

Nature doesn't talk in words; it's how we hear it, and nature uses math, not words. Whether it is a human heart pumping blood rhythmically via the aorta, or a Vertical Axis Wind Turbine (VAWT) turning in the desert of Egypt, both follow fundamentally similar principles. As a student who wants to connect Medical Devices to Mechanical Engineering, I have discovered that "flow" is a point of connection between Medicine and Engineering.

Fluid dynamics, in both the turbine and the heart, have been used in this example. The fluid dynamics equations I have used to determine the torque on my VAWT prototype are governed by the same laws as the hemodynamic laws.

The use of Bernoulli's Principle is illustrated by this example:

$$P + 0.5 \rho v^2 + \rho gh = \text{CONSTANT}$$

A change in fluid velocity is followed by a change in fluid pressure as described by this equation. This helps me explore how wind, when used as a lift producing force on turbine blades, functions. In the medical area, this describes that when an artery becomes narrow (stenosis), the speed at which blood flows increase quickly, causing a dangerous pressure to drop.

The starting torque was the most important part of the recent Vertical Axis Wind Turbine I built that would pump water. This is the minimum amount of force required to make the turbine move from the point it is not moving at all because of its weight (inertia).

$$T = r \times f \sin \theta$$

It is interesting to note that the basic laws of levers and torque also apply to the way the human musculoskeletal system works. The limbs in our body act as "biological machines" because they contain tendons that exert force on the joints at specific angles to move the body's parts. The fundamental physics (levers & torque) for the musculoskeletal system to create movement are the same as those found in understanding the torque needed to lift a bucket of Water in an arid climate; understanding the torque that the Heart must generate to pump blood against systemic resistance.

Why does mathematics matter? It matters because of Efficiency. My goal when I researched was to create energy with a value of 150 Joules. Because of this, every single

millimeter in the design of my 3D-printed blade has an effect. This is like the "Biological Optimization" that is found in the human body. The branching of our lungs and blood vessels takes a fractal shape to maximize the surface area for the smallest amount of "volume".

After finishing this paper, I'd see doctors + engineer sharing a lot in common, too. They both are trying to keep it "Homeostasis" of their respective systems - the doctor keeping a biological system homeostasis, and the engineer keeping a mechanical system homeostasis. When we learn about mathematics related to force, flow and energy applications, we not only learn to understand living things basically but also use it to keep them (either by repairing a real heart or giving a person a way to drink water when living in a desert)