

Chain Physics

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Figure 1: <https://zdtan.wordpress.com/education/>

1 Introduction

Chains generally obey classical mechanics, which make them accessible objects of study for high school students. Quite sophisticated analysis can be done using the mathematics of calculus and Newton's laws of motion, without invoking Lagrangian or Hamiltonian mechanics.

Yet chains display subtle physics, because they are extended objects, and can move in different directions along their lengths. We are considering here massive chains, rather than the approximation of light chains in the context of masses attached to their ends.

2 Questions

2.1 Shape of chain hanging under gravity (uniform mass density, uniform field)

- How to setup mathematical equation for static equilibrium? (Differential equation)
- What are the solutions? (Catenary)

2.2 The chain fountain popularised by Steve Mould

- Why does the chain fountain rise mysteriously out of the container?

2.2.1 Overview

- What is the history of the discovery? (Playing with mechanical model of polyethylene oxide)
- How did this phenomenon impact physics education? (IYPT, Cambridge outreach)

2.2.2 Physics

- How to approach the problem and develop a model to understand it?

- Steady-state behaviour (Constant speed) ([exploring the anomalous force](#))
- Three branches
 - Rising branch (Balance of tension and weight)
 - Turning branch (Circular motion, centripetal acceleration, radius cancels!)
 - Falling branch (Balance of tension and weight)
- The need for an anomalous force
 - Dimensional analysis (Table has more important effect than floor)
 - Numerical simulations (Zero gravity suspension)
 - Physical models (Reaction force from surface)
- Differential equation for a catenary
- Dissipation (Conservation of momentum means half the work done is “lost”)

3.2.3 Education-focused

[About Cambridge partnership Isaac Physics \(Cambridge\)](#)

3.2.4 News and blogs

[NYTimes Nature Science](#) There are some early reports and blogs that analyse this, but they don’t get the full physics, so I’m not linking to them here.

3.3 Catenary (Hanging chain)

[Wikipedia derivation](#)

3.4 Ring in Chain (Magic trick)

[M. Vollmer, K.-P. Möllmann \(TPT 2011\)](#)

3.5 Unfurling string on tabletop

[J. A. Hanna, C. D. Santangelo \(PRL 2012\)](#)

3 References

3.1 YouTube playlist

[Various chain physics phenomena](#)

3.2 Chain Fountain

3.2.1 Initial discovery

[Steve Mould](#)

3.2.2 Research articles

[J. S. Biggins, M. Warner \(RSPA 2014\)](#) [J. S. Biggins, M. Warner \(pre-print\)](#) [R. Martins](#)