ME338: Manufacturing Processes II
Course Project End-Term Review

Manufacturing Hand Pump

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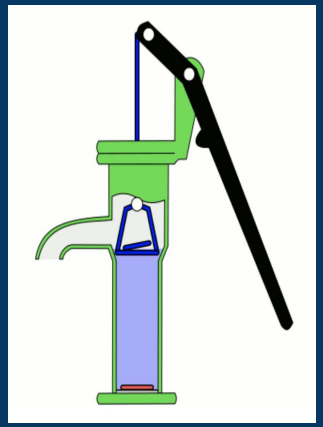
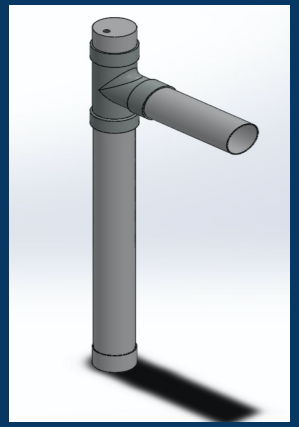




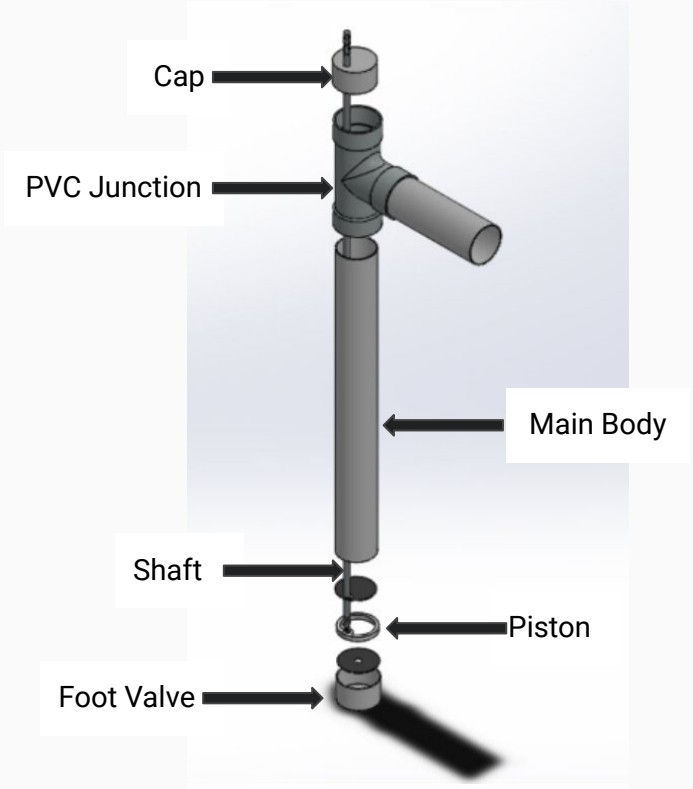
Description

- Manually operated pumps
- Leverage human power and mechanical advantage to allow the easy transfer of fluids from one location to another.
- Up stroke of the piston -> suction brings in water
- Down stroke of the piston -> allows water to flow above the piston

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.

Components



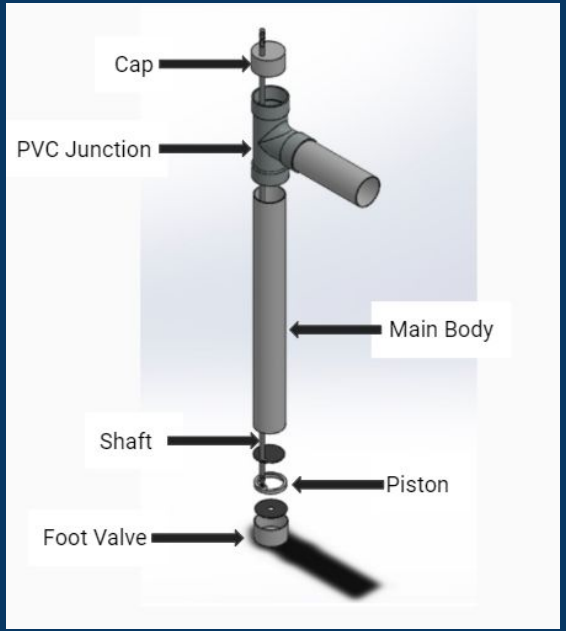
- Main Body
- Foot Valve
- Piston
- Shaft
- PVC Junction
- Cap

Design Consideration

- Design consideration is heavily dependent on the material
- Components should not be very complex -> easy to manufacture
- Easy to assemble/disassemble

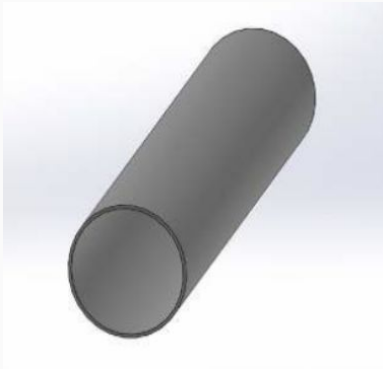
Design Planning Outcome

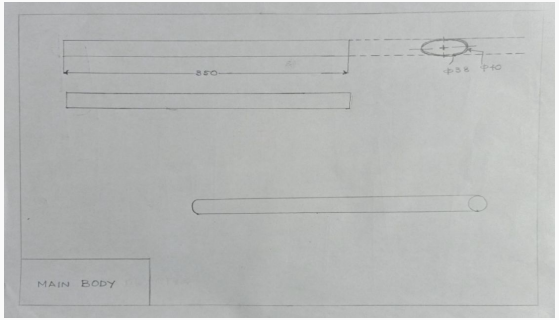
- The piston is connected to a shaft, located inside the main body of the pump.
- A one-way valve is located on top of the piston.
- A PVC junction is located on top of the main body serving as a side exit for the water.
- The foot valve is attached to the bottom of the pump.



Main Body

- Its main function is to provide water a smooth path to travel up.
- Additionally, it joins most of the components together
  - Foot valve is connected to the top
  - Piston traverses up and down the main body
  - PVC junction is fixed at the top
- Material Used : PVC Pipe
  - Advantages:
    - Extremely cheap
    - Easily available
    - Easy to work
    - Strong enough for the application
  - Disadvantage:
    - Poor cylindricity
- Alternative Material : Aluminum Tube
  - Stronger, better cylindricity and harder than PVC
  - Expensive!

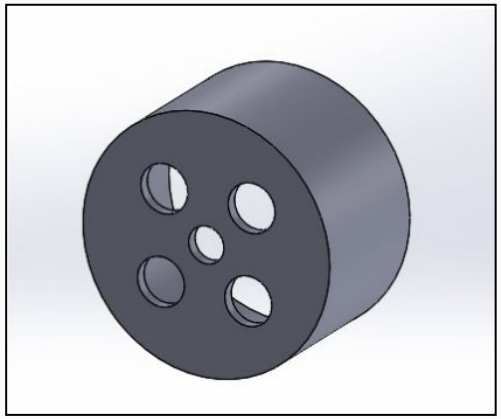


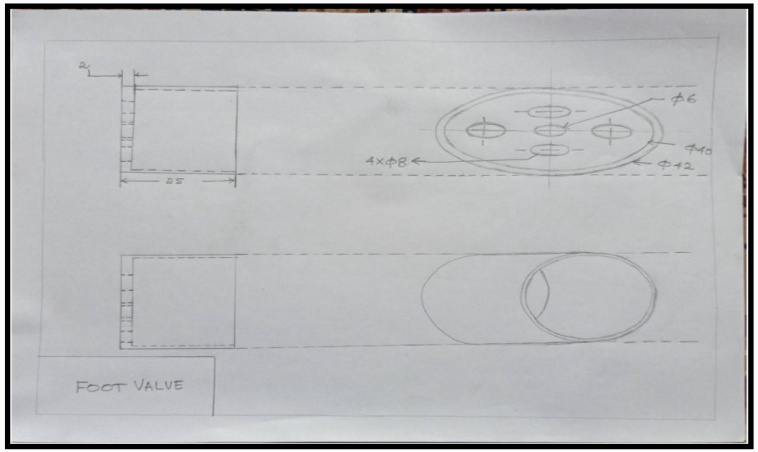


Foot Valve

- The main functionality - to provide a single way valve for water to enter the main body of the pump.
- Significantly increases the efficiency of the pump
- Foot valve has 2 components:
  - PVC cap : 4 holes through which water flows into the main body
  - Seal : placed on top of cap, to control water flow

Rubber Seal



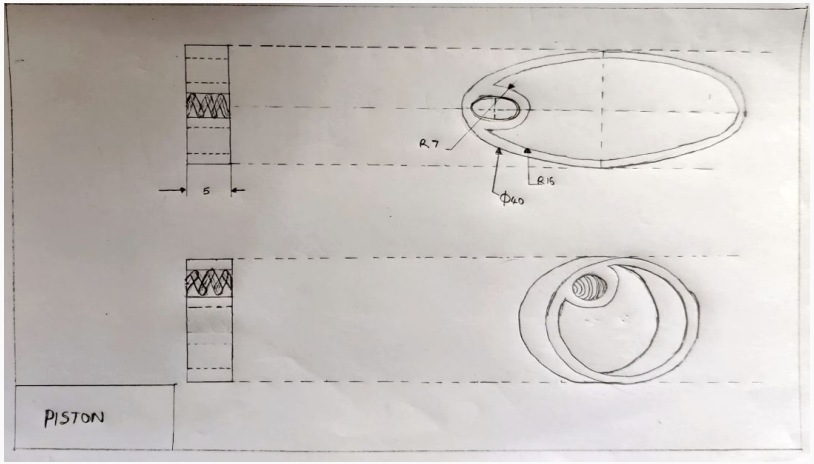


Foot Valve - Material

Material Used	Alternative
• PVC cap: cheap component, easily accessible, easy to work with and strong enough • Rubber seal: cheap component and high elasticity • Plastic nut & bolt: strong and easy to install and uninstall • Rubber O-ring: cheap and easy removal	• Aluminium cap: much stronger, but low cost and easier preprocessing made PVC more preferable • Leather seal: waterproof, elastic and easy to work with but not as cheap as rubber • Rivet: good substitute but difficult to uninstall • Glue sealant: higher strength and sealing ability but difficult to use and remove

Piston

- Its main function is to provide enough suction to overcome the effects of gravity while effectively drawing water into the main body of the pump.
- Material Used : Plastic
  - Advantages:
    - High strength to size ratio
    - Ease of use
    - Cost-effective
  - Disadvantage:
    - Strength
- Alternative Material : Aluminum
  - Stronger than plastic
  - Not workable

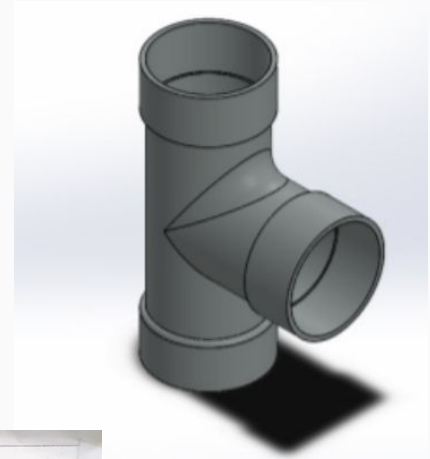


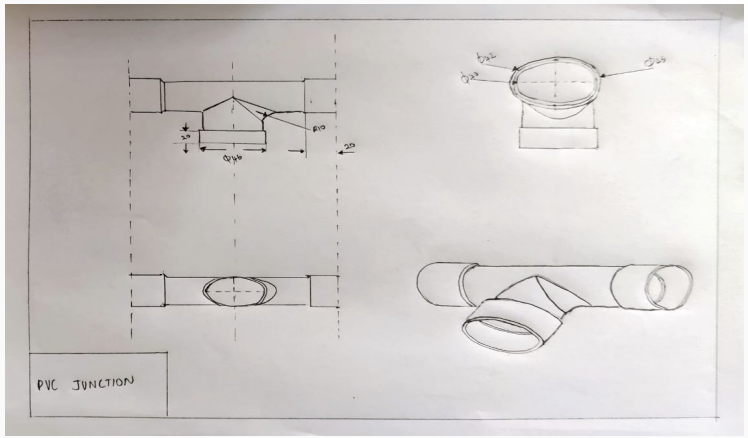
Shaft

- Transfers the input movement to the piston.
- It undergoes very little stress as it is only being moved up and down at a slow rate.
- Material Used : Aluminium
  - Advantages:
    - Strong
    - Suitable for the application
  - Disadvantages:
    - Expensive
    - Not workable
- Alternative Material : Plastic
  - Cheap, workable
  - Not strong enough for the application

PVC Junction

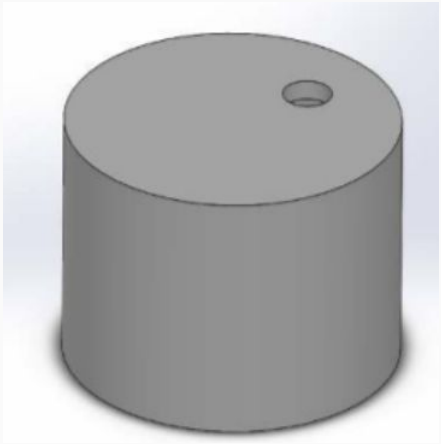
- Stationary part of the pump
- Allows the water to exit the pump from the side
- Undergoes little to no stress; the only minor amount of stress would come from flexing in the pump.
- Material Used : PVC
  - Advantages:
    - Cheap
    - Stronger
    - Elastic
    - Workable
- Alternative Material : Hose
  - Expensive
  - Not strong enough
  - Not elastic
  - Not workable

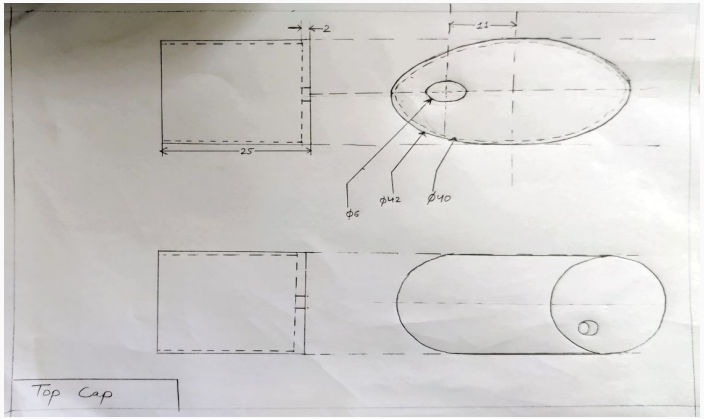




Cap

- Seals the top of the pump to ensure no time, water or energy is wasted while pumping
- The small hole in the cap is for the shaft to maintain a straight line of movement
- Material Used : PVC
  - Advantages:
    - Easy to work with
    - Elastic
    - Cost-friendly
  - Disadvantage:
    - Strength
- Alternative Material : Aluminum
  - Stronger
  - Very expensive & not easy to work with





Process Selection

- Cutting
  - Cutting PVC and plastic
  - Cutting Metal
- Drilling
  - Battery Drill
- Turning
  - Lathe
- Cutting Thread
  - Tapping
  - Die cutting

Manufacturing

PVC : Pipe, Junction and End cap

PVC pipe, junction and the end cap are produced using the process of extrusion.

Rubber Seal

One of the production methods include mould technology.
The most elementary way to form a mould involves toasting of iron.

Plastic Nuts & Bolts

Production of plastic nuts and bolts is done through plastic injection molding process.

Plastic Pistons

Injection molding process is used to create plastic pistons.
Holes are tapped into the piston using a battery drill so that it serves as a connection with the shaft.

Rubber O-ring

Rubber O-ring

Injection molding process is used to create rubber O-rings.

Aluminium Shaft

Aluminum rods are manufactured through the process of extrusion.
The desired shape is then obtained after cutting process.
Die cutting process is used whenever threading is required.

Finishing and Coating

- To provide shape to the area of the piston where water passes, the operation of filing is done which produces a circular file.
- The process of deburring is carried out to remove burrs from machined metal products. It would be used all throughout the production of our hand pump.
- Coating of the PVC material is done to protect the components of the hand pump from water and environmental damages :
  - Two Coat Finish -> Waterborne primer topcoated with a compatible epoxy
  - One Coat Finish -> Water-reducible epoxy
- Aluminum anodizing is done to convert the metal surface into a decorative, durable, corrosion resistant and anodic oxide finish.

Circular file

Deburring tool

Machines / Equipment

- Extrusion machine: manufacture the PVC pipe, shaft, and PVC cap.
- Cold saw : cut the PVC pipe into the correct size for each component.
- Pipe cutter : cut pipes and tubing
- Battery drill machine : drilling circular holes in PVC for the top cap and in the foot valve.
- Lathe machine : turning the plastic piston.
- Bench vice : hold the hand pump components stationary

Bench vice

Extrusion machine

Lathe machine

Pipe cutter

Battery drill machine

Cold saw

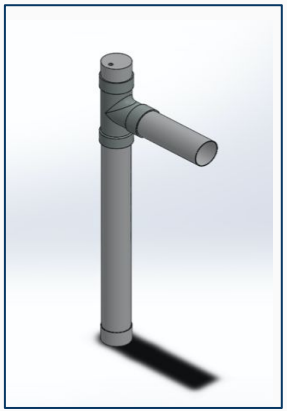
Assembly

The piston rubber seal is placed on top of the piston. Then, one end of the shaft is placed on the piston and through the other end, the PVC pipe, the PVC junction, and the Cap are connected.

The flexible piece of rubber is then placed inside the foot valve i.e. PVC cap. The PVC end cap is directly connected at the bottom of the main body i.e. PVC pipe using plastic nuts and bolts.

Finally, the rubber O-ring is used to seal the small gap left between the hole and the bolt that attaches the rubber seal to the foot valve.

Pump exploded isometric assembly



Pump isometric assembly

Inspection

Proper inspection was performed and critical details were noted down during and after each and every process to make sure we end up with a high-quality product. Some inspections carried out include :

- Weight checks - If a product is overweight, the checkweigher will instantly reject the product and alert the issue immediately.
- Dimensional checks - These are done for every part before assembly.
- Visual Dent Inspections - To prevent early failure and maintaining visual aesthetics.
- High Pressure Test - To check if the main body can tolerate high pressures at even high temperatures.
- Cyclic Corrosion Testing (CCT) - This test brings about the type of failure that might occur naturally, in an accelerated manner by simulating different climatic conditions.

Cyclic Corrosion Testing (CCT) chamber

Weighing scale

Cost Analysis

Manufacturing time and labour cost for each manufacturing process

Process	Estimated Time (in minutes)*	Cost (in ₹) [at unskilled labour rate of ₹480/day]
Cutting PVC and plastic	20	6.673
Cutting rubber	15	5.00475
Cutting metal	10	3.3365
Drilling	20	6.673
Turning	30	10.0095
Filing	15	5.00475
Tapping	10	3.3365
Die cutting	15	5.00475
Deburring	15	5.00475
Assembly of components	25	8.34125
Total	175	58.38875

Equipment Cost

Tools/Equipment	Cost (in ₹)
Cold saw	77445
Scissors	154.89
Pipe cutter	2065.2
Battery drill	7744.5
Lathe	77445
Round file	774.45
6mm Tap	413.04
6mm Die	619.56
Deburring tool	1032.6
Bench vice	6195.6
Safety glasses	103.26
Total	173889.84

This does not include the time spent designing the product (~8 hours) => Corresponding cost = ₹160

Cost Analysis

Material Cost

Component	Cost (in ₹)
Main Body	206.52
Foot valve	309.78
Piston	361.41
Shaft	77.445
PVC Junction	361.41
Cap	72.282
Total	1182.327

Materials List

Component	Amount
PVC Pipe	Ø40mm x 400mm
6mm rubber O-ring	X1
Plastic M6 bolt	X1
Plastic M6 nut	X1
Reinforced rubber	10cm2
PVC cap	X2
Plastic	Ø50mm x 100mm
Aluminium rod	Ø6mm x 300mm
PVC junction	X1

Key Takeaways from Cost Evaluation:

Total cost per pump (materials + labour) ~ ₹1240.71575.

However, labour would decrease drastically if pumps were mass produced due to people getting better at their task.

Materials would also become cheaper as they would be bought in bulk.

Work Distribution

- Stage 1
  - Product Proposal - All
- Stage 2
  - Product Description - Rohit
  - Product Applications - Swapnoneel
  - Approximate Cost - Amshuman
- Stage 3
  - Design consideration - All
  - Components
    - Main body, Foot valve - Swapnoneel
    - Piston, Shaft - Amshuman
    - PVC Junction, Cap - Rohit
  - Engineering Drawings
    - Main body, Foot valve - Swapnoneel
    - Piston, PVC Junction - Amshuman
    - Top cap - Rohit
- Stage 4
  - Materials
    - Main body, Foot valve - Swapnoneel
    - Piston, Shaft - Amshuman
    - PVC Junction, Cap - Rohit
  - Process Selection
    - Cutting - Amshuman
    - Drilling, Turning - Swapnoneel
    - Cutting thread - Rohit
- Stage 5
  - Manufacturing - Amshuman
  - Finishing/Coating, Machines/Equipment - Rohit
  - Assembly, Inspection - Swapnoneel
- Stage 6
  - Cost Analysis - Swapnoneel
- Slides - Swapnoneel, Amshuman