

Double Pendulum Simulator

Classroom worksheet · Interactive simulation: <https://lkforge.com/tools/physics/double-pendulum/>

Name: _____ Date: _____

Learning objectives

- Observe sensitive dependence on initial conditions (chaos).
- Contrast predictable and chaotic motion.
- Recognize that a deterministic system can be practically unpredictable.

Variables to change

- Initial angles
- Arm lengths
- Masses

Procedure

1. Release the pendulum from a small starting angle and watch the motion.
2. Release it again from a nearly identical angle and compare the two paths over time.
3. Release it from a large angle and observe the motion.

Observations

Describe how quickly two nearly identical starts diverge from each other.

Questions

1. What happened when you started from two almost-identical angles?
2. Is the double pendulum random?
3. How does a single pendulum differ from a double pendulum?

4. Why can't we predict its exact position far into the future?
5. Name another real system that shows sensitive dependence on initial conditions.

Answer key (instructors)

- **1.** The motions matched briefly, then diverged completely — the hallmark of chaos.
- **2.** No. It is fully deterministic (governed by fixed equations) but extremely sensitive to initial conditions, so long-term prediction is impractical.
- **3.** A single pendulum is periodic and predictable; adding a second arm couples the motion and produces chaos.
- **4.** Tiny uncertainties in the starting state grow exponentially, so any measurement error eventually dominates.
- **5.** Weather, turbulent fluids, or a Lorenz-type system — the “butterfly effect.”

The double pendulum is deterministic yet chaotic: nearby starting states diverge exponentially, so its long-term motion is unpredictable even though the equations are exact. It is a classic, visual demonstration of the butterfly effect.