ARCHIMEDES PRINCIPLE DEMONSTRATION USING A SUBMARINE APPARATUS

Centre for Indian Knowledge Systems (CIKS), IIT Guwahati

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Professor, Dept of Mechanical Engineering

CERTIFICATE

This is to certify that the work contained in this report entitled "**ARCHIMEDES PRINCIPLE DEMONSTRATION USING A SUBMARINE APPARATUS**" by **Himujjwal Bhattacharya**, has been carried out at the Centre for Indian Knowledge Systems, Indian Institute of Technology Guwahati under my supervision and that it has not been submitted elsewhere for a certificate.

Prof. U.S. DIXIT
Department of Mechanical Engineering
Indian Institute of Technology Guwahati

July 2023

STUDENT DECLARATION

I hereby declare that the entire work embodied in this report entitled "**ARCHIMEDES PRINCIPLE DEMONSTRATION USING A SUBMARINE APPARATUS**" has been carried out by me. No part of it has been submitted for any certificate of any institution previously.

I take full responsibility for the content and accuracy of this report. I understand that any act of plagiarism, intentional or unintentional, is a serious academic offense and may lead to severe consequences, including academic penalties and disciplinary action.

Date: 04/07/2023

Himujjwal Bhattacharya

Intern IIT Guwahati

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Sincerely,

Himujjwal Bhattacharya

Abstract

In education, the combination of new teaching methods and technology plays an important ro le in engaging students and improving their understanding of complex scientific concepts. Th is poster illustrates the Archimedean principle with the help of a simple submarine. Archimed es' principle is an important principle in the functioning of liquids and is used in containers, h ydrometers, lactose meters, etc.

The report begins with a general introduction to Archimedes' Principle, an important concept in fluid mechanics that describes the motion and behavior of particles in fluids.
This report presents Archimedean principles and training materials designed to facilitate inter active learning in submarines.
It explores the historical background of the Archimedean principle and its importance in various engineering and technical applications, with special emphasis on the design and opera tion of submarines. Report also describes the development and use of specialized training equipment designed to teach buoyancy and submarine principles. The gadget combines physi cal objects such as a miniature submarine model and a water tank with interactive content.
In summary, this report describes an educational tool/device, the submarine, based on Archim edes' principles for creating interactive learning. It indicates the quality of learning tools, thin king strategies and the ability to change the learning process.

Contents

Chapter 1

Introduction

1.1 Pedagogy

Pedagogy is the discipline and practice of teaching and learning. It includes the ideas, concepts and theories teachers use to facilitate learning and support the intellectual, social and emotional development of students.

Pedagogy is concerned with understanding how people learn, designing instruction and activities, and assessing and evaluating student progress. It considers factors such as students' backgrounds, abilities, interests, and cultural backgrounds to create effective learning. Effective education is studentcentered and emphasizes participation, critical thinking, and knowledge development.

It considers the diverse needs and work of its students and strives to create a coherent and stimulating learning experience. Key concepts and methods usually seen in Pedagogy include:

1) **Active Learning**: Students are encouraged to participate in learning, for example, through discussion, problem solving and manual labor.

2) **Differentiated Instruction**: Modify instruction, materials, and assessments to meet students' diverse needs and abilities.

3) **Scaffolding:** Provide appropriate support and guidance to help students develop their knowledge and skills and gradually develop their independence.

4) **Cooperative Learning**: Build relationships and collaboration among students, for example, through teamwork, collaboration, and peer learning.

5) **Positive attitude**: Includes the of self reflection and continuing professional development to improve teaching.

6) **Learning Assessment**: Use a variety of assessment techniques, such as assessment and feedback, to monitor student progress and inform teaching decisions.

7) **Technology Integratio**n: Integrate technology tools and resources to enhance the teaching and learning experience, such as interactive multimedia, online platforms, and courseware.

Pedagogy is an innovative program that consistently incorporates the latest research and best practices in education. Effective teaching relies on evidence
based strategies and an understanding of how students acquire and use knowledge.

1.2 Archimedes Principle

It states that when a body is immersed in a fluid, it experiences an upward buoyant force equal to the weight of the fluid it displaces. Fig 1.1 shows the principle of Archimedes where a weight of 4 N has been attached, when submerged gets a weight of 1N when it displaces a weight of 3N.

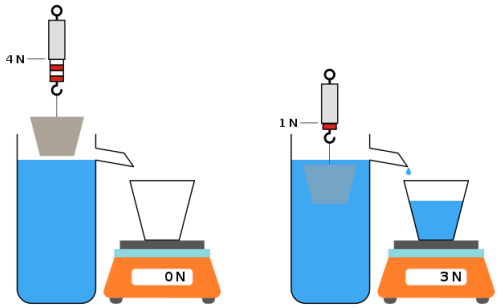

Fig 1.1 Apparatus to show Archimedes Principle

Source : Wikimedia : https://commons.wikimedia.org/wiki/File:Archimedes-principle.svg

1.2.1 Buoyancy:

Buoyancy is the upward force exerted on an object immersed in or floating on a fluid, such as water or air. The three types are :-

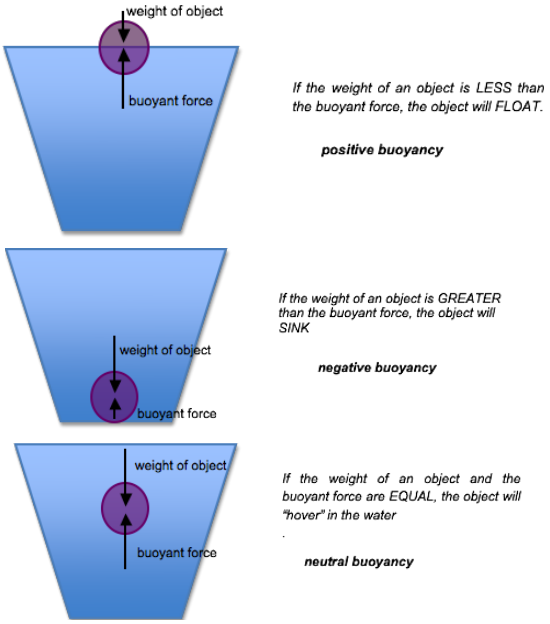

Fig 1.2 Types of Buoyancy

Source : Wikimedia : https://commons.wikimedia.org/wiki/File:BALLS.png

1.3 History of Archimedes Principle

Eureka! Eureka!
Archimedes is asked to prove that the new crown made for King Hieron of Syracuse is not of white gold like goldsmiths. Archimedes is full of baths and when he enters, he can see that water is flowing from his face and that his body has changed water as much as his body weight.
Archimedes knew that gold was heavier than any other metal that the crownmaker could replace, so he came to his own conclusion that the crown was not pure gold.

1.3.1 History related to India

1) **Aryabhata** wrote the Aryabhatiya in the 5th century AD, which discusses the concepts of gola (sphere) and golārdha (hemisphere) and explains why objects are floating or in water.

2) **Bhascarra II**, 12th century AD, in his treatise "Lilavati", discussed many mathematical co ncepts, including the behavior of objects in water and the concept of buoyancy. The 12th-century Indian mathematician and astronomer Bhaskara II's Sanskrit text "Bhaskara's Ardharatna" discusses buoyancy and hydrostatics. Bascarra II explained the concept of buoyancy by stating that an object in a liquid exerts a buoyant force equal to the weight of the water moving through the object.
3) **Brahmagupta**, an Indian mathematician and astronomer who lived in the 7th century, also gave an idea about buoyancy and the behavior of floating objects.His Brahmasphutasiddhant a discusses the properties of liquids and their effects on objects immersed in them.

Also, ancient Indian shipbuilding techniques and practices provide evidence for competitive u nderstanding. Indian shipbuilders built huge ships that could navigate many bodies of water, including rivers and oceans. Although these shipbuilders did not develop it according to Archimedes, they understood the principles of buoyancy well.

Although Archimedean principle is not directly related to India but Indian scientists of that time contributed to the understanding of terms related to buoyancy as well as water and fluid dynamics.
His work laid the foundation for further exploration of these principles over the next several c enturies.

1.4 Applications of Archimedes Principles

Archimedes' principle has many practical applications in many fields.Here are some examples:

1) **Buoyancy and Floating Bodies**: Archimedes' Principle states that an object placed in a flu id has a buoyant force equal to the weight of the fluid it moves. This principle is used to build ships, submarines and other floating structures to ensure their stability and buoyancy.

2) **Hydrometer**: Hydrometer is an instrument used to measure the specific gravity or density of a liquid. Their work is based on Archimedes' law, the buoyancy to which the hydrometer is subjected is used to determine the density of the liquid.

3) **Gases**: Gases rely on Archimedes' law to rise and float through the air. By heating the air i nside the balloon, it reduces the cold air around it and creates an upward force that lifts the ba lloon.

4) **Density Meter**: Density meter is an instrument used to measure the density of a material. They work according to the Archimedes principle, which compares the buoyancy applied to a known object with the buoyant force applied to the measured object.

5) **Submarines**: Submarines use Archimedes' principle to control their depth and buoyancy. By adjusting the amount of water in the ballast tank, they can control the overall density of th e submarine, allowing it to submerge or resurface.

6) **Fluid Mechanics**: Archimedes' principle is the basis of fluid mechanics studies. It helps to understand the behavior of fluids, such as the flow of water in pipes, the design of pumps, an d the calculation of the forces of fluids on submerged objects.

These are just a few examples of how Archimedes' principle is useful in many fields, from en gineering and transportation to scientific measurement and water dynamics.

Chapter 2

Project Prototype

2.1 Project Prototype (Model to Show Buoyancy, Submarine)

- A project to demonstrate how a submarine floats and sink in water has been made with a simple bottle and a balloon.
- Bottle has been made with holes and a balloon is inserted with a pipe attached to the balloon as shown. A tank is also being used in the process to demonstrate the process.

2.2 Working

- When air is blown in the balloon the balloon get inflated and covers the bottle which increases the buoyant force, resulting in the floatation of the bottle. Fig 2.1 shows the floatation of the prototype
- When air is removed from the balloon the bottle sucks the water from the tank through the holes, which reduces the buoyant force.Fig 2.2 shows the sinkage of the prototype

Fig 2.1 Floatation of the Prototype

Fig 2.2 Sinkage of the Prototype

Chapter 3

Actual Model

3.1 Construction

The 3D printed parts are designed in a CAD software to get the approximation to design a model, and integrated view has been show in the Fig 3.1.

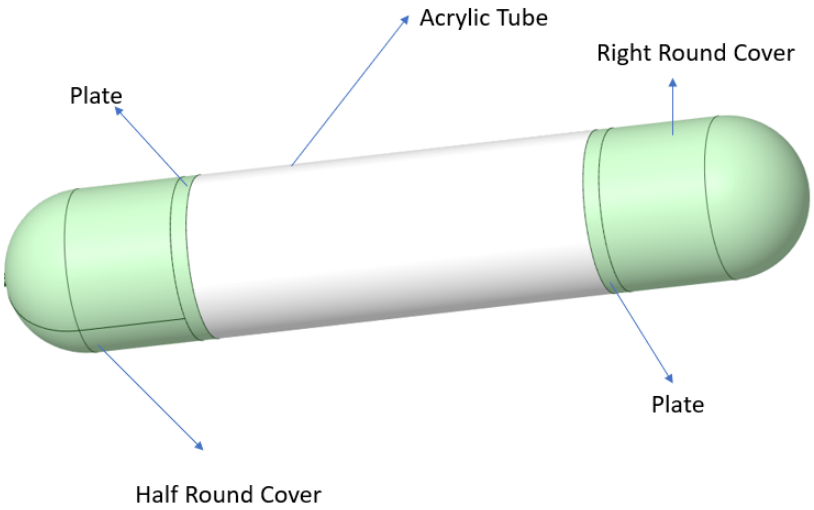

Fig 3.1 : Integrated View CAD

3.1.1 3D Printed Parts (Required)

- Required 3D models have made in CAD Software.
- Fig 3.2 – 2 Half Cups which will be added together
- Fig 3.3 – Cuboidal surface to support Motor or spring to power the screw
- Fig 3.4 – Cup in the other end
- Fig 3.5 – 2 Plates to cover the cups

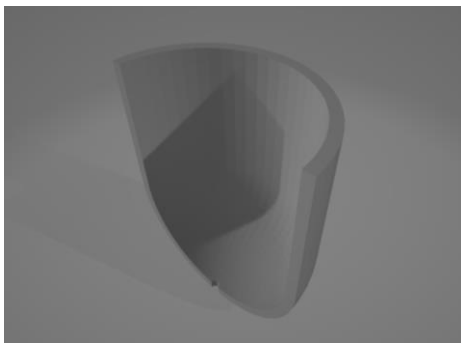

Fig 3.2

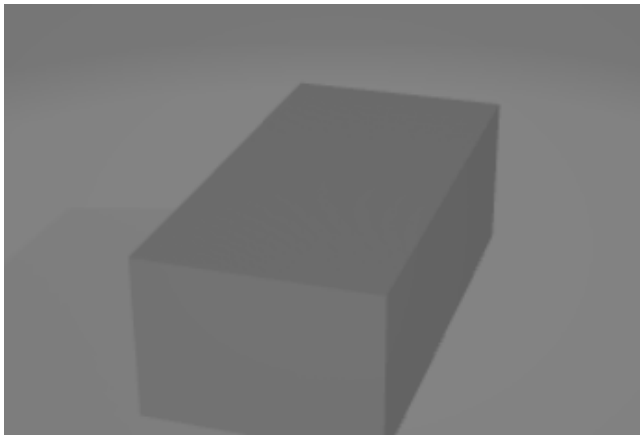

Fig 3.3

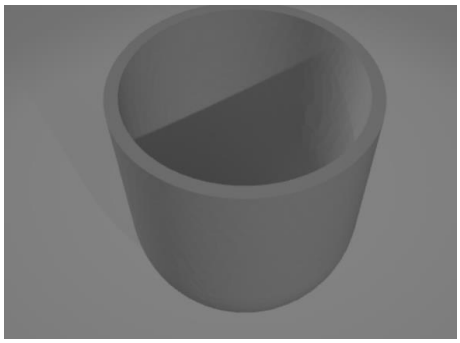

Fig 3.4

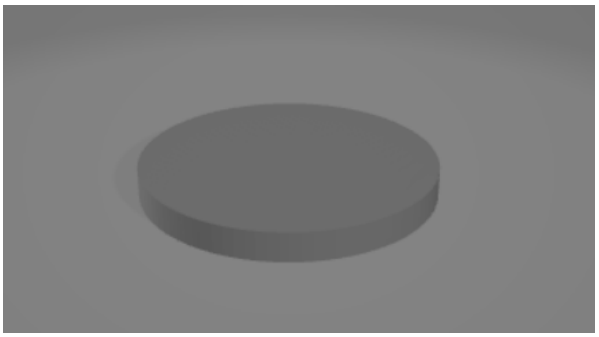

Fig 3.5

3.2 Project Addition / changes

- A Hand Pump is also added to blow the Balloon, which acts as the air compressor inside the Submarine
- A propeller has been added to show its propulsion.

3.2.1 Hand Pump

A pump has been made using two one way valve and a injection, in order to blow the balloon in the model (Air compressor in case of a submarine). The Pump has been shown in Fig 3.7.

Fig 3.7 Pump

3.2.2 Propeller

A propeller is a rotating fan-like structure that is used to propel the ship by using the power generated and transmitted by the main engine of the ship. The propeller has been shown in Fig 3.8.

Fig 3.8 Propeller

3.3 Working

3.3.1 Sinking:-

When we leave the submarine in the surface of the water the submarine sinks since the water inside the tank fills the model through the holes in it, causing the density of the model to be more than that of the water, resulting it to sink as shown in Fig 3.9.

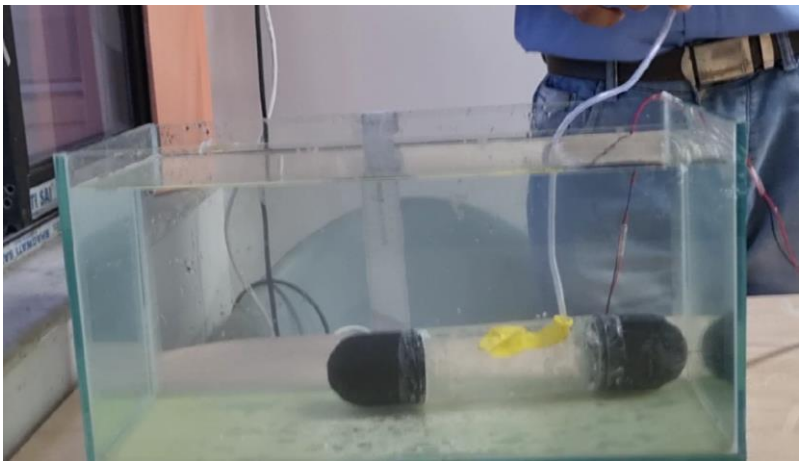

Fig 3.9 Sinkage of the submarine

3.3.2 Floating/Rising :-

When we blow air in the balloon inside the submarine which act as the ballast tank, it causes the overall density of the model to be decrease that that of the water , resulting it to float, as shown in Fig 3.10.

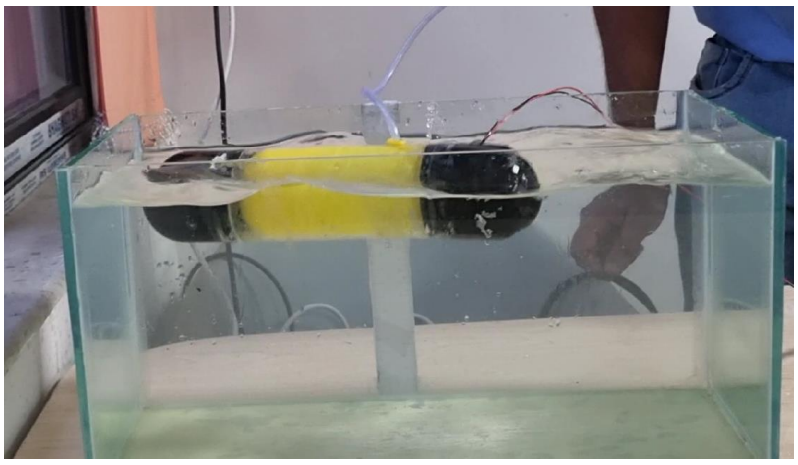

Fig 3.10 Floatation of the Submarine

3.4 Processes used in the development of the model

3.4.1 3D Printing

- 3Dprinting has been done the ends where the DC Motor has been attached along with the weights.
- The software used was UltiMaker Cura
- The 1st figure shows the printed parts

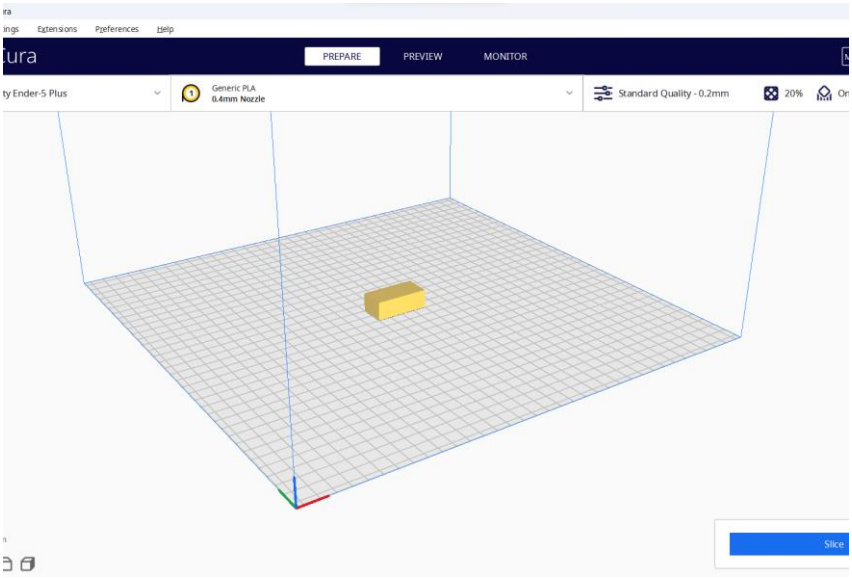

Fig 3.11 - 3D Printing Software used / UltiMaker Cura

Fig 3.12 – 3D printed parts

3.4.2 Drilling

- The acrylic tube has been made holes using the drilling machine in Central Workshop, so to ensure the flow of water in and out of the Tube(Model).

Fig 3.13 Drilling Operation

3.4.3 Cutting

Some part to adjust the weight in the ends has been cut using a Circular saw in the Central Workshop

Fig 3.14 Cutting Operation

Chapter 4 :

Equations and formulas used

4.1 Buoyant Force (*Fb*):

The buoyant force is the upward force exerted on an object immersed in a fluid. It can be calculated using the formula:

$$Fb = \rho \times V \times g \tag{4.1}$$

where

Fb is the buoyant force,

ρ (rho) is the density of the fluid,

V is the volume of the fluid displaced by the object,

and *g* is the acceleration due to gravity.

4.2 Weight of the Fluid Displaced (*W*):

The weight of the fluid displaced by an immersed object is given by :

$$W = \rho \times V \times g \tag{4.2}$$

where

W is the weight of the fluid,

ρ (rho) is the density of the fluid,

V is the volume of the fluid displaced by the object,

and *g* is the acceleration due to gravity.

4.3 Weight of the Object (*Wo*):

The weight of the object itself can be calculated using:

$$Wo = m \times g \tag{4.3}$$

where

Wo is the weight of the object,

m is the mass of the object,

and *g* is the acceleration due to gravity

4.4 Net Buoyant Force (*Fnet*):

The net buoyant force on an object is the difference between the weight of the fluid displaced and the weight of the object:

$$Fnet = Fb - Wo \tag{4.4}$$

where

Fnet is the net buoyant force,

Fb is the buoyant force,

and *Wo* is the weight of the object.

4.5 Density of the Object (ρo):

The density of the object can be determined using the relationship between the density of the fluid and the density of the object :

$$\rho o = Wo / (V \times g) \tag{4.5}$$

where

ρo (rho sub o) is the density of the object,

Wo is the weight of the object,

V is the volume of the object,

and *g* is the acceleration due to gravity.

4.6 Critical Findings

The weight of the Submarine should be made in such a way that it should get submerged while the ballast tank is filled with water, it should not also exceed the weight so that even if the tank is filled with air it should float

Conclusion

A model to show the buoyancy effect in submarine has been made including a Archimedes Screw to be used as a propeller, moreover a hand pump which is acting in place of a air compressor has been made to pump the balloon, which acts the ballast tank in the submarine

Archimedes' Principle is a significant idea in the field of fluid mechanics that describes how fluid-borne particles move and behave.

In order to promote interactive learning in submarines, this report introduces Archimedean ideas and training resources.

With a focus on the construction and operation of submarines, it examines the historical context of the Archimedean principle and its significance in several engineering and technical applications. The report also discusses the creation and application of specialised device made to impart knowledge of underwater theory and buoyancy. The device mixes interactive information with real-world elements like a water tank and a model submarine.

In conclusion, this study describes the submarine, an interactive learning tool/device based on Archimedes' ideas. It reveals the standard of the learning resources, thinking techniques and the ability to change the learning process.

Appendix

Material Used

Sl. No.	Material	Cost (INR)	Quantity	Total Cost (INR)	Description
1	Acrylic Tube	580	1	580	ID- 54 mm OD – 60 mm
2	Epoxy Resin -199	199	1	199	-
3	DC Motor	22	4	88	-
4	Wires	30	1	30	10 m
5	Balloons	60	1 packet	60	-
6	Pipes	-	-	-	-
7	Syringe	42	1	42	50 ml
8	One way valve	10	2	20	-
9	Metal Weight	-	-	-	-
Total				1019	

Reference

1) Wikimedia Commons. [Archimedes Principle]. Licensed under Creative Commons Attribution-ShareAlike 4.0 International. Retrieved from [https://commons.wikimedia.org/].
2) OpenAI. (2021). ChatGPT (GPT-3.5). History of Archimedes Principle. Retrieved on [15/06/2023], from [https://chat.openai.com/].