

Beauty of Water Movement in Leonardo's Paintings in Renaissance

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Abstract. Tracing back to the period between the 14th century and to the 17th century, the Renaissance was started in Italy, with the essence of humanism, which means the reverence for the Greek and Roman culture. Leonardo Da Vinci tends to be the originator of the theory of waves. This article focuses on Leonardo Da Vinci's fluid flow-related work and thought, as well as the beauty of the spiral, as exhibited in his notebooks, letters, and artwork. From the standpoint of water whirlpools, pigtail patterns, and Leonardo Da Vinci's cardiovascular research, using analogies, case analysis, and literature analysis, the beauty of the Renaissance's blending of science and art could be demonstrated. In addition, from the perspective of the values or contributions that Leonardo Da Vinci left behind, the emphasis may be placed on the reverence and awe that Leonardo bestowed upon life, and from the case studies of Golden Horn in Istanbul and The Chateau de Chambord that Leonardo proposed, the cultural heritage's aesthetic value as well as architecture value could be recognized and fully protected.

Keywords: Renaissance, Leonardo Da Vinci, spiral, fluid mechanics, water movement.

1. Introduction

Physics is a natural discipline that focuses on the study of matter, energy, space, and time, as well as their relative qualities and relationships. It investigates and analyzes natural occurrences in order to comprehend the laws of nature. Water is one of the most abundant chemicals on Earth and a crucial natural resource. Solving the enigma of water has long been a significant objective for scientists. Fluid mechanics evolve gradually as a result of human conflict with nature and industrial practice. Fluid mechanics is a discipline of mechanics that focuses primarily on the rest state and motion state of the fluid itself, in addition to the law of interaction and flow when there is relative motion between fluid and solid boundary barriers. Based mostly on Newton's equations of motion and the conservation of mass, the majority of its research focuses on water and air. On top of that, the research methods of this hydromechanics may mainly include: experimental research, theoretical analysis and numerical calculation. Not only is the Renaissance a replication of the ancient model, but it is also the revival of the ability to study and mimic natural phenomena. The history of Greek science as it was digested, revised, and developed throughout the medieval period is the subject of the history of medieval science. After the dark night that was the Middle Ages, science began to make a comeback with unexpected powers, centering on the growth of natural philosophy, the promotion of experimental science, the astronomy revolution, the physics and mathematics revolution, and the life science revolution. "Leonardo says, one should not flee into belief in miracles, but trust the natural arguments [1]." The notes that Leonardo Da Vinci kept throughout the time of the scientific revolution that occurred during the Renaissance are without a doubt an exceedingly important source of information. Not only can it be seen that the rudiment of the idea of motion synthesis and decomposition of classical mechanics can be seen in Leonardo Da Vinci's notes, but it can also be seen that the process of Leonardo Da Vinci's acquisition of knowledge was based on his knowledge of the former, as well as the combination of nature itself. The historical significance of Leonardo Da Vinci's series of studies lies not only in the fact that he obtained a series of significant understandings and results, but also in the fact that he extensively applied and promoted experimental research methods, as well as his emphasis on exploring the general law of object motion. Unquestionably in the use of the scientific research approach that integrates theoretical study with fieldwork, Leonardo Da Vinci is a pioneer in

the field of study known as "experiential theory." This article focuses on Leonardo Da Vinci's study of the motion of water and the methods of research are mainly the case analysis as well as the literature analysis.

Conceptual fluidity is one of the main features of Leonardo Da Vinci's thought, and indeed it permeates his life and work. As he moved between different states, patrons, and commissions for works ranging from engineering designs to portraits, and as he gained experiences of the world through them, it is evident from a close examination of the contours of Leonardo's life that he frequently returned to the study of natural world fluid flows. The discoveries that have been made possible by the writings and works of Leonardo Da Vinci, in particular the Leonardo Da Vinci Surgical System and the research that he did on heart valves, have contributed to an increase in the average lifespan of people and helped to promote the development of medical standards.

In addition, Leonardo's innovation and his research on spiral shape demonstrate the mix of aesthetics and science, which is important to keep in mind while thinking about the management of cultural heritage preservation. Both aesthetics and science can be seen in the spiral staircase of Chambord Castle in France as well as the Golden Horn in Istanbul, Turkey.

The Chateau de Chambord is one of the most famous castles in the world as it is an emblem of French Renaissance architecture. It was built early in the 16th century and has been part of the UNESCO World Heritage list since 1981. "A striking innovation is the monumental double spiral staircase which rises through the centre of the keep reaching a glass ceiling and which provides an entrance to the roof pavilion [2]." On top of that, each of the stairs displays a 360-degree turn between steps, allowing two individuals, one ascending each staircase, to maintain visual contact yet never meet. This mysterious design has recorded by Leonardo Da Vinci inside his manuscripts as well as his notebooks, showcasing the unrivaled beauty of the combination of science and art. With regard to the Golden Horn in Istanbul, Turkey, also demonstrates the scientific design combined with the movement of water. The design of the bridge over the Golden Horn is as follows: Leonardo's designs show a graceful arc bridge with flared ends like a swallow's tail. The bridge's design and creative use of stone represent Leonardo's great vision, given the technology of the period. Here's a modern rendition of Leonardo's bridge idea as a cultural link between Istanbul and Kazan: the bridge Leonardo envisaged for Istanbul concretizes the old concept in a practical and feasible method adapted to current rules and site limitations. This new design aims to offer the content and spirit of the original old one without making a strict copy, employing Leonardo's technique but incorporating modern material and form understanding to recreate his innovative approach.

2. Description of Three Leonardo's Work

2.1. Water Whirlpool

From rising bubbles in water, drawings of flumes, series of deluge drawings, to drawings of vortices in the aorta as well as a sketch of a bearded man or Ginevra de' Benci, vivid curves are evident in Leonardo Da Vinci's paintings, which reflects the enlightenment of Leonard's key ideas of fluid mechanics. "Leonardo's observations were structured through inherited concepts of how nature was thought to operate" [3]. On top of that, the assumptions of his times and his analysis could be found in his visual written texts like the Codex Atlanticus.

The topics such as "where the turbulence of the water is generated", "where the turbulence of the water is maintained for some time" as well as "where the turbulence of the water is lost" and so on, that kinds of questions of studies written in Codex Atlanticus, showing Leonardo Da Vinci's vision of modernity beyond his time. One of the examples is a deluge (see Figure.1).



Fig 1. LEONARDO DA VINCI (VINCI 1452-AMBOISE 1519) A deluge c.1517-18. Black chalk, pen and ink, wash | 16.2 x 20.3 cm (sheet of paper) | RCIN 912380 [4]

When the wind blows over water and earth, from the point of view of clouds, sand, leaves, and all of these other light materials, when they come across a storm, they may become detached from the ground or even bend to the earth, much like the people who are following the storm. Leonardo described that "their branches twisted out of their natural growth and their leaves tossed and turned about" [1]. This distortion tends to suggest Leonardo Da Vinci's earliest comprehension and depiction of spiral form. It is possible to get a strong impression of great natural forces such as wind and fluid from Leonardo's description.

The water whirlpool is depicted quite well in this artwork by the artist. The painting may not depict a snapshot in time, but rather a progression that takes place over a period of time; this painting not only has a powerful visual effect on people, but it also allows for more in-depth observation and perception. The value of this painting is further demonstrated by the presentation of Leonardo's growing scientific spirit and practice.

It is common knowledge that Leonardo spent his childhood in a little village located close to the river Arno. Not only the water that is visible on the top of the water, but also the mysteries that are at the bottom of the river may be uncovered by Leonardo Da Vinci. On top of that, he engaged in an in-depth investigation of wave theory.

As a result of his research, the diversity of wave patterns and the propagation of waves in the form of vibration were discovered. These findings represent significant achievements and an accumulation of knowledge for future generations. According to his experience and knowledge, the shape of the water wave that is produced on the surface of the water as a result of the impact that a moving body has is that of a semicircle. However, because of the disparity between the state of the medium and the source of the wave, the wave can take many different forms as it travels through the medium. Therefore, the wave that is created by the force of the moving object's impact on the water is hemispherical in the air or in the interior of the water where it occurs. Since water on the surface is surrounded by air, water deeper within the body of water is still surrounded by water on all sides. In addition, because water is a living substance, the hydrosphere will stretch when the surface of stationary water, which was initially moving in a circular circle, enters the interior of moving water, causing the circular wave to become oval when it reaches moving water. Since water is dynamic, this phenomenon will occur when the surface of stationary water, which was originally traveling in a circular circle, enters the interior of moving water. According to Leonardo Da Vinci, water waves are not the flow of water itself; rather, they are the vibration form caused by items impacting the surface of the water and causing the vibration to spread about. The following observation can be drawn from the picture titled "A deluge": Strong gusts of wind and storms, as well as the torquing of plants and trees... "I have seen motions of the air so furious that they have carried, mixed up in their course, the largest trees of the forest" [1]. It is possible to demonstrate the momentum with *A deluge*.

In both his drawings and his writings, Leonardo frequently depicted catastrophic storms during the last ten years of his life. This was one of the artist's favorite subjects. One of the most alluring aspects of Leonardo Da Vinci's paintings is their apparent invisibility. Not only does he document his scientific discoveries in written form, but he also draws them out to better understand them. Here, theory and perception meld into one another and mutually enrich one another. In his notebooks or paintings, he always described or recorded the futile struggle of man and animal against the forces of nature. To Leonardo, with the probable exception of his paintings or art, water is one of the natural world's elements over which he has limited control. Leonardo explored the mysteries of water, showing Leonardo Da Vinci's prediction of the destructive effects of water on human life as well as reflecting his fascination with the beauty of moving water in his paintings or scripts.

2.2. Water and Pigtailed

Leonardo also had some comparisons between water and pigtailed. He discovered that the shadow in the water tended to have a similar way of the movement of hair, with the patterns of either following the weight of the strand or following the contour of the winding. Therefore, with respect to the movement of the mirror of the water, in the same way, water has its own spiraling twists. On the one hand, it follows the primary stream and on the other, they are caused by falling and reflex movement.

According to Leonardo, he had ever mentioned that took note of the motions that occurred on the water's surface, and the movement of the hair is analogous to this. There are two motions, one of which continues with the flow of the water, and the other of which generates the swirling lines; as a result, the water swirls, partially as a result of the push of the main current, and partially as a result of accidental movement and backflow. One of his famous paintings, *Ginevra de' Benci* (see Figure 2), gives the best example of this theory. A logarithmic spiral in geometry that has the golden ratio serving as its growth factor is called a golden spiral. That is, a golden spiral extends itself (or moves further away from its starting point) by a factor of every quarter turn that it completes. The mathematical concept of logarithms was not established until almost a century after Leonardo's death, so it is impossible for him to have known about it. On the other hand, Leonardo would have most likely been familiar with the golden spiral, which is a logarithmic spiral with an exponential growth factor that is related to the golden ratio. The elegance of the golden spiral is particularly apparent in Leonardo's paintings of people's hair, like *Annunciazione*, *Salvator mundi*, *The Baptism of Christ* etc. The open-ended curve of the spiral creates the impression of continuous motion; in truth, it creates the impression of life. It implies the primary principle of life, which is growth.



Fig 2. Leonardo Da Vinci c.1474-1478, Oil on panel [5]

2.3. The Anatomy and Physiology of the Heart

In the early days of cardiology, Leonardo Da Vinci's summary of the anatomy and physiology of the heart represents a significant turning point and places him in the role of a pioneer. Through the use of his drawings, he was able to gain a deeper understanding of human anatomy and the roles played by various organs. Leonardo Da Vinci had a particular fascination with the inner workings of the heart as well as the circulation of blood throughout the body. He was the first person to classify the heart as both a muscle and an organ composed of four chambers. He did this by distinguishing between the two structures of the heart. In addition to this, he expounded on the physiological processes that are the basis for the circulation of blood through the chambers of the heart. Some examples of these processes include the coordinated contraction and relaxation of the muscle groups in the atrium and the ventricle. His insights with reference to the aortic valve in particular were particularly important.

Figure 3 documented his discovery that the blood that flows from the heart gets refreshed and oxygenated in the lungs. In the picture "Vortices in the aorta," both the spiritual function of the heart and the concept of a higher power, which are well-known as supra-natural ideas, are depicted.



Fig 3. LEONARDO DA VINCI (VINCI 1452-AMBOISE 1519) The aortic valve c.1512-13, Pen and ink on blue paper | 28.3 x 20.4 cm (sheet of paper) | RCIN 919082[6]

3. Influence

3.1. Leonardo's Design and his Manuscripts of Chambord Castle

It is reported that Chambord's actual identity was to be both a Renaissance castle and a castle belonging to Francois I. The castle exists not only for the world to discover its extraordinary building skill, but also to convey its philosophical, political, aesthetic, and social significance. Chambord, located deep in the forest and remote from any military zones and urban centers, has a vast architectural scale with a hall measuring more than 100 square meters. Given its excellent location, the Chambord Castle had a protective effect in the 20th century and a considerable number of the art masterpieces in the castle to escape from the war. During World War II, the collections of important Paris museums were moved here, avoiding the looting and the threat of war gunfire that Paris suffered. A number of artefacts, such as the Venus de la Louvre, the Victory of Samothrace, and paintings by Raphael and Da Vinci, were moved to a special place in the Chambord. In this case, Chambord Castle serves as an imaginative museum. "Leonardo's annotated sketches of architectural elements--including central plans, double and quadruple spiral staircases, and windows--with actual details of Chambord" [7]. These are what Leonardo has already thought and contributed to this world heritage.

Categorized into curves, the spiral is generated by a point moving around a fixed point while constantly receding from or approaching it. Stairs, especially in monumental and ceremonial architectural settings on the exterior or interior of ancient buildings, have been elaborated structurally and ornamented as prominent components. “Like all stairs that of necessity express the human scale (as the Italian word *scala* implies), are formally innovative, and serve as an expressive link in the spatial composition of buildings, creating a sense of space-time sequence” [8]. Among all kinds of stairs, the spiral staircase, especially Leonardo’s staircase, tends to be the most beautiful, the arcane staircase; that rises to the sky, that bores through space. The artistic value, as well as architectural value of the double helix staircase in Chambord Castle, is based on the pattern of spiral or helix, at the same time, it tends to be the focus of the main tower in Chambord Castle as well as the central element of the castle. The stairway of Chambord Castle which is shaped like a double helix draws a lot of attention from guests. For the majority of painters and photographers, the spiral generates a tremendous amount of tension, giving the impression that it is ripping apart the many dimensions of time and space, similar to how a time machine would. This creation has a good chance of being both the first and the last architectural effort that Leonardo Da Vinci ever created. The staircase that is shaped like a double helix appears to represent everlasting rebirth or constant renewal.

3.2. The Beauty of the Curve of Leonardo’s Golden Horn Bridge

In his notebooks, Leonardo Da Vinci scribbled down some rudimentary directions for the Golden Horn Bridge for how his idea should be constructed. The manuscripts of Leonardo’s inspiration and his design could be seen in Figure 4. The bridge comprises wooden pieces jammed together. The bridge is self-supporting, requiring no fasteners such as dowels, screws, or nails. As a foundation, Leonardo utilized the “self-locking mechanism,” in which the building strengthens itself under strain. “Leonardo’s design consists of a weight-bearing granite vault with a built-up walkway that forms a crossing between terrain and vault [9].” An arch could be seen as a curved and symmetrical structure that spans a gap and often bears the weight of a bridge, roof, or wall that is located above it and also it is “a pure compression form” [10]. “Arches appeared as early as the 2nd millennium BC in Mesopotamian brick architecture [11].” Its applications bear great artistic value as well as scientific value, the Golden Horn Bridge could be seen as a good example.

Many documents literature focuses on the mechanical property of this bridge, from the perspective of Spreading Supports and Stress Conditions, which is divided into uniform stress as well as uniform crushing stress as well as triangular stress distribution. Leonardo Da Vinci’s drawings have contributed greatly to modern engineering. With regards to the design of the bridge, “the arch of interest includes 20 voussoirs”, the initial geometry is presented [12].

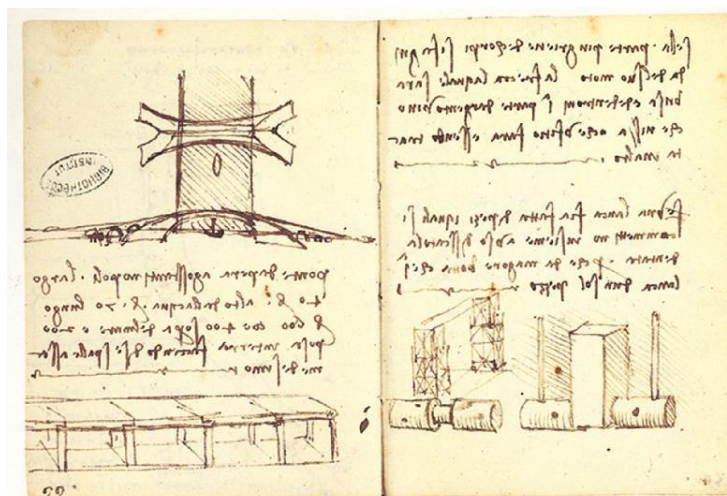


Fig 4. Golden Horn Bridge designed by Leonardo da Vinci in 1502. Paris Manuscript L, Folio 65v and 66r [13]

4. Conclusion

To sum up, with regard to Leonardo Da Vinci's achievements of both theories and creation in paintings, he made the craft-based era of art come to an end and at the same time, he played a pioneering role in the scientific-based as well as art-based era. Any great scientific achievement comes from freedom of thought. The Renaissance provided Leonardo Da Vinci with a free academic atmosphere, which formed his aesthetic and scientific thought. The idea that Leonardo Da Vinci's aesthetic is completely reliant on the sacred proportion relationship that already exists between all of the different components is the central idea that underpins it. It is critical that these aspects work together to produce a proportion that is not only attractive but also compels the spectator to continue looking at it. On the other hand, with regard to his scientific concept, in painting techniques, Leonardo Da Vinci places a great deal of importance on the application of natural science in painting. His research perspective, color science, anatomy, learning and composition proportion, and scientific theory guided his painting creation.

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