**Challenge #3**

**Use the power of the internet and of LLMs to identify a physical system that solves differential equations inherently, through its physical properties, without executing instructions as a traditional processor does.**

Below are the list of systems that model the physical laws naturally:

1. Analog Computers and Electrical Circuits (RC, RLC, Op-Amps)

2. Mechanical Systems (Mass-Spring-Damper)

3. Optical Systems (Diffraction, Fourier Optics)

4. Soap Films and Minimal Surfaces

5. Neurons and Hodgkin-Huxley Model

6. Quantum Systems

7. Fluid Dynamics and Navier-Stokes Equations

I have gone through papers and articles based on some of the above systems. Below is the detailed view of the papers.

1. G. A. Barrios, J. C. Retamal, E. Solano, and M. Sanz, “Analog simulator of integro-differential equations with classical memristors,” *Scientific Reports*, vol. 9, no. 1, Sep. 2019, doi: [10.1038/s41598-019-49204-y](http://dx.doi.org/10.1038/s41598-019-49204-y).

This paper demonstrates how memristors—resistive components with memory—can be used in analog circuits to solve integro-differential equations inherently. Instead of using digital processors, the physical behaviour of memristors within a circuit simulates the mathematical behaviour of complex systems, offering a powerful platform for modelling nonlinear dynamics and potential applications in neuromorphic computing.

1. General Purpose Analog Computers (GPAC): <https://en.wikipedia.org/wiki/General_purpose_analog_computer>

GPACs, as introduced by Claude Shannon, are theoretical analog machines composed of interconnected integrators, multipliers, and constant sources. These devices physically model differential equations by mapping mathematical operations directly onto electrical components, enabling them to solve equations continuously and inherently, without needing digital algorithms.

1. Historical Analog Computing Devices: <https://en.wikipedia.org/wiki/Mallock_machine>

This historical analog computing device, built in the 1930s, used electrical transformers to solve systems of linear differential equations. It stands as an early example of how physical systems can inherently perform computations, offering insights into pre-digital methods of solving complex mathematical problems via purely physical interactions.

1. RLC Circuits and Differential Equations: <https://en.wikipedia.org/wiki/RLC_circuit>

RLC circuits—made of resistors, inductors, and capacitors—naturally embody the mathematics of second-order linear differential equations. Their voltage and current responses over time represent the solutions to such equations, allowing these circuits to inherently simulate oscillatory and damping behaviours found in physical and engineering systems.