

Comps Presentation Outline

Jared Baur

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I. INTRODUCTION

Double pendulum is a well known example of chaotic behavior.

First half cycle is relatively predictable and repeatable, but after that chaos is prevalent.

Can a baseball bat (or any other swinging element) be designed so that all the energy from the first pendulum arm (arms of person swinging bat) can be transferred to the bat?

II. CHAOS¹

$$\Delta x(t) \sim \Delta x(t_0)e^{\lambda t} \quad (1)$$

Equation 1 describes the separation between nearby trajectories (so this describes the difference between expected values and actual values.

As time increases, the chaos increases.

Show tandem double pendulum to show unpredictability

pendula that are released from a larger initial angle (or a bat that is swung after traveling a large distance from

the arms) produce trajectories that quickly diverge from one another

A. Cause of Exponential Growth

III. EQUATIONS OF MOTION

Explain why Newtonian equations are used instead of Lagrangian equations

Talk about moment of inertias for both pendulum arms

Talk about initial conditions for different situations

IV. EXPERIMENTAL RESULTS

Talk about procedure taken to produce experimental results

V. ENERGY TRANSFER

Center of percussion for bats²

Building the perfect bat that transfers all energy

VI. RELEVANCE TO OTHER APPLICATIONS

Overarm throwing (upper arm is first pendulum arm and lower arm is second pendulum arm)

¹Shinbrot, American Journal of Physics **60**, 491 (1992).

²Cross, American Journal of Physics **73**, 330 (2005).