# Rapid Prototyping Practice Topic:

# Archimedes Screw Pump


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Abstract:

The Archimedes screw pump is a remarkable engineering invention that has been in use for over two millennia. Its unique design and efficient operation have made it a popular choice for a wide range of applications, from irrigation systems to water drainage and wastewater treatment. This report provides a comprehensive review of the Archimedes screw pump, focusing on its design principles, historical significance, and various contemporary applications.

Design principles and the working mechanism of the screw pump are then explained, highlighting the key components, such as the helical screw, casing, and drive system, that enable its efficient operation.

Moreover, the report explores the diverse applications of the Archimedes screw pump in modern times. These applications include water transportation in agricultural irrigation systems, drainage in flood-prone areas, wastewater treatment processes, and renewable energy generation through hydropower. The advantages and limitations of using Archimedes screw pumps in each application are examined, considering factors such as flow rates, energy requirements, maintenance, and environmental impact.

Keywords: Archimedes Screw Pump, Helical Screw, Water Transportation

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Introduction:

The Archimedes screw pump is an ancient yet ingenious engineering invention that has stood the test of time for over two millennia. Named after the renowned Greek mathematician and inventor Archimedes, this pump has played a pivotal role in fluid handling and has found diverse applications across different civilizations and eras. Its simple yet efficient design has made it a preferred choice for tasks ranging from irrigation and drainage to wastewater treatment and renewable energy generation.

The history of the Archimedes screw pump dates back to the 3rd century BC in ancient Greece, where it was first described by Archimedes himself. The pump's design was inspired by the principles of a simple machine called the screw,

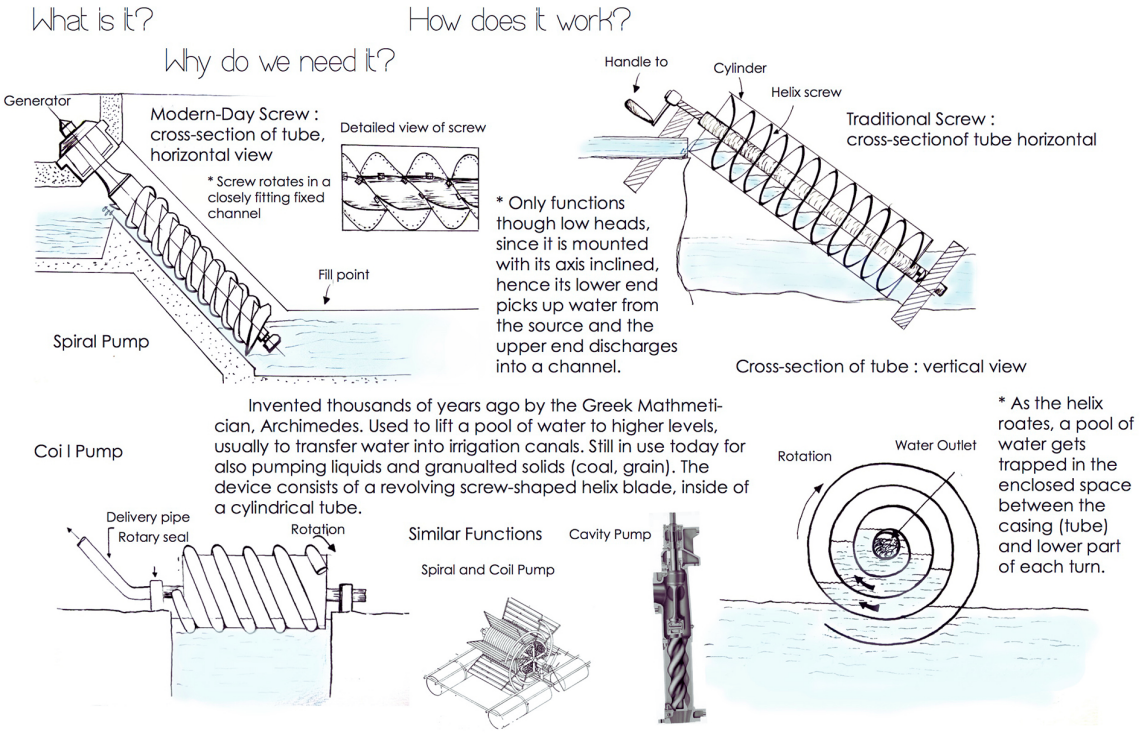
which consists of a spiral surface wrapped around a cylindrical shaft. Archimedes recognized the potential of this shape in displacing water and conceived a mechanism that utilized a rotating screw within a hollow tube to lift and move fluids.

The ingeniousness of the Archimedes screw pump lies in its ability to effectively move water or other fluids by converting rotational motion into the axial flow. The helical screw, positioned inside a casing or tube, creates a series of chambers that trap and carry fluid as it rotates. As the screw turns, the fluid is pushed along the spiral path and gradually lifted to a higher level or transported horizontally, depending on the orientation and configuration of the pump.

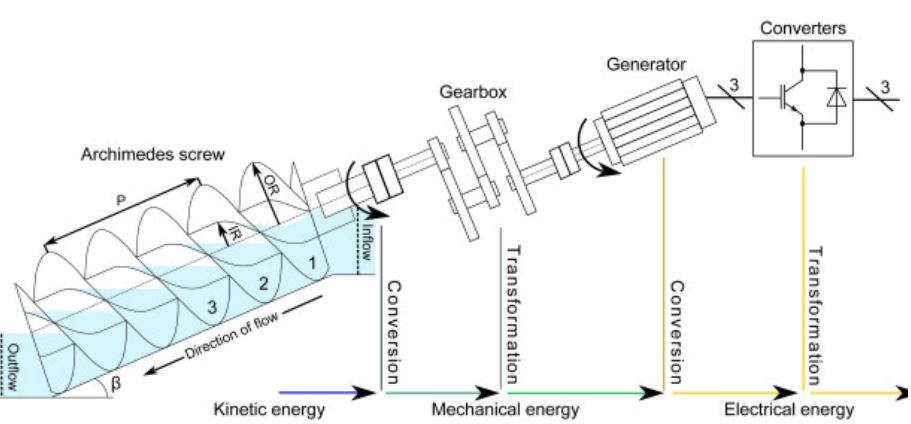
In recent years, the Archimedes screw pump has gained renewed attention as societies strive for more sustainable solutions in water management and renewable energy generation. Its ability to harness hydropower for electricity generation and its low environmental impact make it an attractive option in the context of climate change and the growing need for clean energy sources.

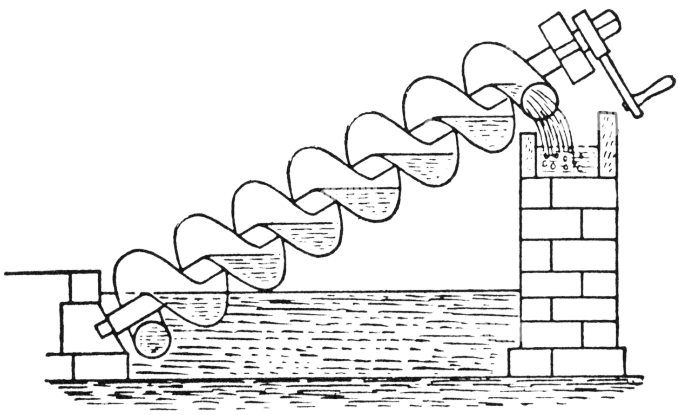
By understanding the capabilities and potential of the Archimedes screw pump, we can further harness its power and contribute to the development of sustainable and efficient solutions for fluid handling, water management, and renewable energy generation.

Summary:



# Archimedes Screw Pump Principle:



The Archimedes screw pump operates based on a fundamental principle: the conversion of rotational motion into axial flow. This principle allows the pump to lift and transport fluids, making it a reliable and efficient tool for various fluid handling applications.

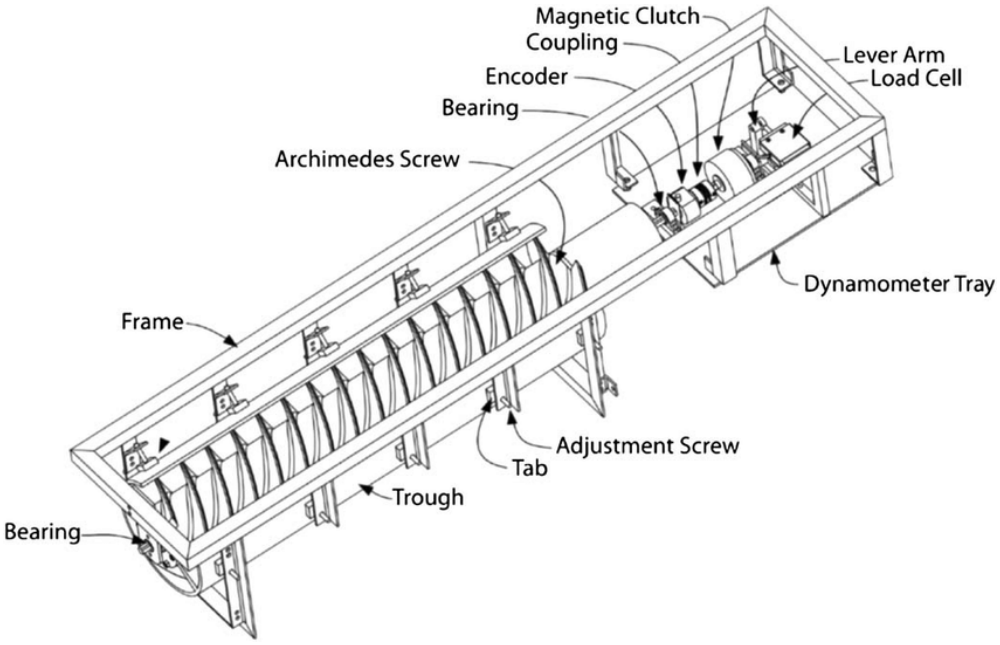
At its core, the Archimedes screw pump consists of a helical screw or auger, which is positioned inside a cylindrical casing or tube. The screw is designed with a continuous spiral surface that wraps around the central shaft. As the screw rotates, it creates a series of interconnected chambers or pockets between the screw and the casing.

When the screw is immersed in a fluid, such as water or sludge, and begins to rotate, the fluid enters the pockets formed by the helical threads. As the screw continues to rotate, these pockets or chambers move along the length of the screw, gradually displacing the fluid.

The key principle behind the operation of the Archimedes screw pump lies in the shape and orientation of the helical screw. The threads of the screw are positioned at an angle, which enables them to push the fluid in a specific direction as the screw rotates. The direction of the flow can be either vertical or horizontal, depending on the desired application and the configuration of the pump.

As the fluid moves along the spiral path of the screw, it is effectively lifted or transported within the pump. The continuous rotation of the screw ensures a steady flow, with the fluid being pushed from one end of the pump to the other. This axial flow mechanism allows the Archimedes screw pump to handle fluids with varying viscosities, including thick or abrasive materials.

Schematic of Setup of Archimedes Screw:




1. Helical Screw: The helical screw, often referred to as an auger, is the central component of the pump. It consists of a continuous spiral surface that wraps around a central shaft. The shape and pitch of the helical threads determine the fluid displacement and flow direction as the screw rotates.

2. Casing or Tube: The casing or tube encloses the helical screw and provides a confined space for fluid movement. It contains the spiral path of the screw, allowing for the creation of pockets or chambers that trap and transport the fluid.

3. Drive System: The drive system is responsible for rotating the screw. It typically consists of a motor, gearbox, and couplings. The motor provides the power, which is transmitted through the gearbox to control the speed and torque applied to the screw.

4. Inlet: The inlet is the entry point for the fluid into the pump. It is designed to allow the fluid to easily enter the screw mechanism for subsequent displacement and transport.

5. Outlet: The outlet is where the fluid exits the pump after being lifted or

transported by the screw. The design of the outlet may vary depending on the specific application and desired flow rate.

6. Support Structure: The support structure provides stability and rigidity to the pump assembly. It ensures that the screw and casing are securely held in place, allowing for smooth and efficient operation.

7. Bearings: Bearings are used to support the rotational movement of the screw shaft. They reduce friction and ensure smooth rotation, contributing to the overall efficiency and longevity of the pump.

8. Seals: Seals are used to prevent leakage and maintain the integrity of the pump system. They are typically positioned at key joints and connections to minimize fluid loss and maximize efficiency.

9. Control Mechanism (optional): In some applications, Archimedes screw pumps may incorporate control mechanisms such as valves or flow regulators to manage the flow rate or direction of the fluid being handled.

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Working of Archimedes Screw:

1. Fluid Entry: The process begins with the immersion of the Archimedes screw in the fluid to be handled. The fluid enters the screw through the inlet, which is usually positioned at a lower level than the desired discharge point.
2. Rotation of the Screw: The screw is connected to a drive system, typically a motor, which rotates it. As the screw rotates, its helical threads interact with the fluid, creating a series of interconnected chambers or pockets.
3. Fluid Entrapment: As the helical threads of the screw move through the fluid, the chambers or pockets are gradually filled with the fluid. The shape and orientation of the screw's threads cause the fluid to be trapped within these chambers.
4. Fluid Displacement: As the screw continues to rotate, the trapped fluid is pushed along the spiral path of the screw. The rotational motion of the screw converts into axial flow, gradually displacing the fluid towards the outlet of the pump.
5. Lifting or Transporting Fluid: The continuous rotation of the screw results in

a steady flow of fluid from the lower end to the upper end of the pump (in vertical applications) or horizontally (in horizontal applications). The fluid is lifted or transported by the screw's action.

6. Fluid Discharge: At the outlet of the pump, the fluid is discharged to the desired location or further processes. The design of the outlet may vary depending on the specific application and requirements.

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Application of Archimedes Screw:

1. Irrigation: Archimedes screw pumps are commonly used in agricultural settings for irrigation purposes. They can efficiently lift water from a lower water source, such as a river or lake, and distribute it to fields or crops that require watering.
2. Drainage and Flood Control: These pumps are effective for draining excess water from low-lying areas, basements, or construction sites. They can also be used for flood control, helping to remove water from flood-prone areas and redirect it to appropriate drainage systems.
3. Wastewater Treatment: Archimedes screw pumps play a crucial role in wastewater treatment plants. They are used to lift and transport sewage or wastewater from lower levels to higher treatment processes, such as screens, grit chambers, or clarifiers.
4. Fish and Wildlife Protection: In some cases, Archimedes screw pumps are employed in fish ladders or fish passes. These structures help fish navigate around obstacles, such as dams or weirs, by lifting them to a higher water level. This aids in their migration and preserves their natural habitats.
5. Industrial Applications: Archimedes screw pumps find use in various industrial applications where the movement of liquids or slurries is required. They can be used for transferring fluids between different processes, as well as for managing liquid waste.
6. Renewable Energy Generation: In certain cases, Archimedes screw water pumps are used in hydroelectric power generation. The rotating screw can be connected to a generator to produce electricity as water flows through the pump, utilizing the principle of hydropower.
7. Water Features and Decorative Applications: Archimedes screw pumps can be employed in decorative water features, such as fountains or ornamental displays, to circulate water and create visually appealing effects.

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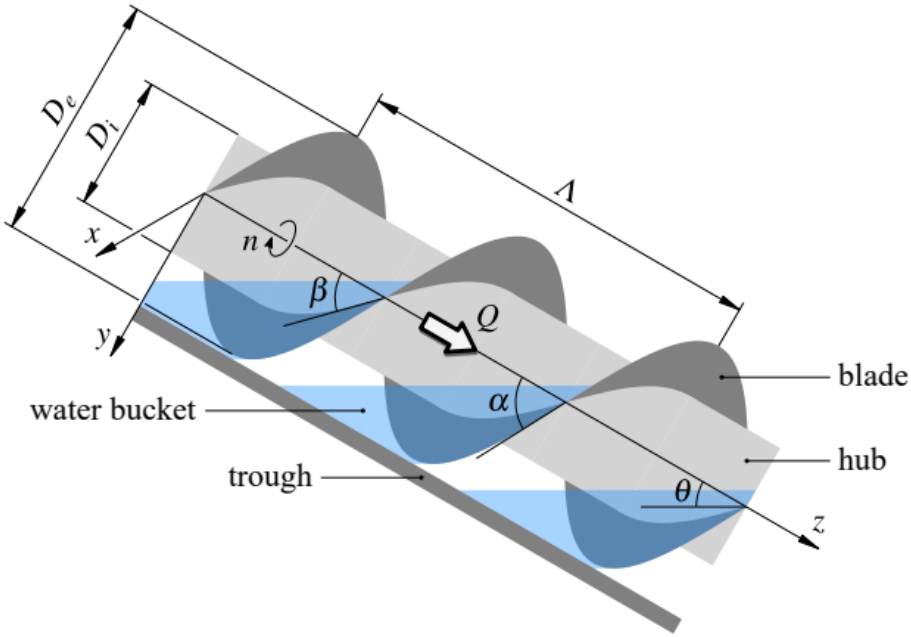
Design Specifications of Archimedes Screw:




The geometry of an Archimedean screw turbine depends on two types of parameters:

• Internal parameters. They can be appropriately chosen and/or modified at design time.

• External parameters. They depend on the installation location, hence they cannot be changed by the designing engineer.

The designing of the turbine aims at assessing optimal values of the internal parameters based on the external ones.

Outer (exterior) Diameter and Radius, De and Re, respectively (m);

• Inner (hub) Diameter and Radius, Di and Ri, respectively (m);

• Screw Length, L (m);

• Installation Angle, i.e. the angle build by the runner with the horizontal, **θ** (degrees);

• Screw Slope, K = tan**θ**;

• Blade Pitch, **Λ** (m);

• Number of Blades, N.

Two dimensionless parameters are particularly important for the design of an Archimedean screw:

• Diameter ratio,**δ** =Di/De=Ri/Re

• Dimensionless Pitch, as proposed by Rorres [4]:

**λ** =K**Λ**/2**π**Re=K**Λ**/**π**De

From the point of view of the turbine operation, the important parameters are the following:

- Turbine Head, H (m);
- Turbine Discharge, Q (m);
- Turbine Speed, n (rpm);
- Hydraulic Power (power available in the water stream that flows through the turbine), Ph (kW);
- Shaft (or mechanical) Power, Ps (kW);
- Turbine efficiency, **η**

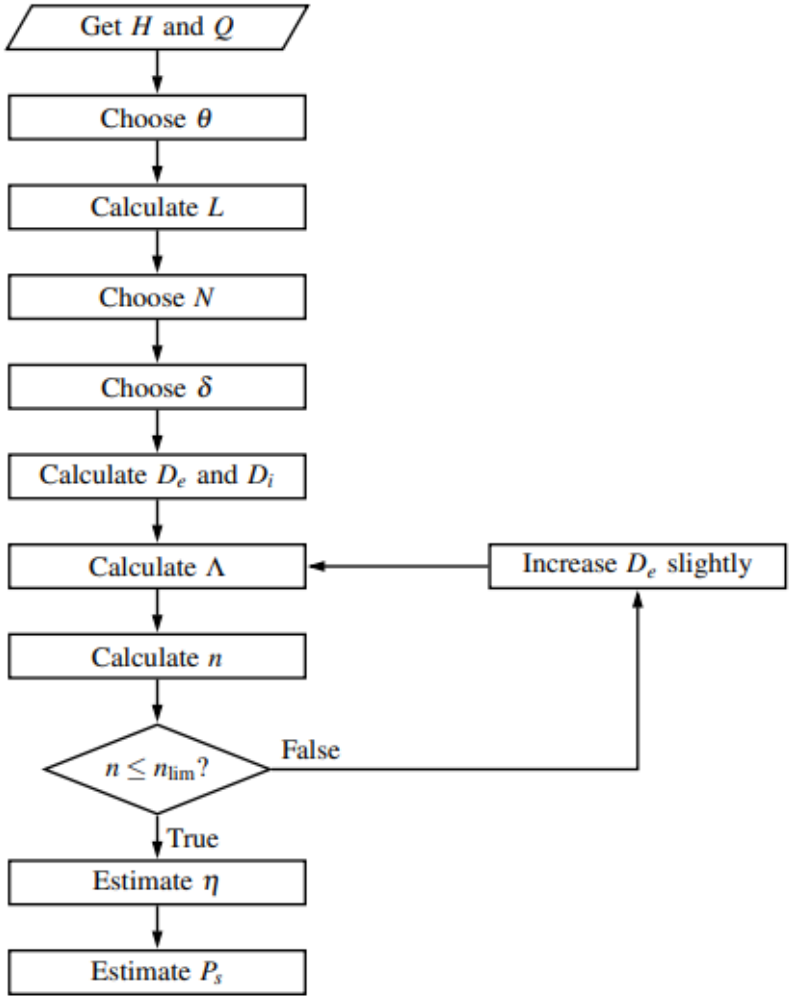
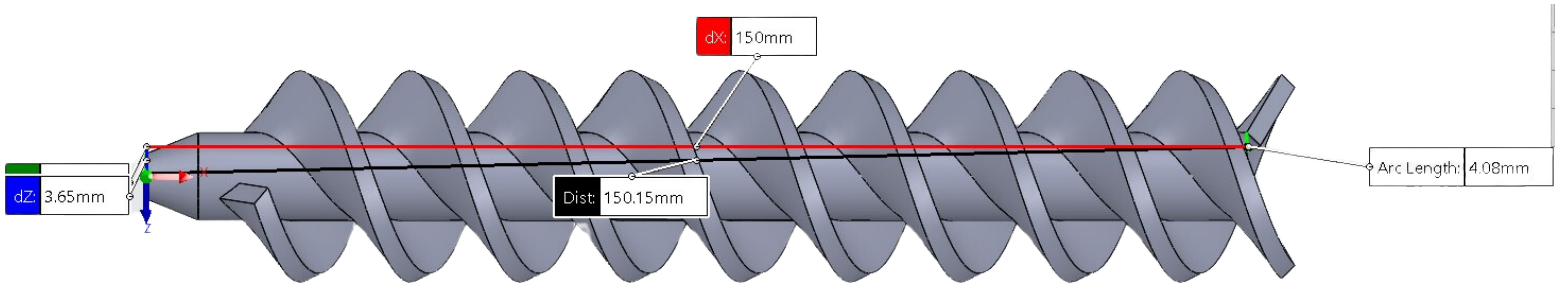
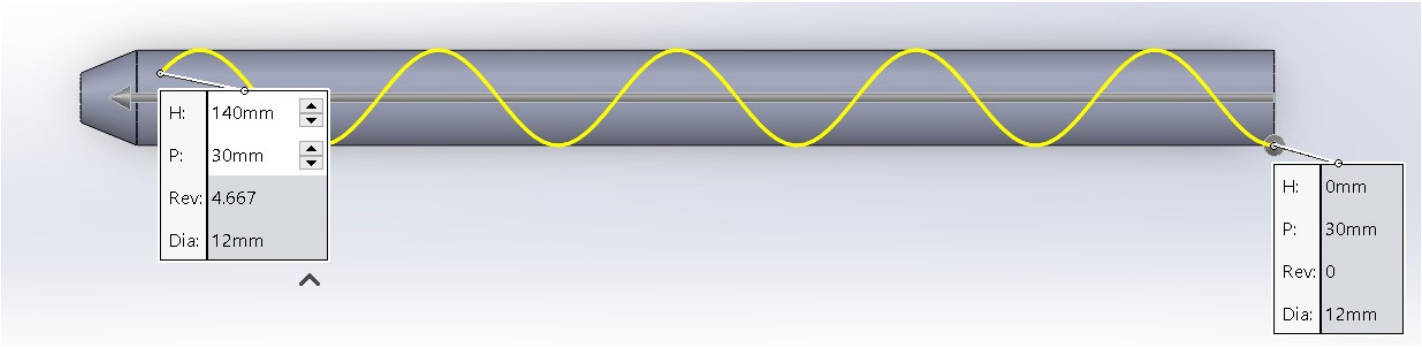


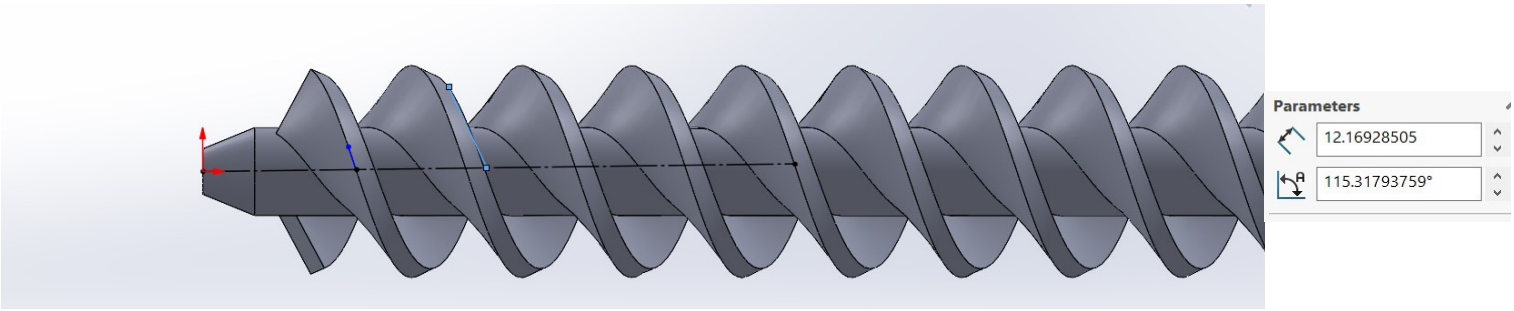

**Figure 6.** Design procedure for Archimedean screw turbines.

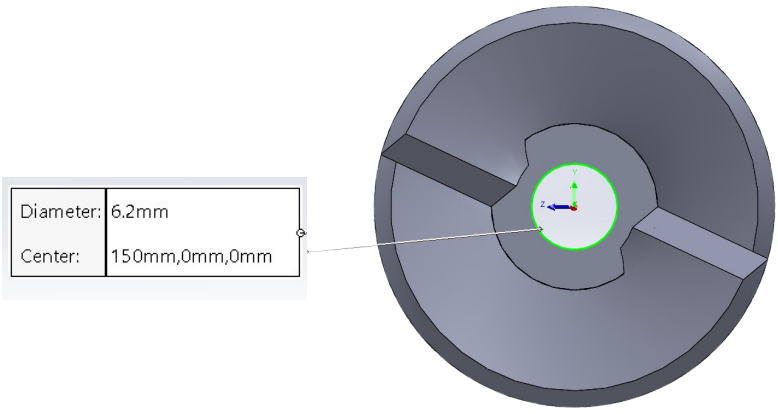
## The values which we have chosen:

1. Archimedes Screw



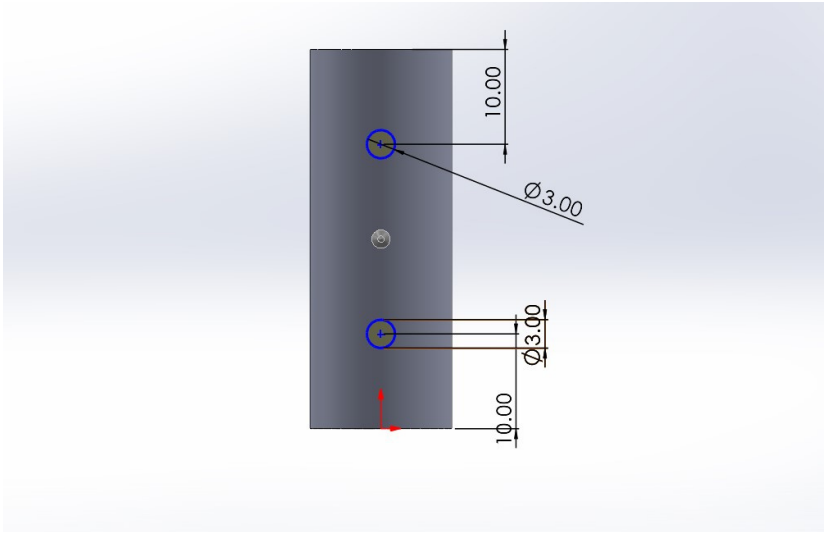



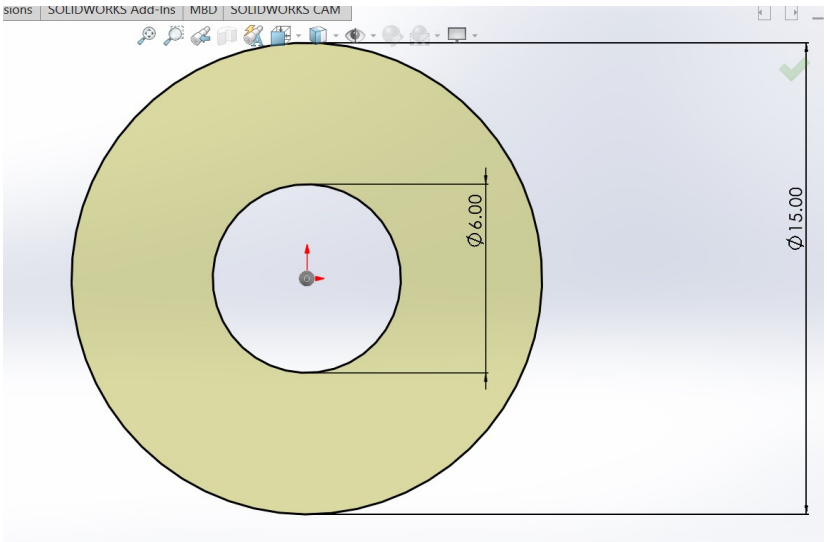



The values which we have chosen:

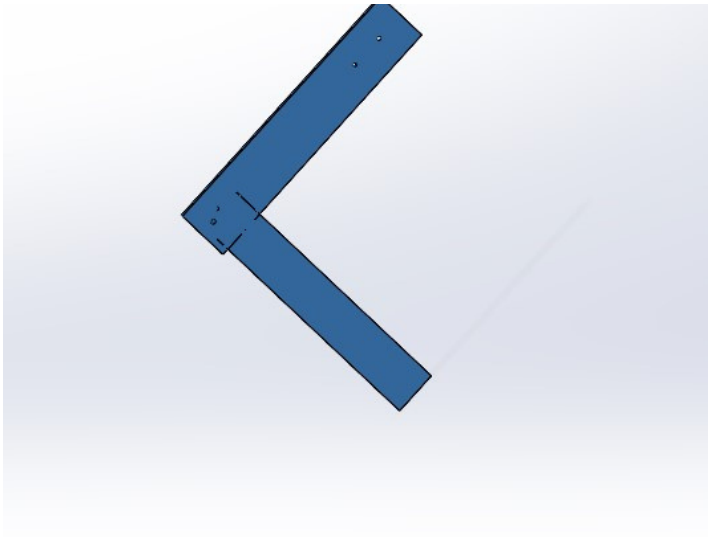
2. Coupling

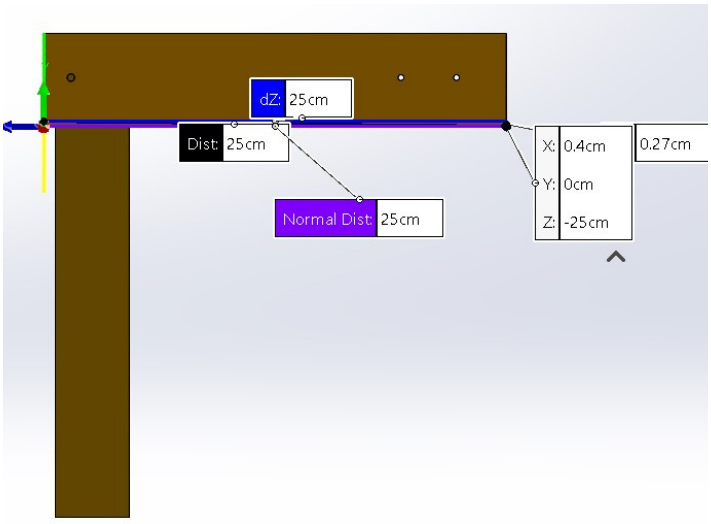


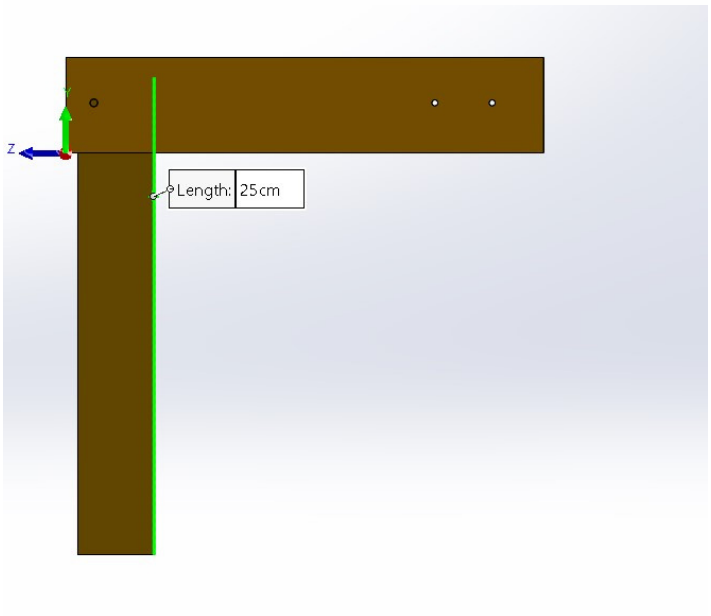



The values which we have chosen:

3. Wooden Support





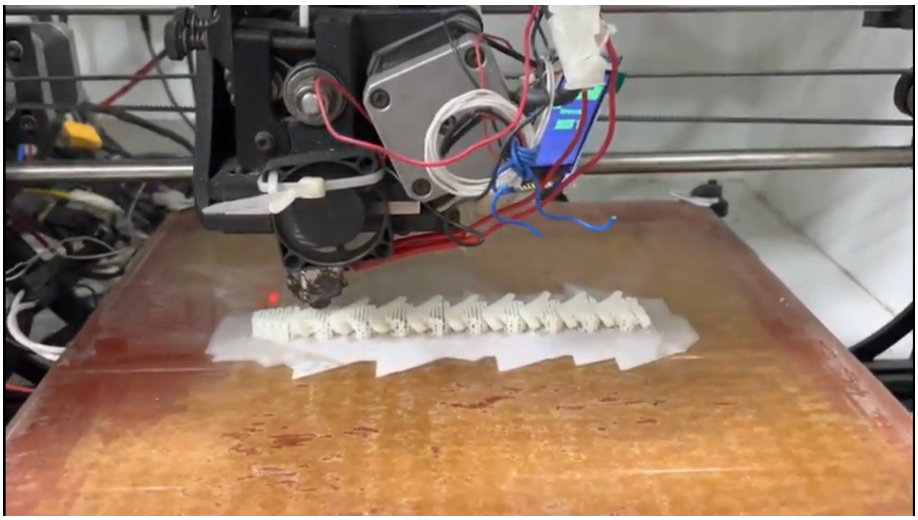
Components Used in Our Project:

1. Archimedes Screw
    - The main element with the above mentioned dimensions. There is, as such, no proper formula to calculate dimensions for Archimedes screw. We have referred to various videos [ mentioned in the reference section] and scaled according to our preference.
2. Acrylic Pipe (Internal Diameter: 32mm)
    - It will act as an outer wall for the screw and help in flow of fluid.
3. DC Motor (1000 rpm)
    - To get the desired output from the screw a High RPM motor is required.
4. Coupling (Internal Diameter 6mm on both sides)
    - It is used to connect the shaft of the motor and the threaded screw on which our Archimedes screw is mounted to transmit power.
5. Threaded Screw (Diameter 6mm)
    - Motion of the threaded screw will transmit the rotational motion to the screw.
6. Water Storage Tank
7. Wooden Support
    - To give the whole structure (basically the motor and pipe) support.

Techniques we have used:

1. Fused Deposition Modelling (FDM): To print Archimedes Screw and Coupling
    a. Material Used: ABS (acrylonitrile butadiene styrene)
    b. Nozzle Temperature: 240°C
    c. Bed Temperature: 110°C
2. Wood Cutting: To create support for model

Output:



Archimedes Screw During 3-D Pritinting

Archimedes Screw After 3-D Pritinting

Advantages of Archimedes Screw Pump:

1. Changes in flow or water level in the river do not affect the efficiency of the hydraulic system.
2. Studies have shown that fish do not suffer from the implementation of such a hydraulic system, they can cross from one end to the other of the turbine in maximum safety.
3. Due to the screw shape of the turbine and the way it operates, branches or other debris can pass on without affecting the functionality of the system, thus reducing maintenance costs.
4. The lifetime of such a system can be up to 40 years.
5. They do not have a negative impact on the environment.
6. The amortization period of the investment is relatively short.
7. Maintenance costs are low.
8. The installation time of such a system is short.
9. The system is very solid, wear-resistant.
10. It fits perfectly into the landscape due to the small size and elegance of the screwdriver mechanism.
11. Fossil fuel is saved by capitalizing on the hydropower potential of a river.

Future of Archimedes Screw Pump:

The future of the Archimedes screw pump looks promising as advancements in technology continue to enhance its efficiency and expand its applications. Integration with automation and control systems, optimization of designs, and the use of modern materials will further improve its performance. The screw pump's versatility, durability, and ability to harness renewable energy make it a sustainable solution for fluid handling and water management in the years to come.

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You can access all the .stl files we have created and used for this project at:

https://github.com/SaketKaswa20/Archimedes_Screw_Coupling

# THANK YOU