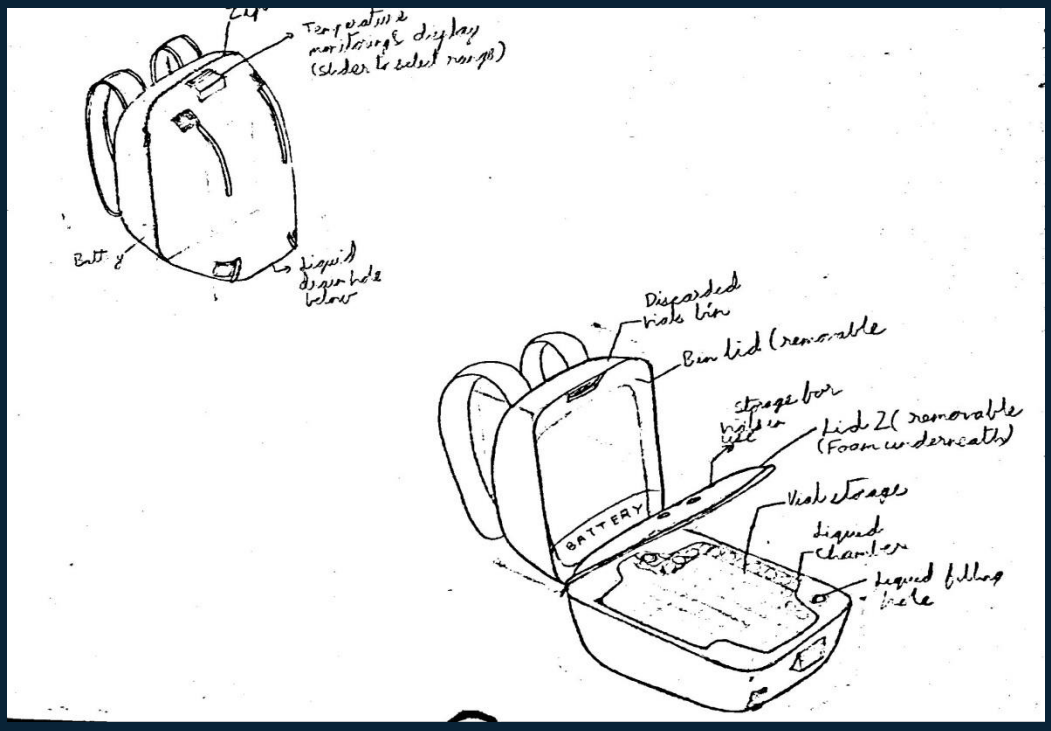
5. ***Air Separation***

   A space between the samples and the cooling layer would be provided so that condensation does not erase the important markings in the vials and blood samples.

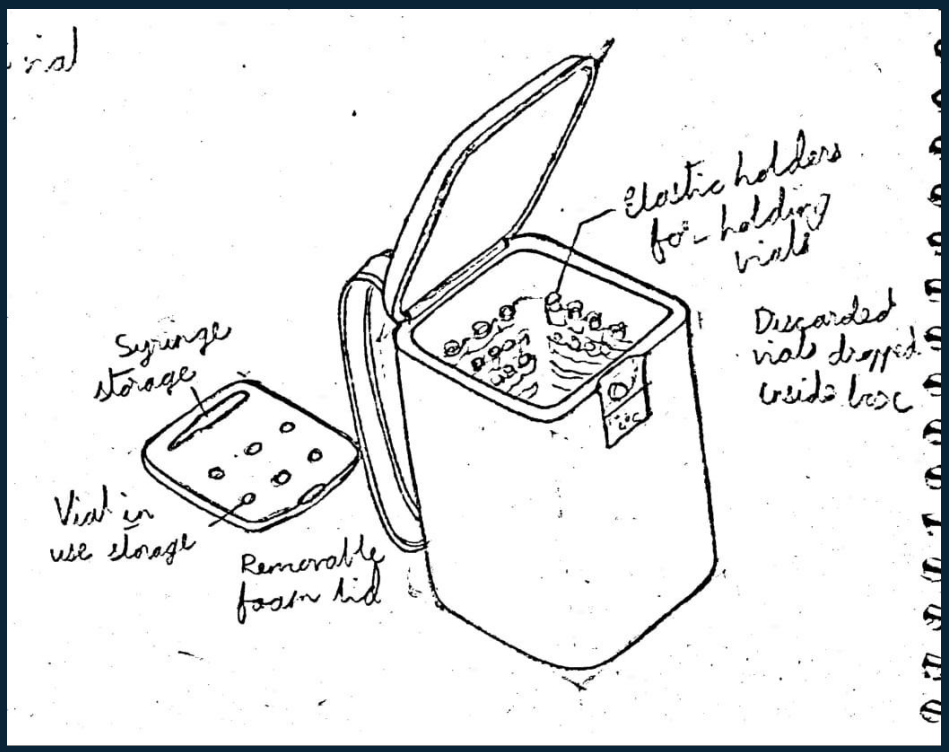


Sketches for the Prototype –

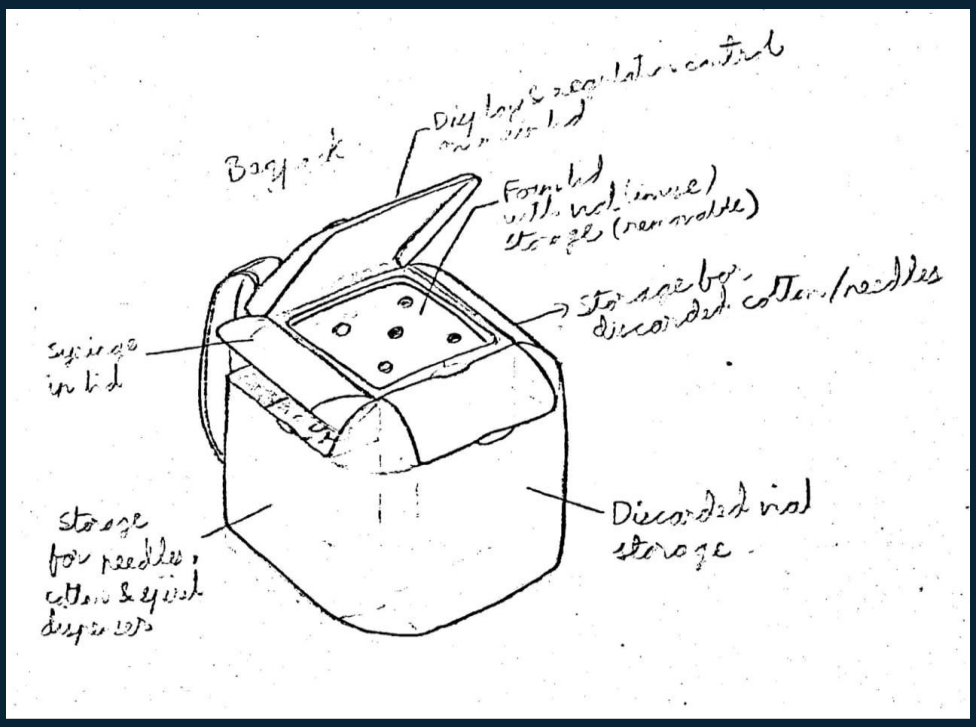
1.



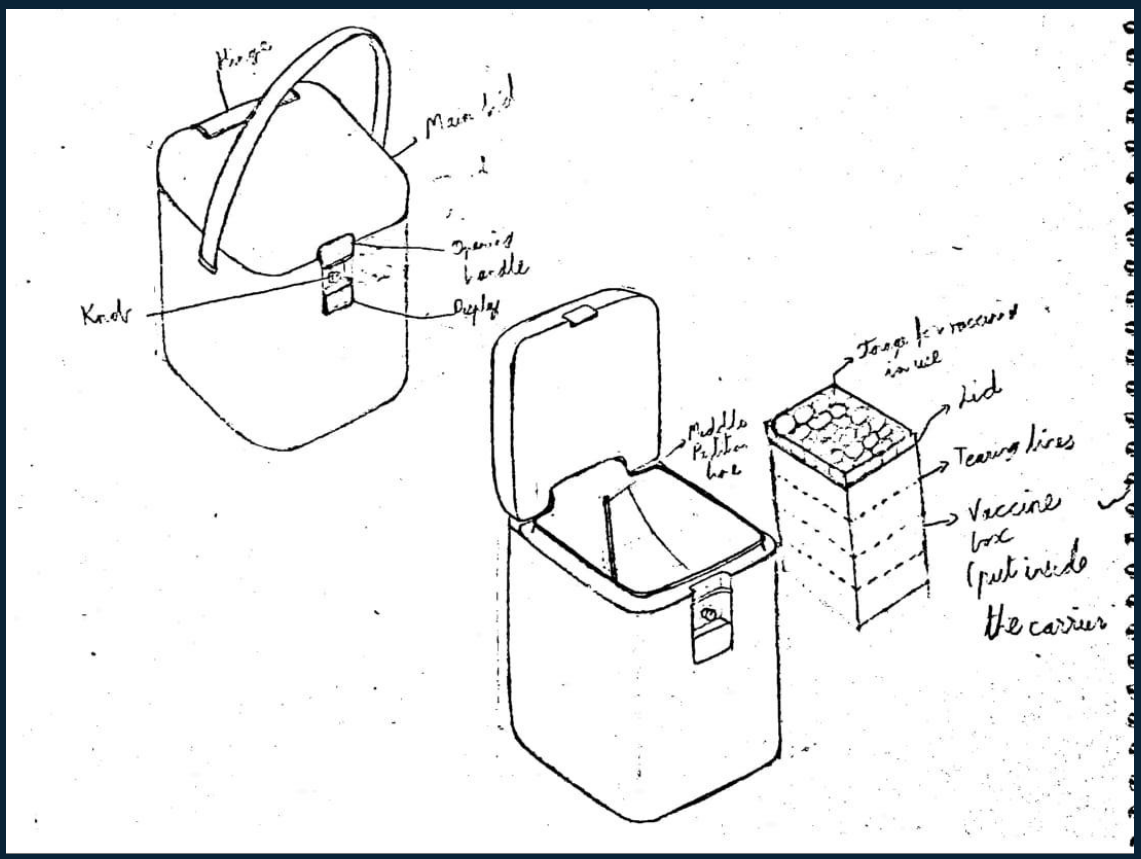
2.



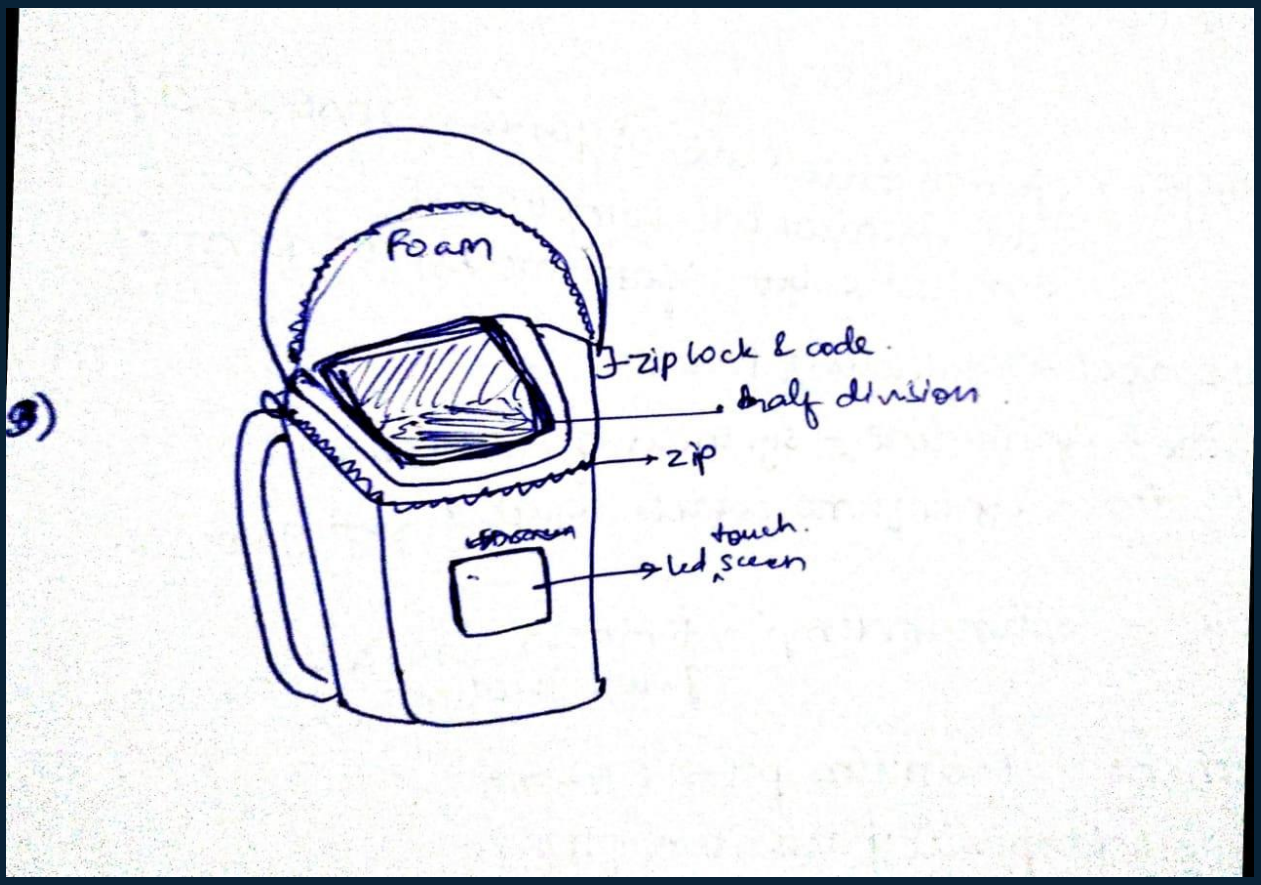
3.


Bag pack
Discarded vial storage

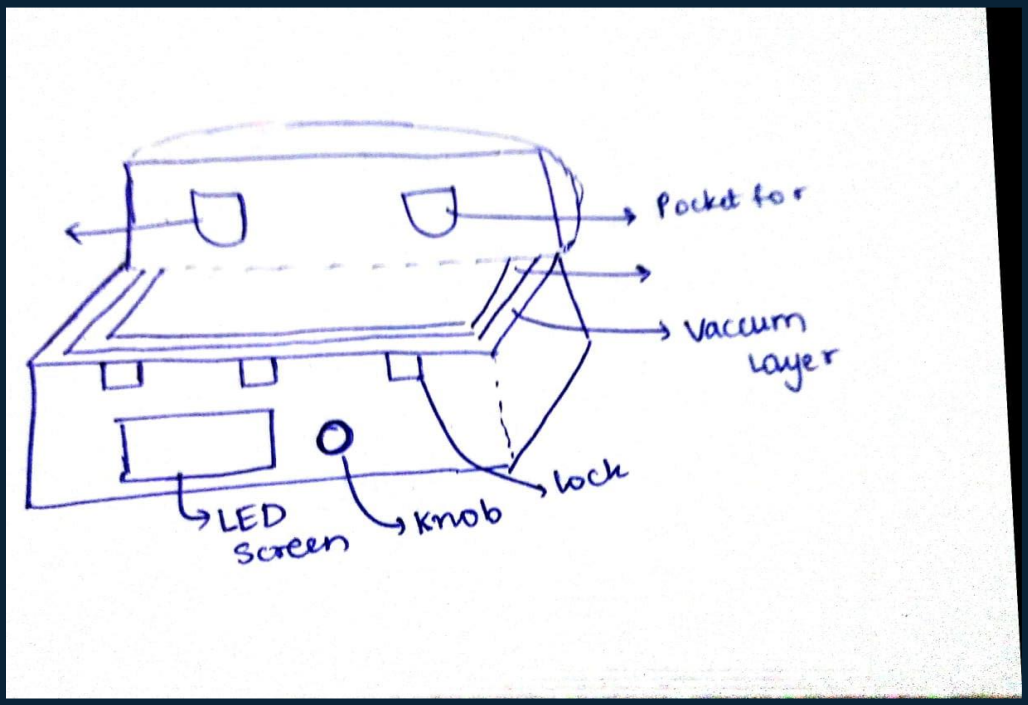
4.


Lid
Tearing lines
Vaccine box (put inside the carrier

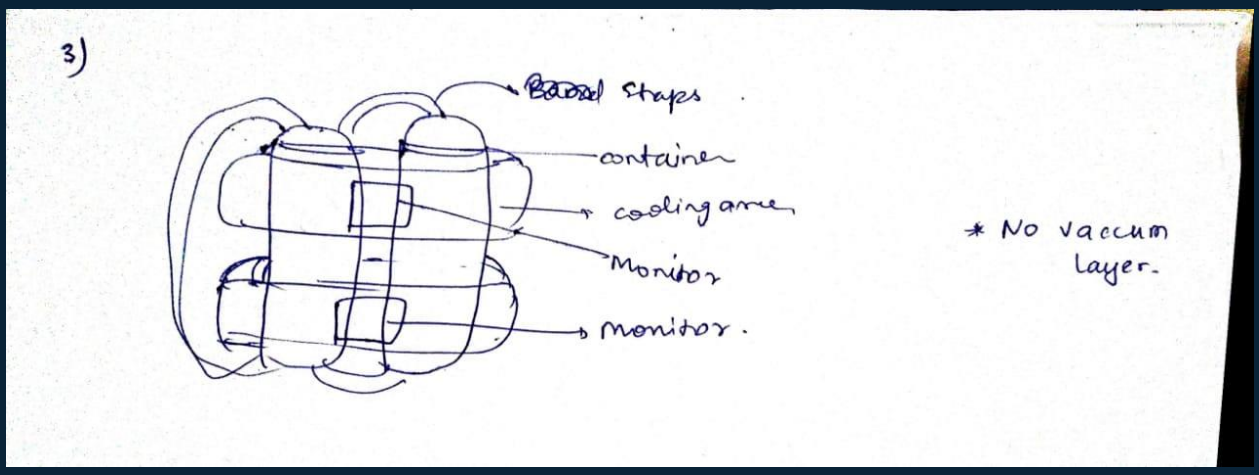
5.


Foam
zip lock & code.
half division.
zip
touch.
led screen

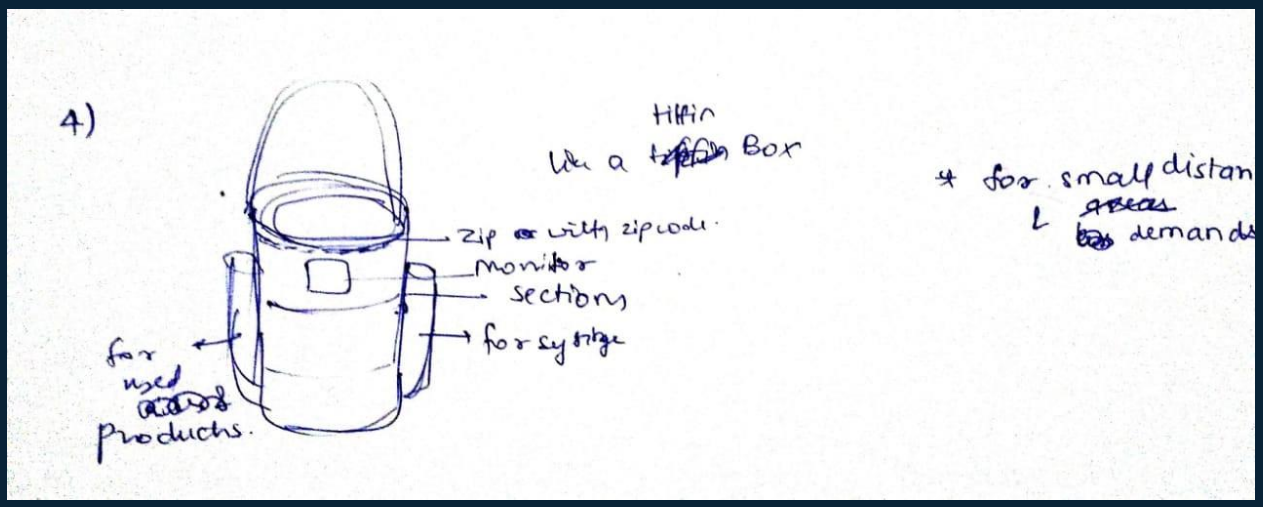
6.


Pocket for
vacuum layer
lock
LED screen
knob

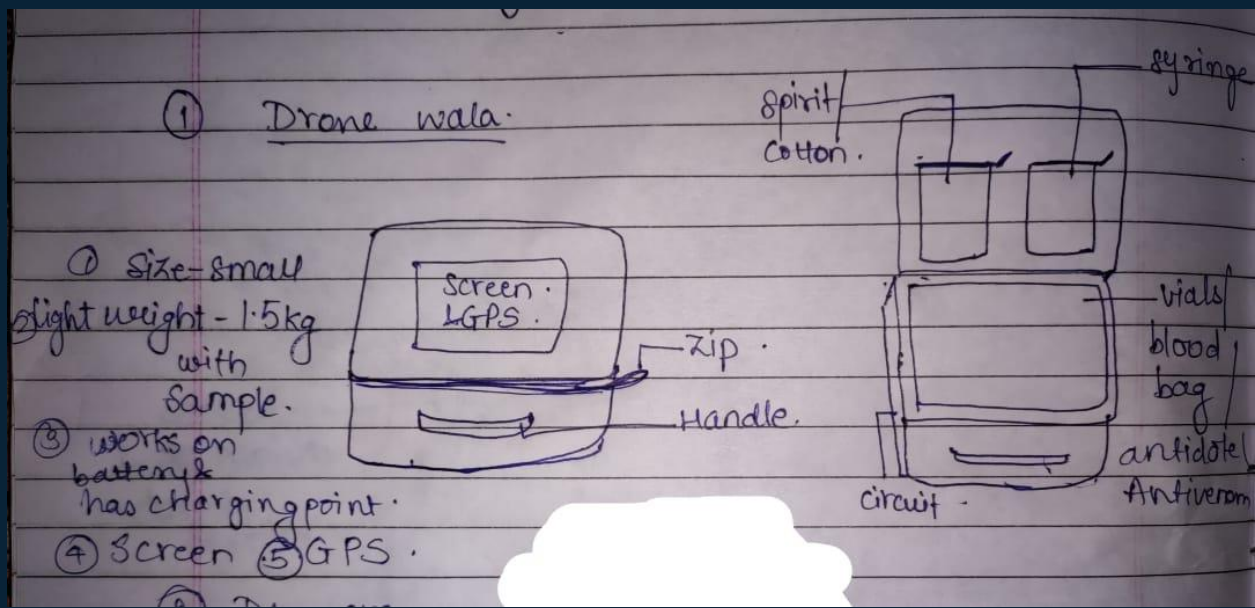
7.


3)
Straps
container
cooling area
Monitor
monitor.
* No vaccum layer.

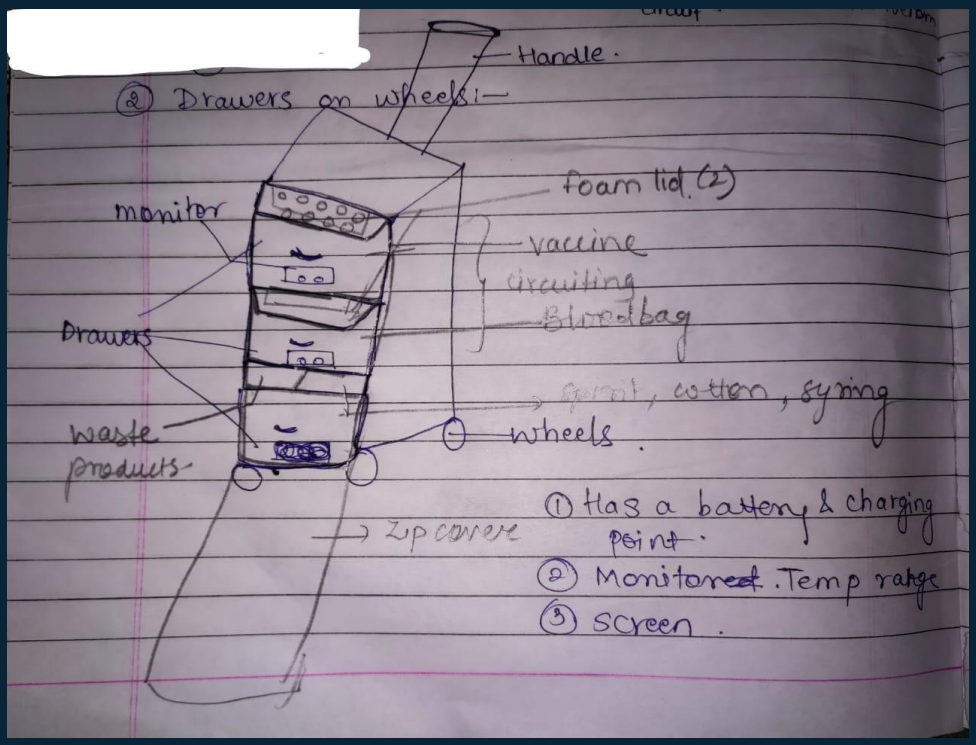
8.


4)
Like a Box
zip with zipcode.
monitor
sections
for syringe
for used products.
* for small distan

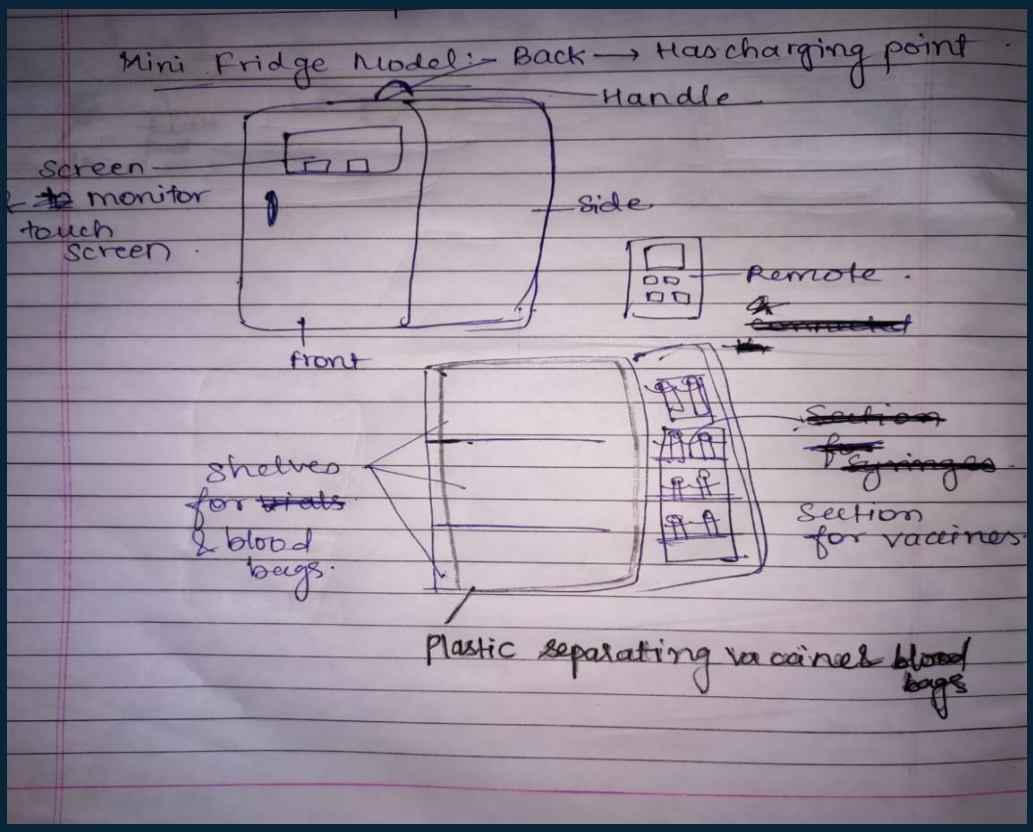
9.


① Drone wala.
② Size - small
③ light weight - 1.5kg with sample.
④ works on battery & has charging point.
⑤ Screen ⑥ GPS.
Screen. GPS.
Zip.
Handle.
spirit
cotton.
syringe
vials
blood bag
antidote
Antiveno
circuit.

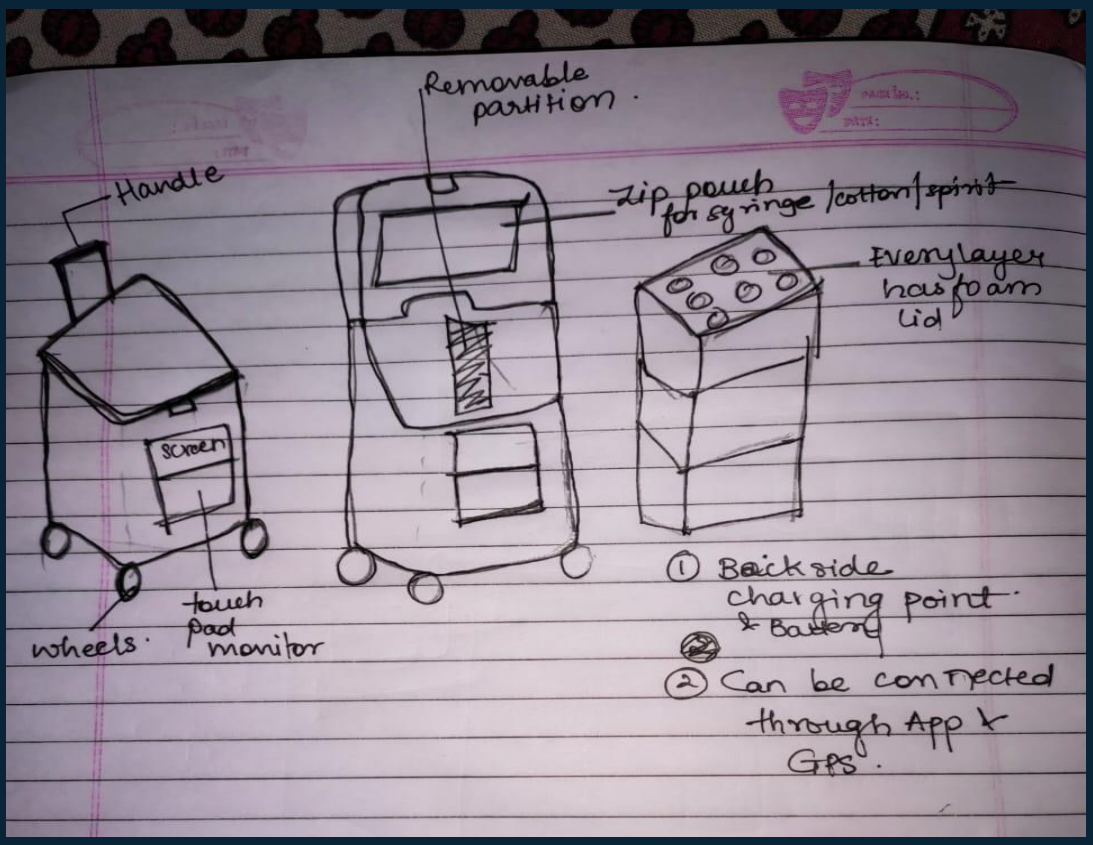
10.


Handle.
② Drawers on wheels:-
foam lid. (2)
monitor
vaccine
circuiting
Blood bag
Drawers
spirit, cotton, syring
waste products
wheels.
① Has a battery & charging point.
② Monitor. Temp range
③ Screen.
Zip covers

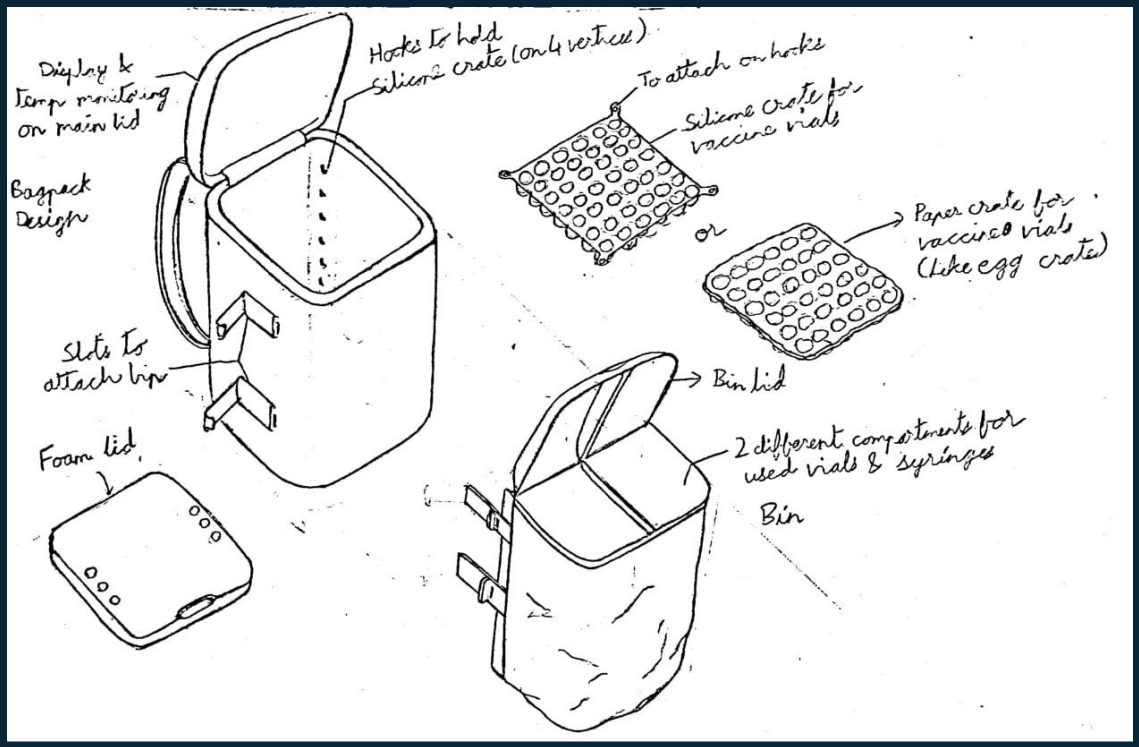
11.


Mini Fridge Model:- Back → Has charging point
Handle
Screen
monitor
touch screen.
Side.
Remote.
Front
Section for Syringes.
shelves for vials & blood bags.
Section for vaccines.
Plastic separating vaccines & blood bags

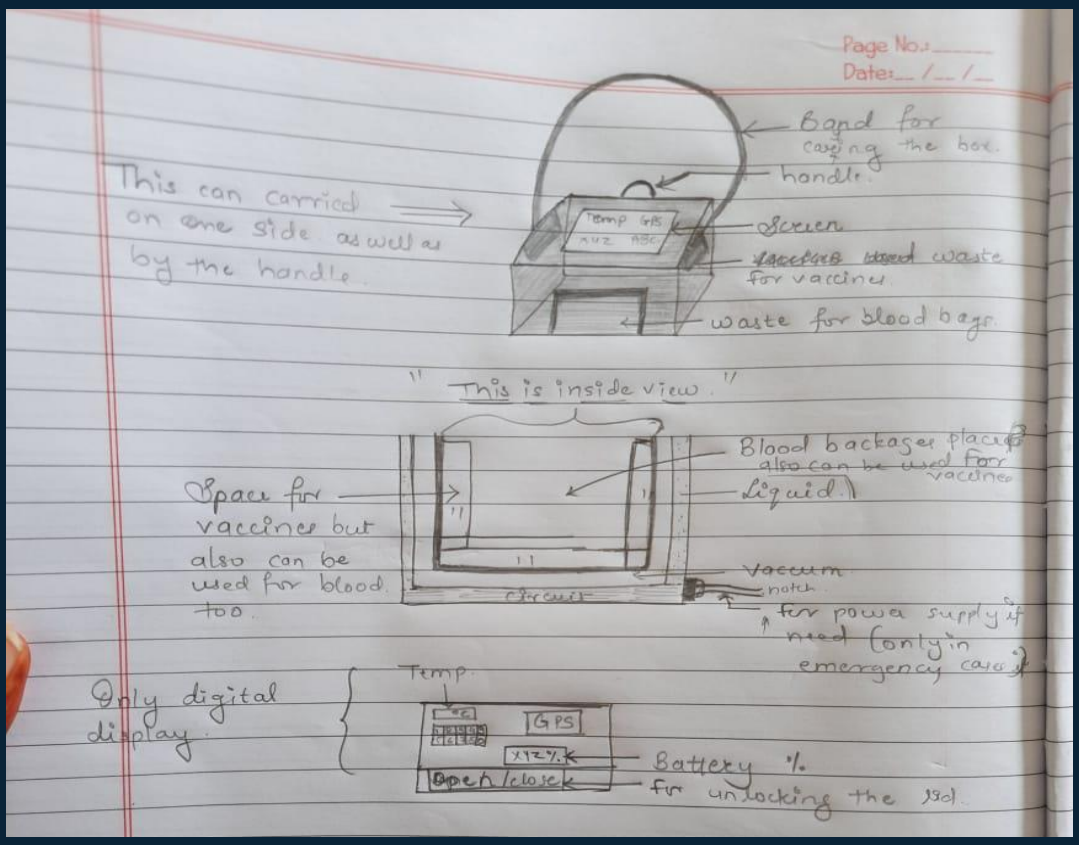
12.


Removable partition.
Handle
Zip pouch for syringe /cotton/spirit
Every layer has foam lid
screen
touch pad monitor
wheels.
① Back side charging point & Battery
② Can be connected through App & GPS.

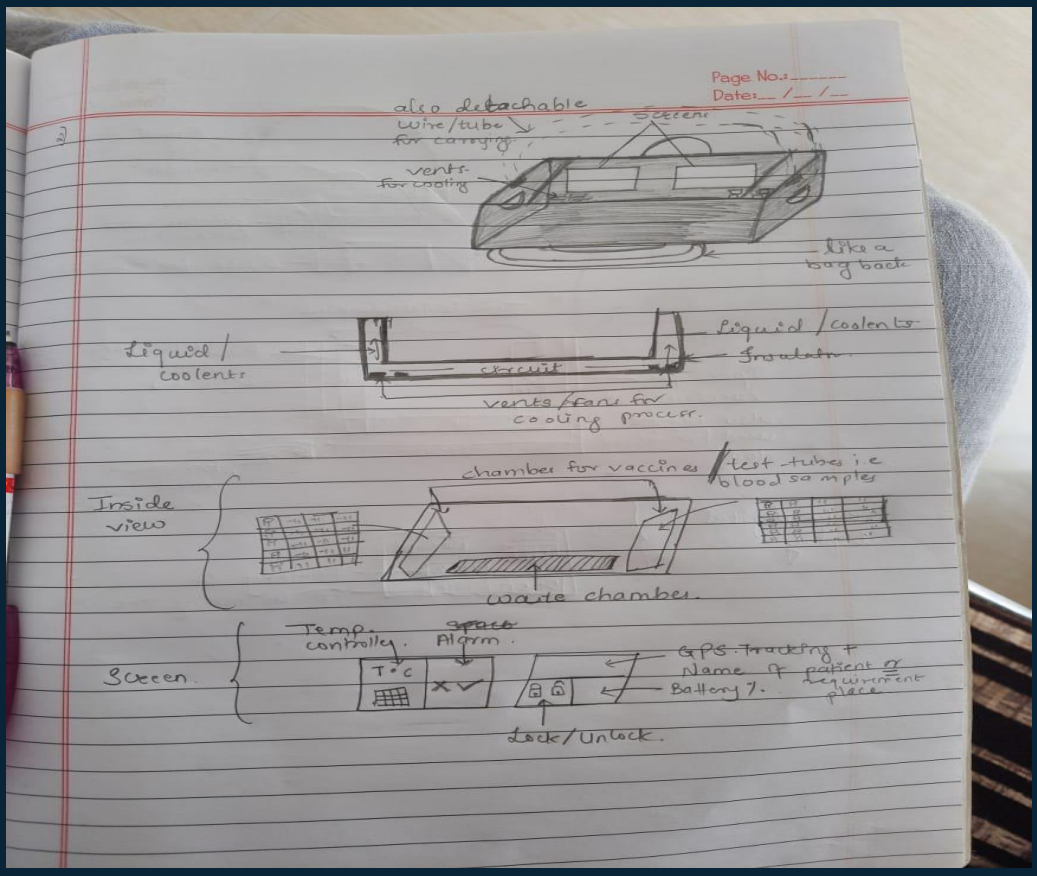
13.


Display & Temp monitoring on main lid
Backpack Design
Hooks to hold Silicone crate (on 4 vertices)
To attach on hooks
Silicone crate for vaccine vials
or
Paper crate for vaccine vials (like egg crate)
Slots to attach bin
Bin lid
Foam lid
2 different compartments for used vials & syringes
Bin

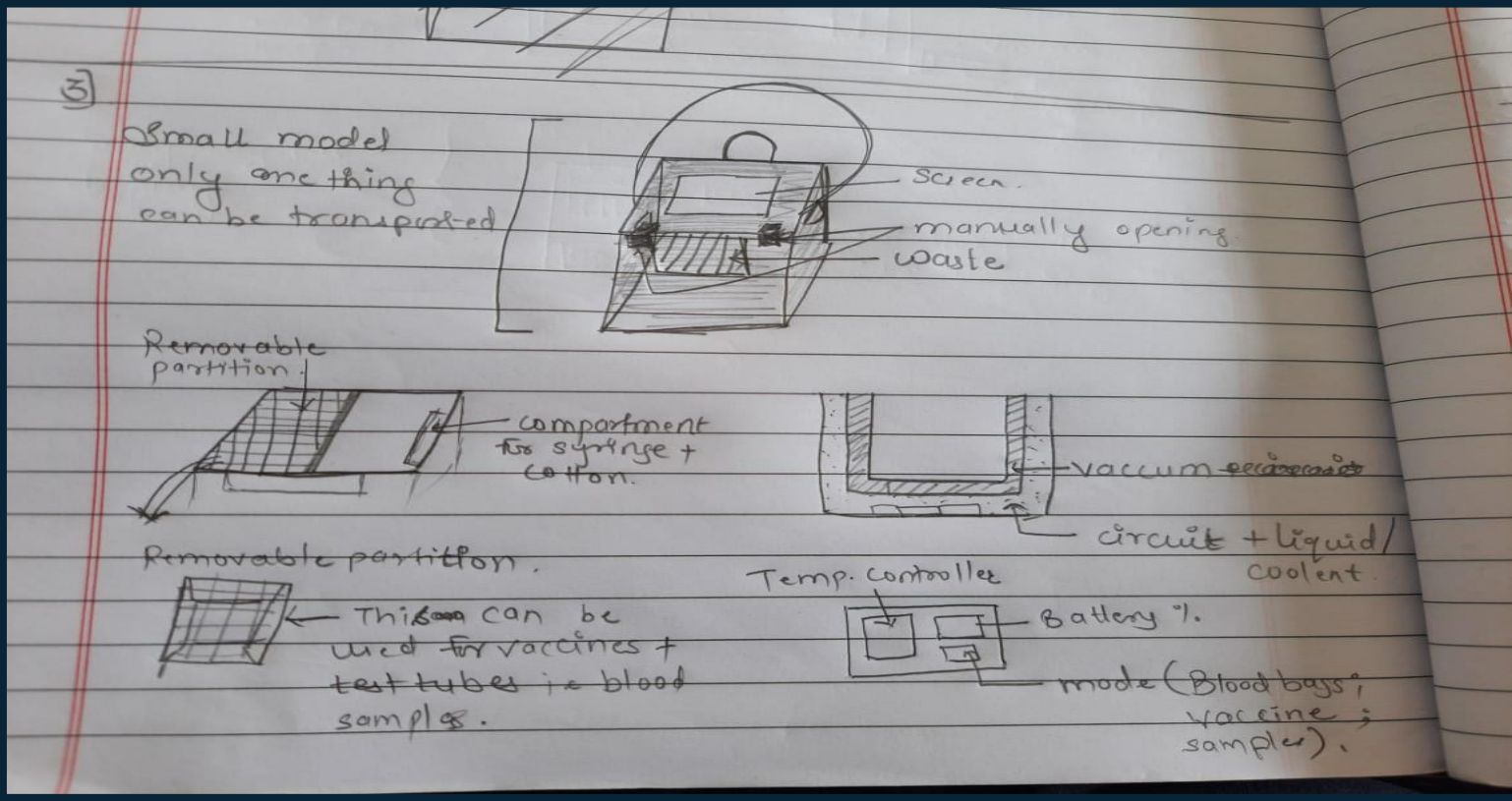
14.


Page No.:
Date:__/__/__
This can carried on one side as well as by the handle.
Band for carrying the box.
handle
Screen
waste for vaccines
waste for blood bags
" This is inside view "
Blood backages placed also can be used for vaccines
Liquid
Space for vaccines but also can be used for blood too.
Vacuum notch
circuit
for power supply if need (only in emergency case)
Only digital display
Temp.
GPS
Battery %
for unlocking the box

15.


Page No.:
Date:__/__/__
also detachable
Wire/tube for carrying
Screen
vents for cooling
like a bag back
Liquid / coolents
circuit
vents/fans for cooling procces
chamber for vaccines
test tubes i.e blood samples
Inside view
waste chamber
Temp. controlley
Alarm
Screen
T°C
GPS tracking + Name of patient or instrument place
Battery %
Lock/Unlock

16.


3]
Small model only one thing can be transported
Screen.
manually opening
waste
Removable partition.
compartment for syringe + cotton.
vaccum
circuit + liquid/ coolent
Removable partition.
This can be used for vaccines + test tubes ; e blood samples.
Temp. controller
Battery %.
mode (Blood bags; vaccine ; sampler).

References –

[11] Thermoelectric Peltier Cooler –

https://en.wikipedia.org/wiki/Thermoelectric_cooling

[12] Thermoelectric Principle –

https://www.marlow.com/how-do-thermoelectric-coolers-tecs-work

[13] Efficiency of Thermoelectric Peltier Module –

https://rimstar.org/science_electronics_projects/peltier_effect_module_cooling_efficiency_test.htm

[14] Thermostat definition and working principle –

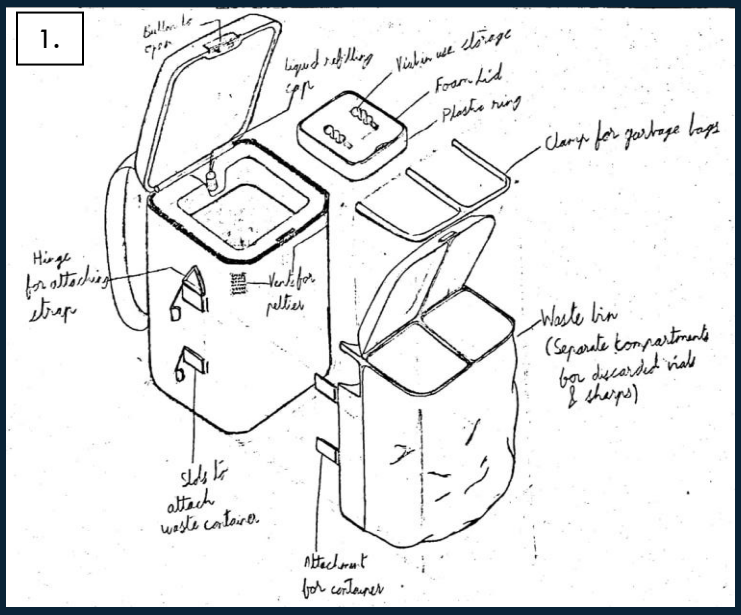
https://www.circuitstoday.com/how-thermostat-works

Week 3

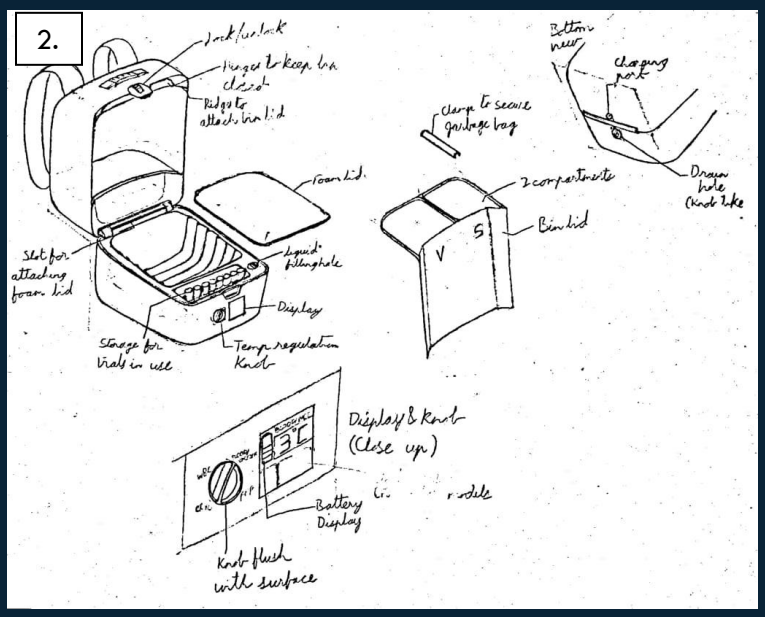
Prototyping

Out of 16 designs, 2 were selected after a mind storming discussion.

1.

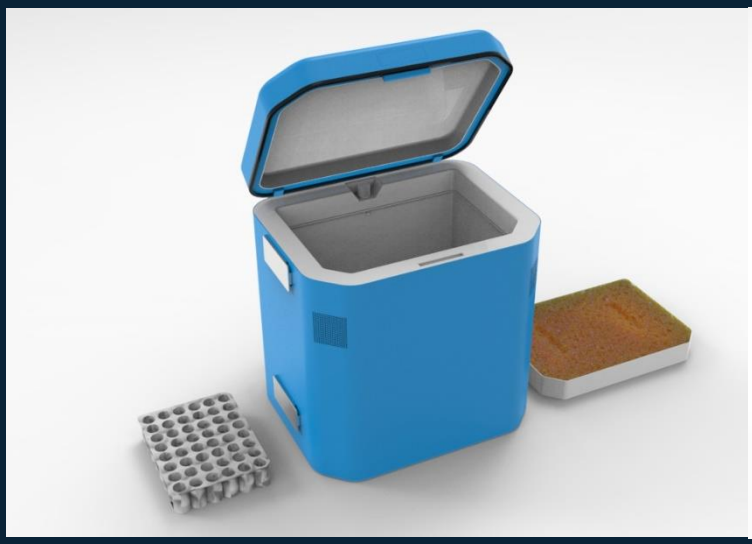


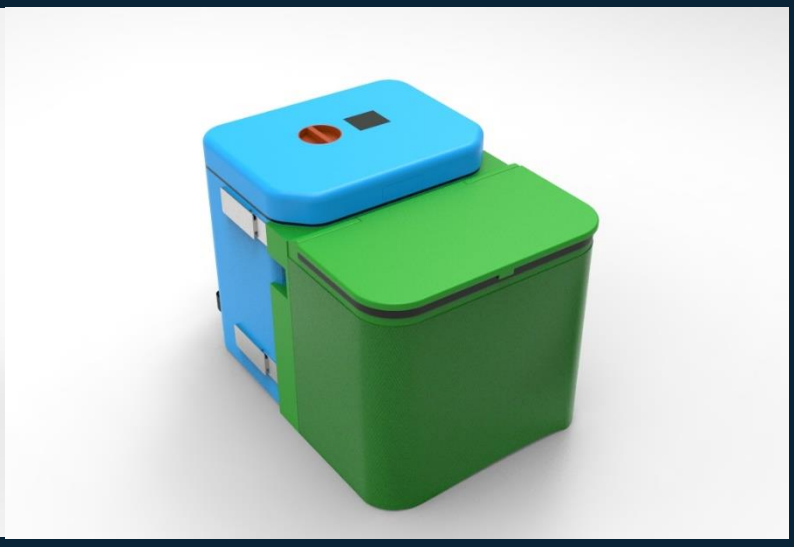
2.



Out of these, the first design was finalized. Design 2 had some issues which were solved by the first design. One of them was extra packaging to prevent any leakage due to travelling.

FINAL DESIGN –





MOOC MODEL -

INNER CHAMBER

Features of our final design –

- Thermoelectric Peltier module
- Arduino with Temperature sensor
- Longer Retaining capacity
- Additional space for biomedical waste
- Digital display with temperature regulation
- User and pocket friendly design

Improvements in further stages –

- Additive features like App and GPS.
- More portable design dedicated to drone service for emergency purposes.
- Contact-less approach
- Including Medical box into our product
- Improving material quality

MARKET ANALYSIS –

Features that make us stand out in the market –

- Ousting Ice packets
- Additional space for biomedical waste
- Common container for Blood samples and Vaccine
- 10 litre capacity
- Eliminating errors due to condensation
- Packaging area defined

Market size and Customer segment –

- Private and Government Hospitals
- PHCs, SHCs, THCs
- Pathology labs
- Blood banks
- Immunization Centers
- Clinics

Cost Estimation –

Here all the cost taken is the retail price. It is all subjected to change.

Product	Retail Price
HDPE granules - 5kgs	₹300
Polyurethane foam	₹2
Heat Sink	₹600
Temperature sensor	₹70
Arduino	₹260
LCD screen	₹250
Peltier	₹390
Bag Strap	₹100
Battery	₹500

TOTAL ESTIMATED COST- ₹2500

(Retail cost subject to change)

Future Revenue Streams –

- Packaging of vaccines and garbage bags specific to our product
- Covid 19 Vaccine program would create a big market for our product.
