ME338 Project : Hand Pump

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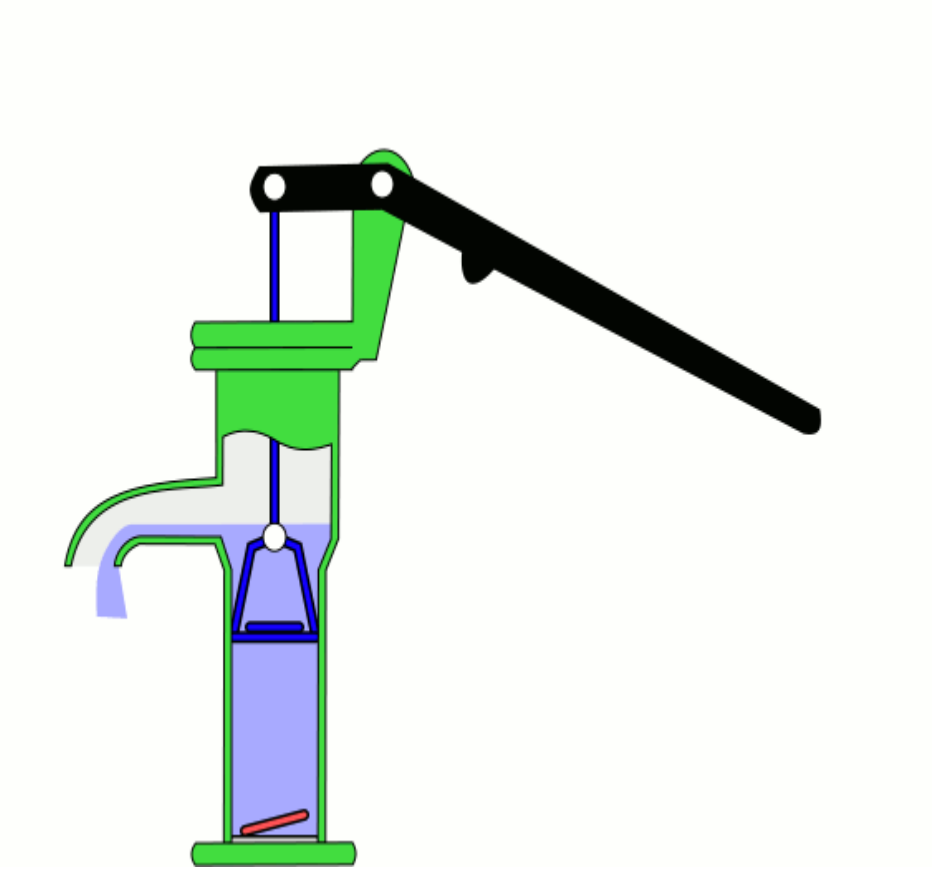

Reference: https://commons.wikimedia.org/wiki/File:Hand_pump_-_Animation_with_soil.gif

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10.09.2022

Stage 1

Title :

Manufacturing of Hand Pump

Team Members :

- Swapnoneel Kayal
- Amshuman Sashi
- Rohit Sankhala

Role of Team Members -

- Swapnoneel Kayal - Materials and Process Selection, Cost Analysis, Documentation
- Amshuman Sashi - Design, Components, Assembly, Final Inspection
- Rohit Sankhala - Product Description & Applications, Equipment Requirements for Manufacturing & Finishing

Stage - 2

Description :

Hand pumps are manually operated pumps. They use human power and mechanical advantage to allow the easy transfer of fluids from one location to another effectively. The specific application of our pump would be to transfer water from a well, which is below ground, to a bucket or some other means of storage, above the ground.

The **piston** is connected to a **shaft**, located inside the main body of the pump, providing enough suction to overcome the effects of gravity, effectively drawing water into the main body. Once the water has made its way into the pump and is trapped by the **foot valve**, the piston on its downward stroke allows the water to travel through its large inner hole and past a one-way valve located on top of the piston, the **one-way valve** then seals the water above the piston and the upwards stroke begins, lifting the water up until it escapes out of the **PVC junction**'s side exit.

Applications :

- They are commonly used in rural areas to withdraw groundwater for daily needs due to shortages and difficulties in delivering the river water to every village.

- The hand-operated water pump is also widely used for agricultural purposes.
- It is one of the most economical and simple solutions for providing a collective drinking water supply in rural areas.

Approximate Cost :

Market Cost - INR 1800/-

Link : https://www.indiamart.com/proddetail/plastic-hand-pump-11836523612.html

Role of Team Members :

1. Swapnoneel Kayal - Materials and Process Selection, Cost Analysis, Documentation
2. Amshuman Sashi - Design, Components, Assembly, Final Inspection
3. Rohit Sankhala - Equipment Required for Manufacturing & Finishing

References :

Web articles:-

- What is a Hand Pump? | How does a Hand Water Pump work? | Engineer Waqar
  Link : https://mechanicalboost.com/hand-pump/
  Accessed on 8/8/2022
- Hand pump
  Link:https://en.wikipedia.org/wiki/Hand_pump
  Accessed on 8/8/2022
- What is a Hand Pump? | Ken Black
  Link:https://www.aboutmechanics.com/what-is-a-hand-pump.htm
  Accessed on 10/8/2022
- Advantages and Disadvantages of Hand Pumps | Fanny Foudja
  Link:https://wikiwater.fr/e36-advantages-and-disadvantages#:~:text=The%20main%20advantage%20of%20hand,particular%2C%20falling%20into%20open%20wells
  Accessed on 12/8/2022

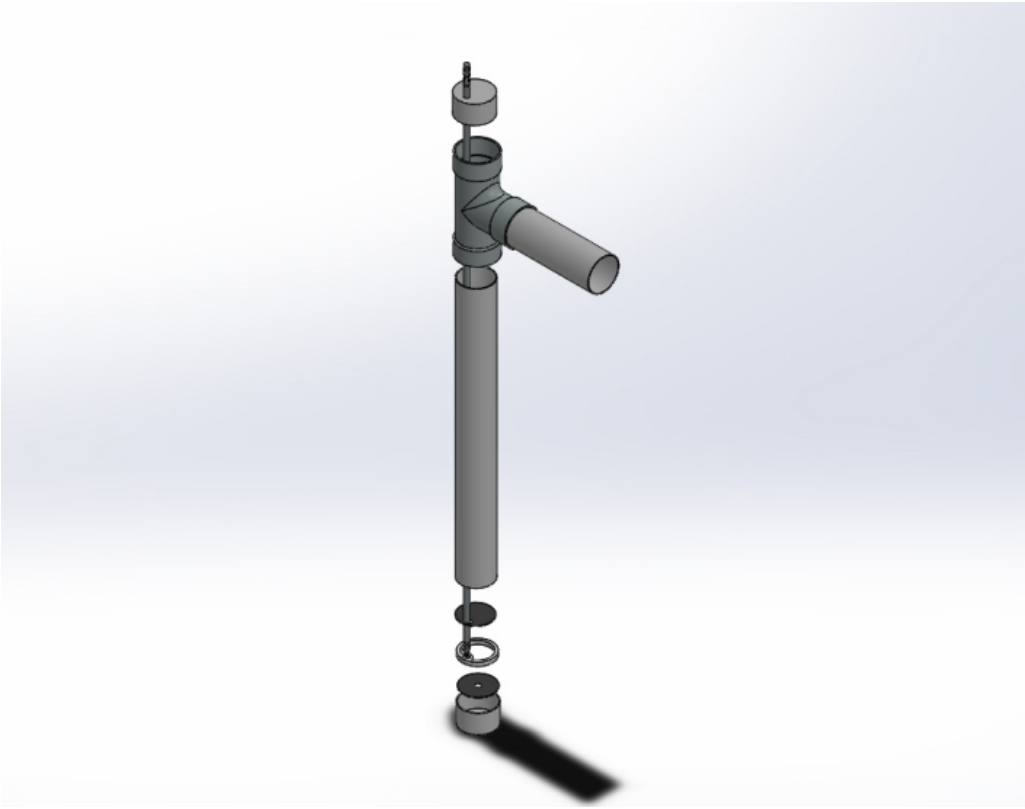
Video reference:

- Mechanical Basics, Working of Hand Water Pump or Hand Operated Water Pump
  Link: https://www.youtube.com/watch?v=gp4Ywytgpkk
  Accessed on 9/8/2022

Stage - 3

Design Consideration :

The **piston** is connected to a **shaft**, located inside the main body of the pump. A one-way valve is located on top of the piston. A **PVC junction** is located on top of the main body serving as a side exit for the water. The **Foot Valve** is attached to the bottom of the pump. The **cap** seals the top of the pump.



The hand pump can be broken down into six main components required for an efficient transfer of water.

These components are as follows :

- Main Body :
    - A cylindrical barrel is used since round pipes are the most efficient shape (largest volume to surface area ratio).
    - Any other pipe would require more energy to pump water due to more surface area to drag on. Also, standard fittings would not work in case of

any arbitrarily shaped pipe.
    - For example, a square pipe would need to have thicker walls in comparison to a round pipe to hold the same pressure hence making it more expensive and heavier.
- Foot Valve :
    - This needs to be cylindrical since it is connected at the bottom of the main body which is also cylindrical
- Piston :
    - The piston located inside the main body of the pump is required to be cylindrical as the main body is also cylindrical.
- Shaft :
    - Shaft is a long rod of any arbitrary shape which is connected to the piston. We prefer cylindrical for ease of work.
- PVC Junction :
    - PVC junction is a rod of 'T' shape for the ease of exit of water. It is connected to the upper part of the main body.
- Cap :
    - Cap seals the top of the pump which has a small hole, for the shaft to pass through.

Components :

Main Body :

The main body is a simple but critical component of the pump. Its main function is to provide water a smooth path to travel up. Additionally, it joins most of the components together. The foot valve is connected at the bottom, the piston traverses up and down within the main body and the PVC junction is fixed at the top.

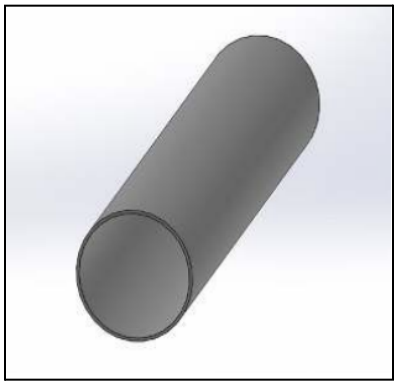
The accuracy of this particular component is not that important in comparison to other parts as adhesives like glue can be used to help seal any holes that exist between joints and rubber seals are used for the piston. Regardless, a more accurate component will always be more efficient than an inaccurate component.

We also would like to have a smooth internal surface. This ensures that the seal will be with the piston nicely and guarantees less water turbulence, hence further improving efficiency.

The main body will be the one that will have to bear with almost all of the frictional forces that will be exerted on the hand pump hence it needs to be strong enough to be

able to resist these forces for the short time it will be used.

Material selection of the main body would need to be done in such a way that a very minor amount of wear is experienced.



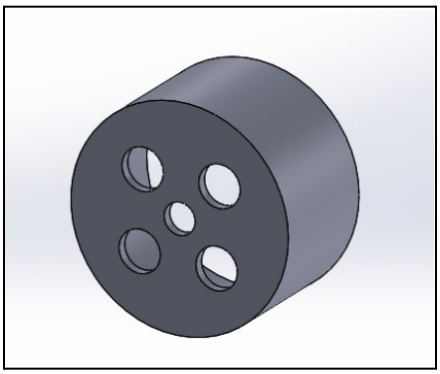
Foot Valve :

The main functionality of the foot valve would be to provide a single way valve for water to enter the main body of the pump. This is an extremely important component of the hand pump since an improper seal at the bottom of the pump will significantly reduce the efficiency of the pump. The resulting loss of water increases exponentially as the distance the water has to travel increases. This is because there is more pressure being applied to the foot valve as a result of gravity, but this added pressure on the foot valve will also help to maintain a proper seal.

The foot valve would also use a flexible piece of rubber placed inside the PVC cap, the PVC cap has five holes drilled into it, the four outer holes allow the water to flow into the main body of the pump when the suction is sufficient enough to overcome the effects of gravity. The inner hole in the cap will be used to hold the rubber seal in place. When the suction is sufficient (upward stroke) water would push the rubber seal out of the way and enter the main body of the pump, and when the suction is released (downward stroke) the pressure of water along with the elasticity of the rubber material would push the rubber downward with enough force in order to seal the four inlet holes.

The accuracy of this particular component is not that important in comparison to other parts as adhesives like glue can be used to help seal any holes that exist between joints.

The smoother the internal surface and accurate the cylindricity of the hole is, the lesser the water turbulence hence further improving efficiency.

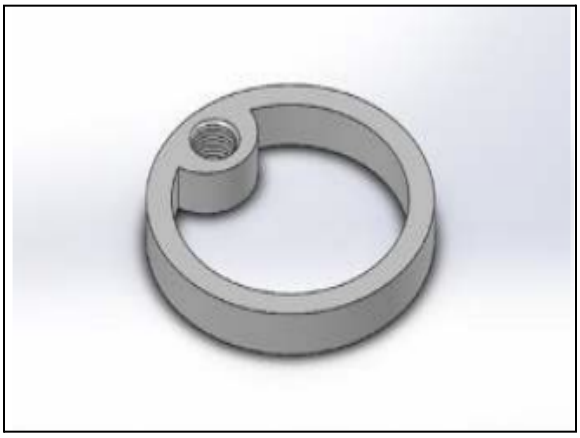


Piston :

The piston's role in the pump is to provide enough suction to overcome the effects of gravity while effectively drawing water into the main body of the pump. This water is trapped by the foot valve. The piston on its downward stroke allows the water to travel through its large inner hole and past a one-way valve located on top of the piston, the one-way valve then seals the water above the piston and the upwards stroke begins, lifting the water up.

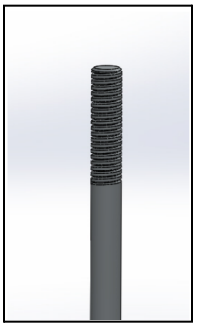
The piston doesn't require any supplementary lubrication as the water does this as well as cools the pump from the heat caused by the minor friction between the piston and main body.

The accuracy of this component is crucial, too large of a gap between the piston and main body will result in no water being pumped. Too small of a gap and the piston will get jammed resulting in pump failure



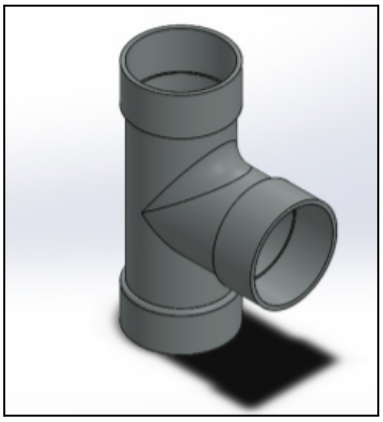
Shaft :

The shaft is the component that transfers the input movement to the piston. The shaft undergoes very little stress as it is only being moved up and down by the test apparatus at a slow rate.



PVC Junction :

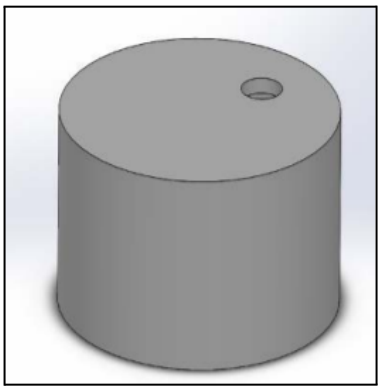
The PVC junction is a stationary part of the pump and role of the junction it to allow the water to exit the pump from the side, this allows for much easier transfer from the pump to the water storage device in comparison to allowing the water to just flow out the top, as this would cause a large amount of spillage and therefore wasted water, time and energy. It undergoes little to no stress, the only minor amount of stress would come from flexing in the pump.



Cap :

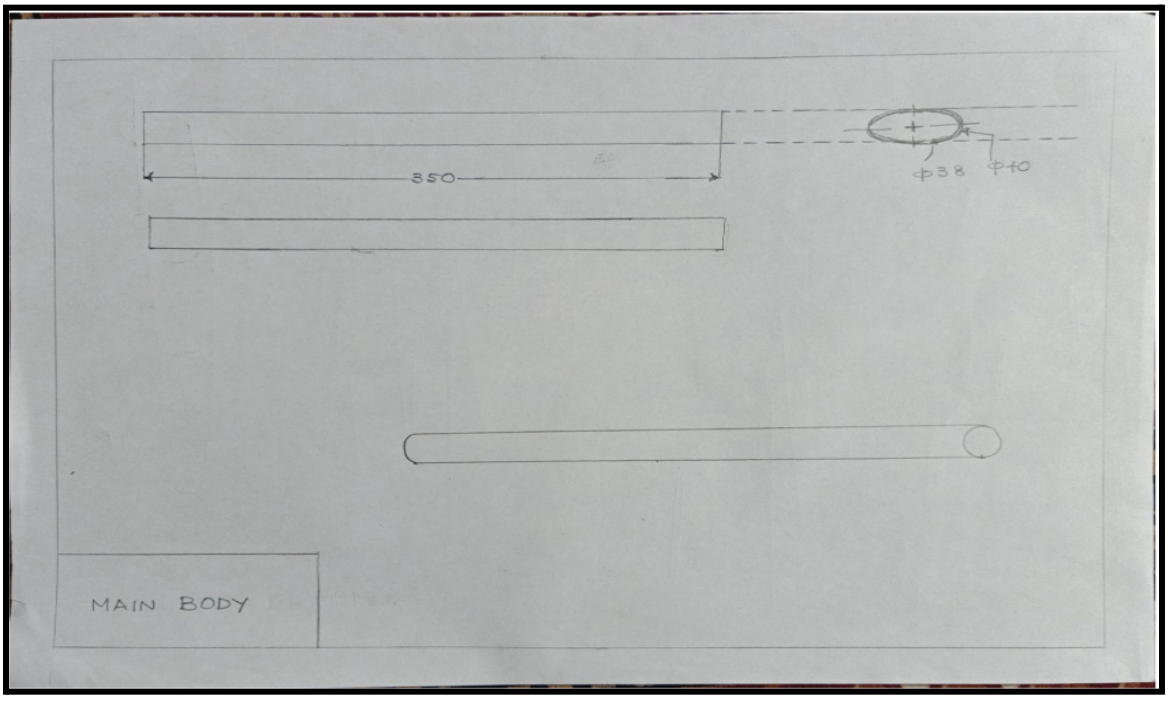
The role of the cap is to seal the top of the pump to ensure no time, water or energy is wasted while pumping. The small hole in the cap is offset like the piston to maintain a straight line of movement for the piston thus reducing the possibility of the piston running on an angle resulting in damage to the pump. The hole in the cap undergoes the

most friction in the pump as it isn't in constant contact with water like other components, however the water keeps the rod lubricated enough to ensure minimal wear. The rod has a smooth finish, this also helps to keep wear to a minimum on the cap. Plus given the short life of this component it would never wear down enough to result in failure of the pump.

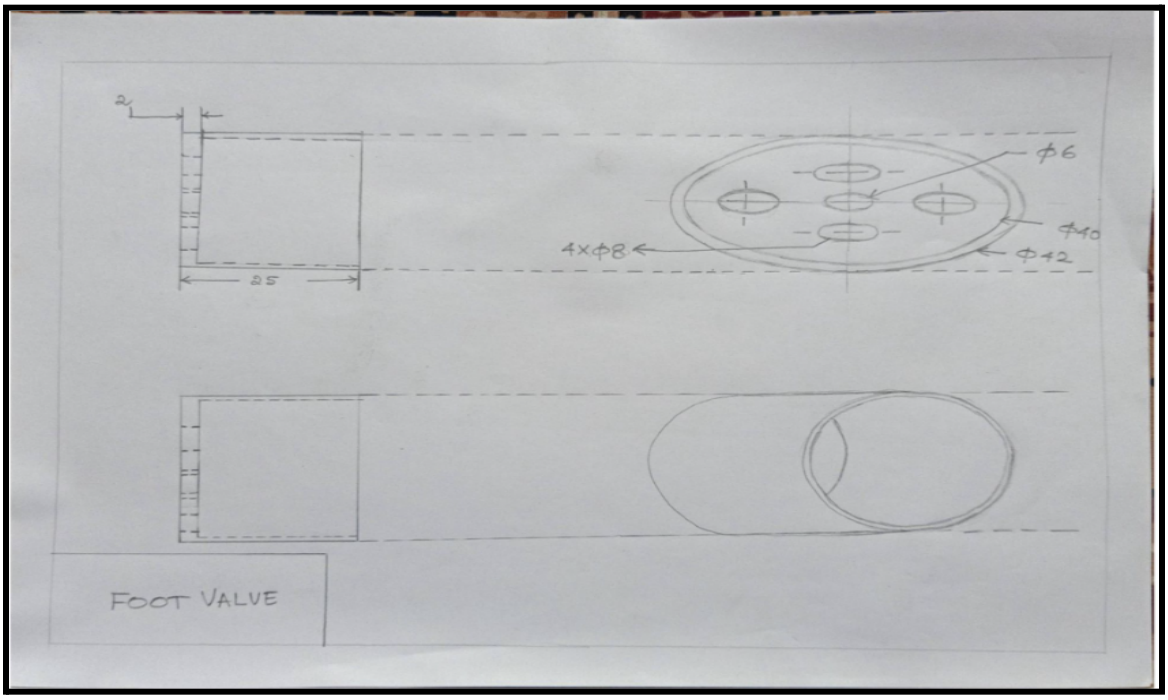


Engineering Drawings :

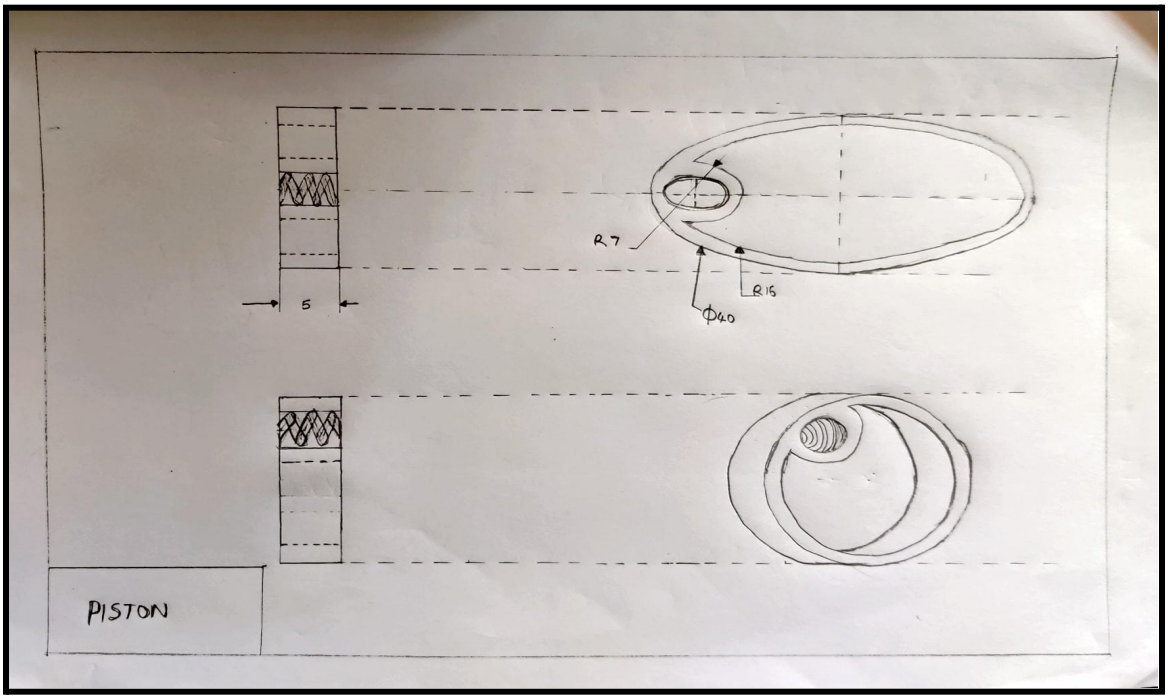
Main Body



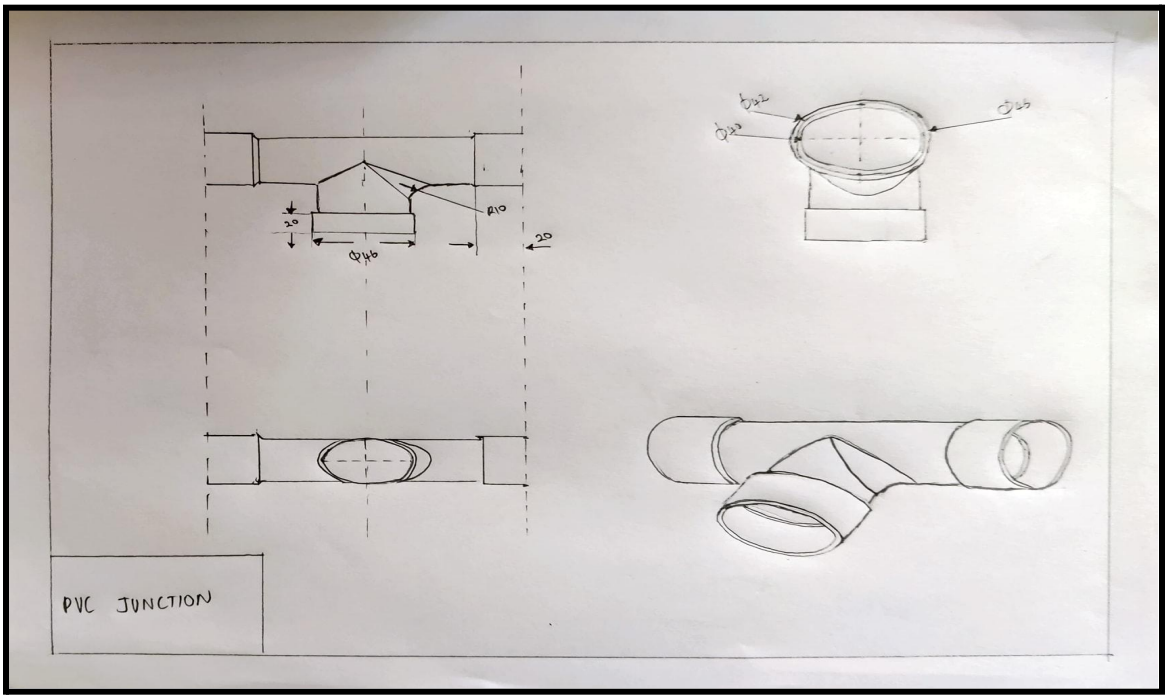
Foot Valve



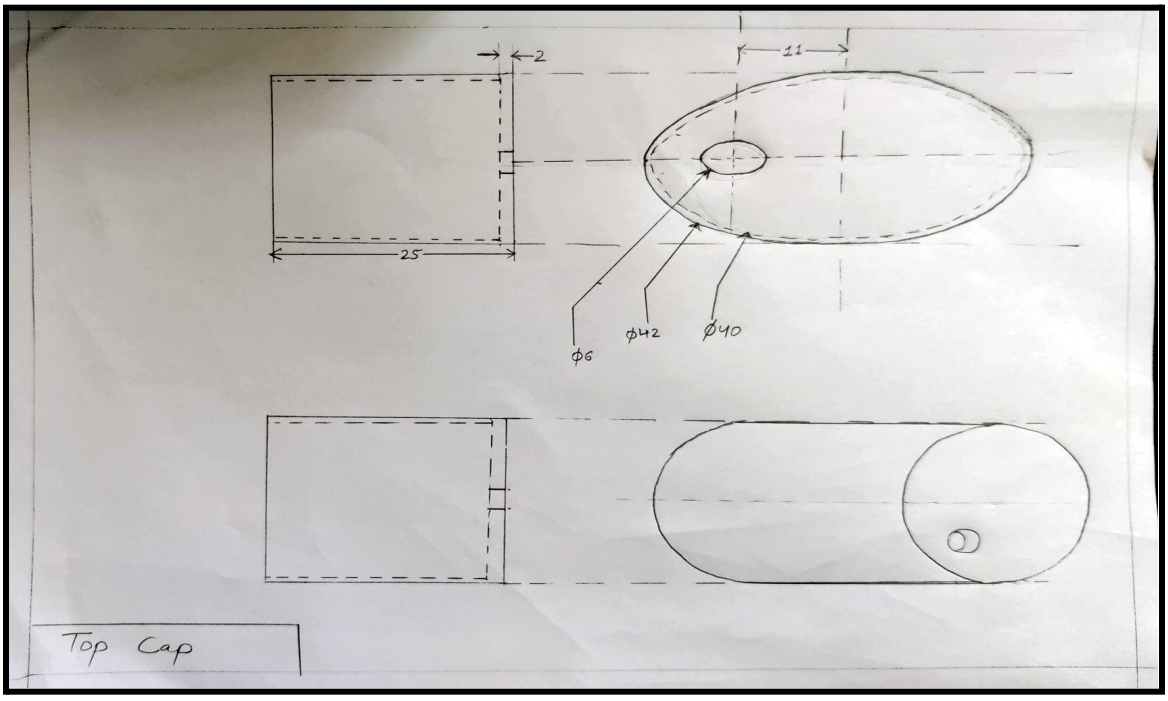
Piston



PVC Junction



Top Cap



References :

Web articles:-

- When to Use a Foot Valve
  https://www.pvcfittingsonline.com/resource-center/when-to-use-foot-valves
  Accessed on 09/09/2022 When to Use a Foot Valve
- What is Hand Pump? Definition, Parts, Working, Applications
  https://www.mechstudies.com/what-hand-pump-definition-parts-working-applications/
  Accessed on 09/09/2022
- Are square pipes better than circular pipes for groundwater pumping?
  https://www.quora.com/Are-square-pipes-better-than-circular-pipes-for-groundwater-pumping
  Accessed on 10/09/2022
- Hand Pump: Types, Components, Mechanism & Working Principle
  https://engineeringlearn.com/hand-pump-types-components-mechanism-working-principle /
  Accessed on 08/09/2022
- How do hand-pumped tube wells work?
  https://www.quora.com/How-do-hand-pumped-tube-wells-work
  Accessed on 08/09/2022
- Hand pump
  Link:https://en.wikipedia.org/wiki/Hand_pump
  Accessed on 10/9/2022
- 3 Way Fitting
  Link: http://www.polyvinpipe.com/3-way-fitting-5657447.html
  Accessed on 10/9/2022