

# Exploring Analog Computers through Vertical Motion Simulation

---

## What is an Analog Computer?

An **analog computer** is a computing device that utilizes continuously variable physical quantities such as voltage, current, or mechanical motion to model and solve problems. Unlike digital computers, which use binary values, analog computers represent data as continuous signals.

Analog computers are especially useful for simulating real-world dynamic systems governed by differential equations, such as physical motion or electrical circuits.

## Applications of Analog Computers

- Simulation of physical systems (mechanical, electrical, thermal)
- Real-time control systems (e.g., early aerospace and defense systems)
- Signal processing (e.g., filters, waveform generation)
- Educational tools for understanding system dynamics
- Solving differential equations in engineering and physics

## Our Project: Vertical Motion Analog Computer

In this project, we simulate the vertical motion of a block under the influence of gravity, damping (resistance) and a spring force. The system is governed by the second-order differential equation:

$$\frac{d^2y}{dt^2} = -g - \frac{b}{m} \frac{dy}{dt} - \frac{k}{m}y \quad (1)$$

where  $y$  is displacement,  $g$  is gravitational acceleration,  $b$  is damping coefficient,  $k$  is spring constant, and  $m$  is the mass.

We use the following analog circuit blocks:

- **Summation Circuit:** Combines voltage inputs representing different forces
- **Integrator Circuits:** Convert acceleration to velocity and then to displacement
- **Deboo Integrator (Howland Current Source):** Provides stable and linear integration.

## Why is This Interesting for you?

- Demonstrates how mathematics governs real-world behavior
- Provides hands-on circuit design experience
- Uses both simulation (LTspice) and hardware (oscilloscope)
- Enhances understanding of dynamics, control systems, and analog design
- Fun and visual way to learn second-order systems