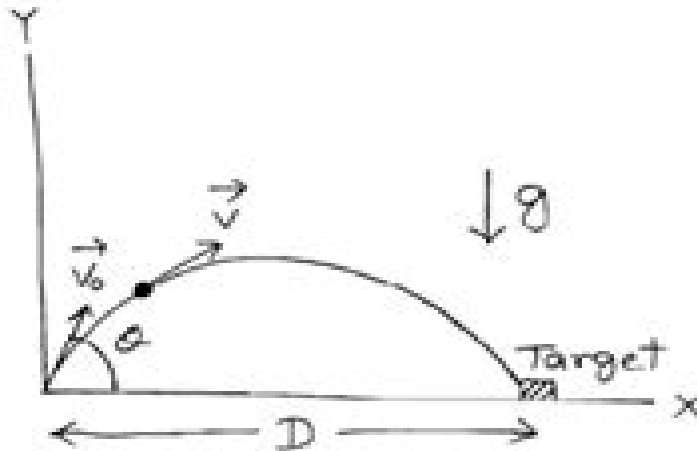


Consider the motion of a projectile in earth's gravitational field. The projectile of mass m is launched from the origin in a direction making an angle θ with the horizontal so as to hit a target placed at a distance D . There is a frictional force due to the air resistance acting on the projectile, which is opposite to the velocity direction and proportional to the square velocity. The equation

of motion from the Newton's Laws is:

$$M \left(\hat{i} \frac{d^2x}{dt^2} + \hat{j} \frac{d^2y}{dt^2} \right) = -Mg \hat{j} - \kappa v^2 \hat{v}$$

The following parameters are given: $g = 10 \text{ m/sec}^2$, $D = 1 \text{ Km}$, and the air friction parameter $\alpha = \kappa / M = 0.001 \text{ m}^{-1}$. If air friction is zero, then the analytical solution is known from elementary physics (formula given below), which you can use to check the results from your computer code. Draw appropriate graphs to discuss all key results.



- Write a computer code to solve the boundary value problem by using the shooting method.
- Determine the initial speed v_0 as a function of θ ($0 < \theta < \pi/2$) so that it hits the target.
- What is the minimum value of v_0 needed for the projectile to hit the target and what is the corresponding θ ?
- Repeat the above for $\alpha = 0.002 \text{ m}^{-1}$ and $\alpha = 0.005 \text{ m}^{-1}$.

Note: I suggested above some values for α . Determine appropriate values from your own numerical simulations so that you can see the effect of friction on motion. If friction is too high, the particle may not reach the target. If it is too low, you obtain results close to the analytical solution from elementary physics, viz., $v_0 = \sqrt{Dg / \sin 2\theta}$.

Numerical Method: Choose one of the following methods to solve the differential equations. Use a constant step size, just small enough that you can reproduce the analytical result for the initial speed v_0 accurate to within 0.001 % for the case of zero air resistance and $\theta = 45^\circ$.

- The fourth-order Runge Kutta Method to carry out the entire integration.

Projectile Motion Using Runge Kutta Methods

Konstantinos Anagnostopoulos



Projectile Motion Using Runge Kutta Methods:

This book delves into Projectile Motion Using Runge Kutta Methods. Projectile Motion Using Runge Kutta Methods is an essential topic that needs to be grasped by everyone, ranging from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Projectile Motion Using Runge Kutta Methods, encompassing both the fundamentals and more intricate discussions.

1. The book is structured into several chapters, namely:
 - Chapter 1: Introduction to Projectile Motion Using Runge Kutta Methods
 - Chapter 2: Essential Elements of Projectile Motion Using Runge Kutta Methods
 - Chapter 3: Projectile Motion Using Runge Kutta Methods in Everyday Life
 - Chapter 4: Projectile Motion Using Runge Kutta Methods in Specific Contexts
 - Chapter 5: Conclusion
 2. In chapter 1, this book will provide an overview of Projectile Motion Using Runge Kutta Methods. The first chapter will explore what Projectile Motion Using Runge Kutta Methods is, why Projectile Motion Using Runge Kutta Methods is vital, and how to effectively learn about Projectile Motion Using Runge Kutta Methods.
 3. In chapter 2, this book will delve into the foundational concepts of Projectile Motion Using Runge Kutta Methods. This chapter will elucidate the essential principles that need to be understood to grasp Projectile Motion Using Runge Kutta Methods in its entirety.
 4. In chapter 3, this book will examine the practical applications of Projectile Motion Using Runge Kutta Methods in daily life. This chapter will showcase real-world examples of how Projectile Motion Using Runge Kutta Methods can be effectively utilized in everyday scenarios.
 5. In chapter 4, the author will scrutinize the relevance of Projectile Motion Using Runge Kutta Methods in specific contexts. This chapter will explore how Projectile Motion Using Runge Kutta Methods is applied in specialized fields, such as education, business, and technology.
 6. In chapter 5, this book will draw a conclusion about Projectile Motion Using Runge Kutta Methods. The final chapter will summarize the key points that have been discussed throughout the book.
- The book is crafted in an easy-to-understand language and is complemented by engaging illustrations. This book is highly recommended for anyone seeking to gain a comprehensive understanding of Projectile Motion Using Runge Kutta Methods.

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