DEVELOPING AND TESTING A LAGRANGIAN MODEL OF THE FLOATING-ARM TREBUCHET

PHYSICS

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My project consisted of developing a mathematical model for the floating-arm trebuchet (a kind of catapult) using Lagrangian mechanics, and building a physical one to test the theory.

Abstract

The floating-arm trebuchet (a kind of catapult) is a modern variant of the famous medieval trebuchet that has received little attention in litterature despite being more energy-efficient than its historical counterpart. Most notably, experimental verification of mathematical models is still lacking from the literature. Here, to compare a Lagrangian mathematical model to empirical results we investigated the relationship between the hook angle of a floating-arm trebuchet and the range.

We started by developing a mathematical model that relied on Lagrangian mechanics, an alternative formulation of classical mechanics which is more appropriate than Newtonian mechanics for complex systems like the floating-arm trebuchet. Combining this Lagrangian model with a numerical analysis of projectile motion with air resistance allowed us to predict the behaviour of the floating-arm trebuchet.

To compare the theory to reality, a small scale floating-arm trebuchet was built and 9 different values of hook angle were tested 5 times each. We observed that theory and results follow the same trend but the maximum range is lower and occurs at a lower value of hook angle than predicted.

Despite the shift between theory and experiment, the similarity in the trend obtained shows that the Lagrangian model is still relatively accurate at describing the relationship between the hook angle of a floating-arm trebuchet and the range. A qualitative analysis shows that the model could be improved in the future by taking into account the effect of friction.