> The SCHOLAR mourns, and the ANTIQUARY weeps over the wreck of ancient learning and art—the PHILOSOPHER regrets that sufficient of both has not been preserved to elucidate several interesting discoveries, which history has mentioned; nor to prove that those principles of science, upon which the action of some old machines depended, were understood; and the MECHANIC inquires in vain for the processes by which his predecessors in remote ages, worked the hardest granite without iron, transported it in masses that astound us, and used them in the erection of stupendous buildings, apparently with the facility that modern workmen lay bricks, or raise the lintels of doors.

Figure 1: The scholar mourns (Ewbank, 1857, p. 2)

It is one of the overarching goals of the present set of experiments to focus in on the idea that a principle can be used to inform design. The intent is to unveil at least one such principle using the undershot vertical waterwheel as a design case. Extracts from the writing of various scholars from bygone eras—specifically Descartes, Smeaton and Ewbank—will be provided here to introduce some context to these experiments. The extract shown in Figure 1 is taken from a book on ancient and modern machines for raising water by the former United States Commissioner of Patents (1849-1852) Thomas Ewbank.[1] The extract is given here to show that even as late as 1857 some of the most qualified technical experts believed not only that principles of science had informed the design and construction of hydraulic machines, but also that the description of such principles had not been preserved in either the ancient or early modern literature.

Ewbank attempted to explain the apparent absence of principles in the literature by referring to what he claimed was a convention of philosophers and scholarship at the time:

> Unfortunately learned men of old, deemed it a part of wisdom, to conceal from the vulgar, all discoveries in science. With this view, they wrapped them in mystical figures, that the people might not apprehend them. The custom was at one time so general, that philosophers refused to leave any thing in writing, explanatory of their researches.

Figure 2: The vulgar classes (Ewbank, 1857, p. 2)

[1] For a brief account of Ewbank's time as Commissioner of Patents see Bate (1973).

Whilst there might be some truth to Ewbank's claim, there is evidence of an early modern tradition that was concerned with the derivation of principles. That tradition became known as Cartesianism, and followed Descartes's key work, *The Principles of Philosophy* (Descartes, 1982). The history of scholarship that followed Descartes's publications became embroiled in many controversies which appear to have made it difficult to establish indubitable facts. But what we know of the period is that key thinkers such as Newton and Leibniz had engaged deeply with Descartes's writing. It is, then, reasonable to assume that Descartes's insistence about the relevancy of principles may have stimulated subsequent design thinking. In addition, following along with Ewbank's argument, it is possible that Descartes's principles had been directly applied by designers but without attribution or acknowledgement.

The eighteenth century publications on undershot water wheel design and analysis by Smeaton, one of the first professional Civil Engineers, partly qualify as examples of Ewbank's argument. I say 'partly' here because Smeaton's writing does in fact mention the idea of a principle, but does not mention its origin, nor how to derive a principle. One principle mentioned by Smeaton will be the starting point for the current experiments. It is a principle whose constancy is between motion and geometry.

, But despite this argument it is possible to see mention of principles in some early engineering literature in the .

Regarding the

In 1759 Smeaton published a ground-breaking experimental analysis of the undershot water wheel. In that analysis 1759

0.2 Experiment 1.

0.2.1 Aim

The series of experiments outlined here aim to test and verify the two principles identified in the introductory section which state that to optimise the effectiveness of an ancient waterwheel the wheel circumference should equal the stream velocity.

Following the V-Modell outlined in the methodology section, each experiment will consist of three parts. A digital simulation and a physical experiment as the test case. In this case, for the simulation, basic methods of geometry and arithmetic will be used to present HTML5 simulation of 1759's concept, displayed on Maud (2022). The basic method will then be transferred from HTML5 into a CAD representation using Rhino3D/Grasshopper, and the CAM will be a 3D fabrication. The physical experiment will then be conducted using a basic stop watch over a distance.

0.2.3 Discussion

Although the simulation experiment The aim as presented above provided two difficulties.

The difficulty becomes evident through an initial dimensional analysis.

If we only focus on circumference and velocity (distance over time) then we have no

B. the ratio of oblique to perpendicular force will equal the ratio between the sine of the angle of incidence (oblique angle) and (sine of?) 90 degrees.

0.3 Method

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