Kathmandu University

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Department of Computer Science and Engineering

Simulation of Projectile Motion

A third year second semester mini project report submitted in partial fulfillment of requirements for COMP 342.

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Chapter 1: Introduction

1.1 Synopsis

The project is simulation of projectile motion of an object projected at a certain angle with the ground and at a certain initial velocity. The resulting path along with the time of flight, the maximum height reached, horizontal range covered, time to reach maximum height, final velocity, etc of the object is calculated by using its initial velocity and projection angle and the projectile formulas in physics. This entire process has been simulated via an animation in a window using Tkinter and python.

1.2 Objectives

To show simulation of projectile motion using Tkinter graphics library according to the initial velocity and angle of projection given by the user.

Chapter 2: Design and Implementation

2.1 System Requirement Specification

Software Specification

- **Programming Languages** Python
- **Operating System** Ubuntu 16.04 LTS
- **Graphics Library** Tkinter

2.2. System Requirement Description

Software Description

2.2.1 Python

Python is a modern, easy-to-learn, object-oriented programming language. It has a powerful set of built-in data types and easy-to-use control constructs.

2.2.2 Ubuntu 16.04 LTS

Ubuntu is an open-source operating system (OS) based on the Debian GNU/Linux distribution. Ubuntu incorporates all the features of a Unix OS with an added customizable GUI, which makes it popular in universities and research organizations. Ubuntu is primarily designed to be used on personal computers, although a server editions does also exist.

2.2.3 Tkinter Graphics Library:

2.2.3.1 Tkinter

The Tkinter module ("Tk interface") is the standard Python interface to the Tk GUI toolkit. Both Tk and Tkinter are available on most Unix platforms, as well as on Windows systems. (Tk itself is not part of Python; it is maintained at ActiveState.) Tk/Tcl has long been an integral part of Python. It provides a robust and platform independent windowing toolkit, that is available to Python programmers using the tkinter package, and its extension, the tkinter.tix and the tkinter.ttk modules. Tkinter is a Python binding to the Tk GUI toolkit. It is the standard Python interface to the Tk GUI toolkit, and is Python's de facto standard GUI.

2.2.3.2 The Tkinter Canvas Widget

The Canvas widget provides structured graphics facilities for Tkinter. This is a highly versatile widget which can be used to draw graphs and plots, create graphics editors, and implement various kinds of custom widgets.

2.2.3.3 When to use the Canvas Widget

The canvas is a general purpose widget, which is typically used to display and edit graphs and other drawings. Another common use for this widget is to implement various kinds of custom widgets.

Chapter 3: Methodology
3.1 Theory of projectile

Projectile motion is a form of motion experienced by an object or particle (a projectile) that is thrown near the Earth's surface and moves along a curved path under the action of gravity only (in particular, the effects of air resistance are assumed to be negligible). This curved path was shown by Galileo to be a parabola. The study of such motions is called ballistics, and such a trajectory is a ballistic trajectory. The only force of significance that acts on the object is gravity, which acts downward, thus imparting to the object a downward acceleration. Because of the object's inertia, no external horizontal force is needed to maintain the horizontal velocity component of the object.

Ballistics is the science of mechanics that deals with the flight, behavior, and effects of projectiles, especially bullets, unguided bombs, rockets, or the like; the science or art of designing and accelerating projectiles so as to achieve a desired performance.

The elementary equations of ballistics neglect nearly every factor except for initial velocity and an assumed constant gravitational acceleration. Practical solutions of a ballistics problem often require considerations of air resistance, cross winds, target motion, varying acceleration due to gravity, and in such problems as launching a rocket from one point on the Earth to another, the rotation of the Earth. Detailed mathematical solutions of practical problems typically do not have closed-form solutions, and therefore require numerical methods to address

3.2 Mathematical parameters:

The projectile initial positions are null (i.e.x_0=0andy_0=0).

Inputs

1. Initial Velocity

The velocity with which the object is projected at the time of projection (t=0) is the initial velocity.
The initial velocity can be expressed as x components and y components:

$u_x = u \cdot \cos\theta$

$u_y = u \cdot \sin\theta$

In this equation,u stands for initial velocity magnitude and θ refers to projectile angle.

2. Angle of Projection

The angle between the object and positive x axis at the time of projection (t=0) is called angle of projection. It is represented by θ.

Outputs

1. Time of Flight

The time of flight of a projectile motion is the time from when the object is projected to the time it reaches the surface. As we discussed previously,T depends on the initial velocity magnitude and the angle of the projectile:

$T=2\cdot u_y/g$

$T=2\cdot u\cdot \sin\theta/g$

2. Acceleration

In projectile motion, there is no acceleration in the horizontal direction. The acceleration,a, in the vertical direction is just due to gravity, also known as free fall:

$a_x=0$

$a_y=-g$

3. Velocity

The horizontal velocity remains constant, but the vertical velocity varies linearly, because the acceleration is constant. At any time,t, the velocity is:

$u_x=u\cdot \cos\theta$

$u_y=u\cdot \sin\theta-g\cdot t$

You can also use the Pythagorean Theorem to find velocity:

$u=\sqrt{(u_x^2+u_y^2)}$

4. Displacement

At time, t, the displacement components are:

$x=u\cdot t\cdot \cos\theta$

$y=u\cdot t\cdot \sin\theta-1/2*gt^2$

The equation for the magnitude of the displacement is$\Delta r=\sqrt{(x^2+y^2)}$.

5. Parabolic Trajectory

We can use the displacement equations in the x and y direction to obtain an equation for the parabolic form of a projectile motion:

$y=\tan\theta\cdot x-(g/2\cdot u^2\cdot \cos^2\theta).x^2$

6. Maximum Height

The maximum height is reached when$v_y=0$. Using this we can rearrange the velocity equation to find the time it will take for the object to reach maximum height

t_h=u·sinθ/g

wherethstands for the time it takes to reach maximum height. From the displacement equation we can find the maximum height

h=u^2·$\sin^2$θ/2·g

7. Range

The range of the motion is fixed by the condition y=0. Using this we can rearrange the parabolic motion equation to find the range of the motion:

R=u^2·sin2θ/g.

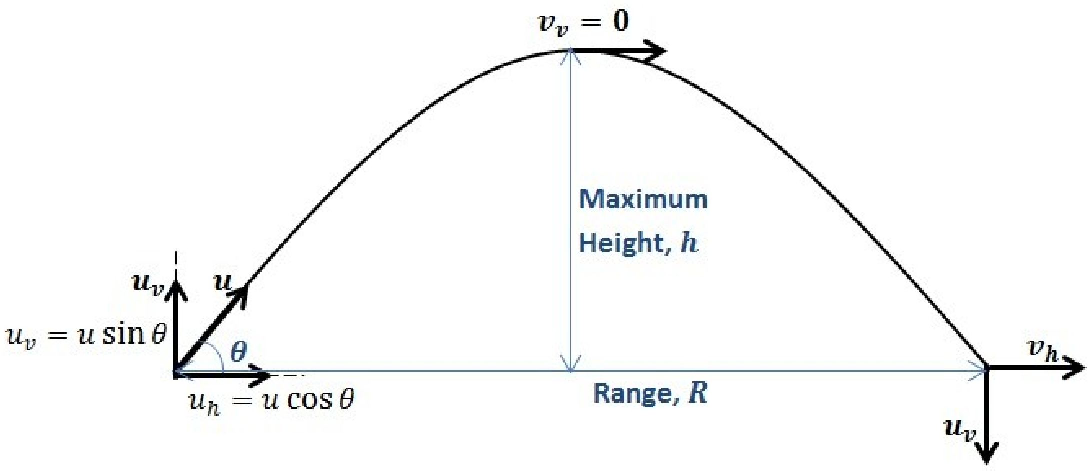

Fig3.2 : Projectile motion

3.3 Algorithm

1. First, a ball was drawn at origin and x and y-axes were drawn.
2. Two input entry boxes were drawn for input of input velocity and angle of projection
3. Two buttons ‘Run’ and ‘Clear’ were drawn.
4. After the user inputs the value in entry boxes and clicks ‘Run’ button, the mathematical formulas are used to calculate the value of Height, Range and Time of flight of projection.
5. The position (x and y coordinates) of the ball was calculated from time t=0 to t=T (time of flight).
6. Finally, the calculated values along with the parabolic path can be seen on the screen.
7. The user may press clear button and enter different values and simulate the result.

Chapter 4: Results

The following results were obtained during the simulation.

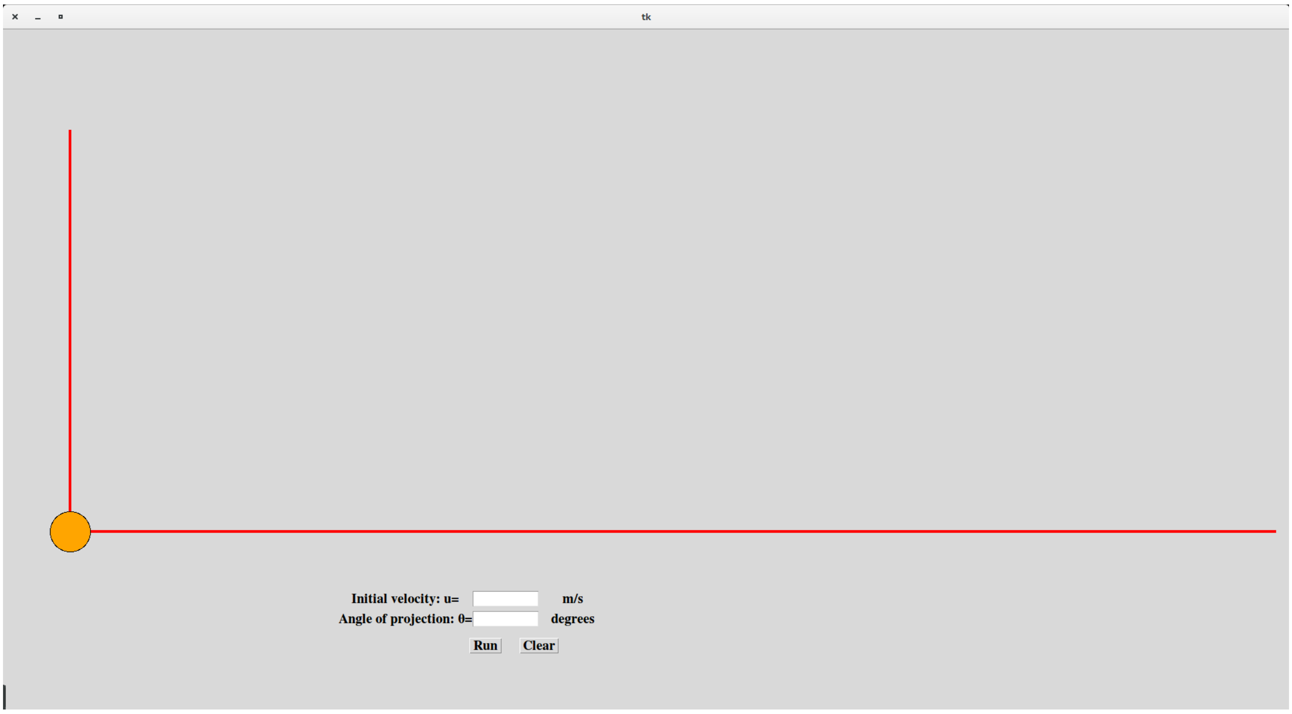

Fig 4.1: Home screen

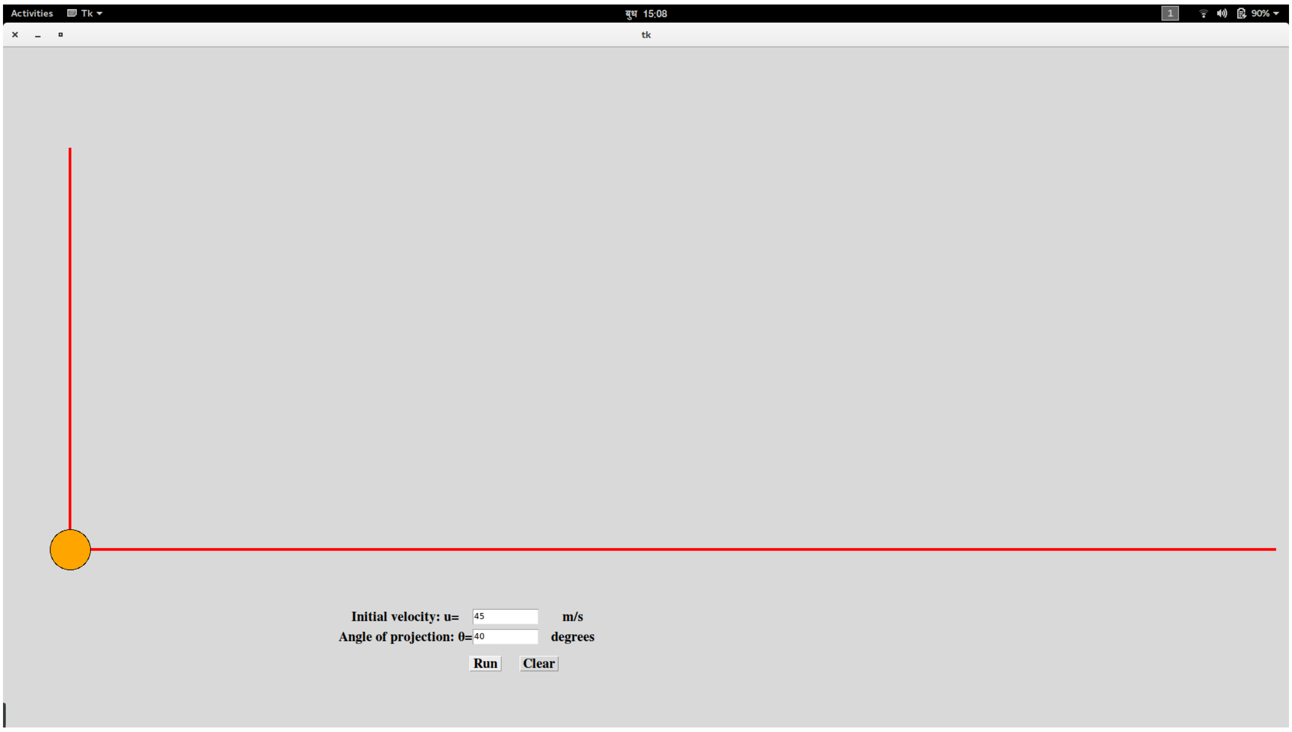

Fig 4.2: Taking input from user

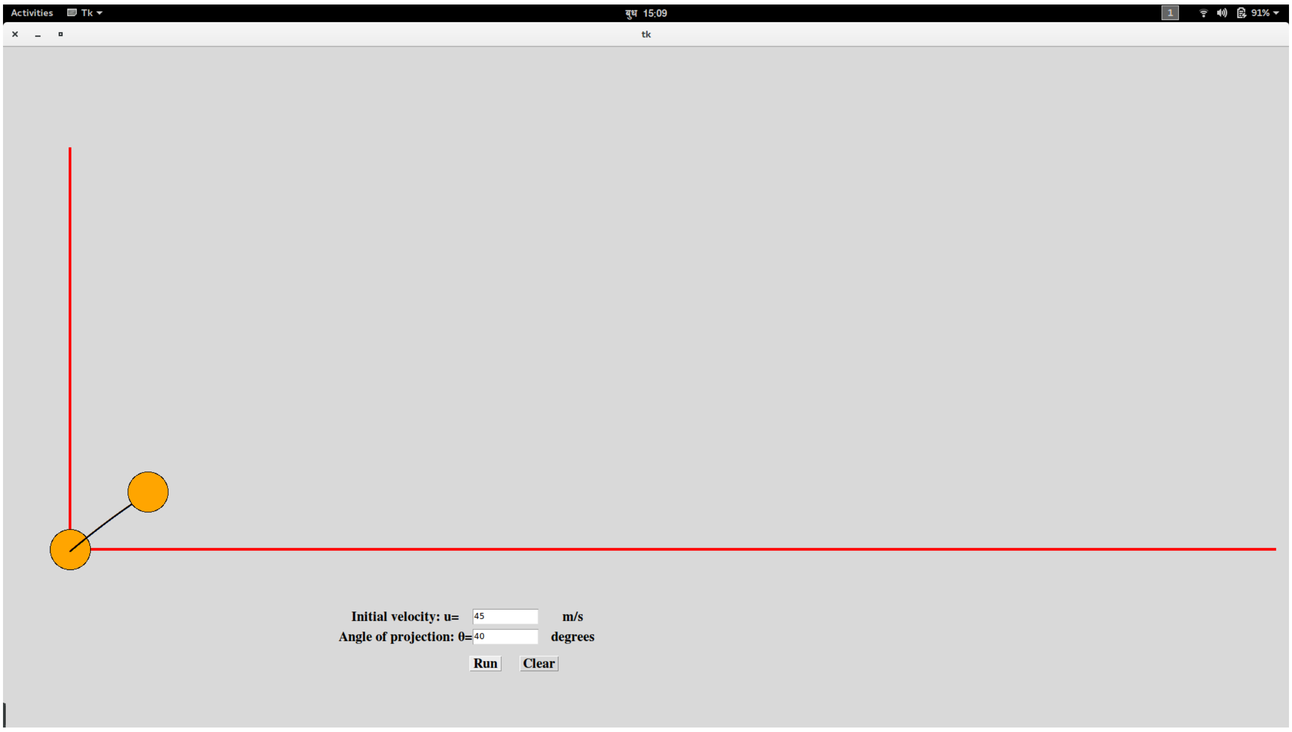

Fig 4.3: Initial motion of the ball

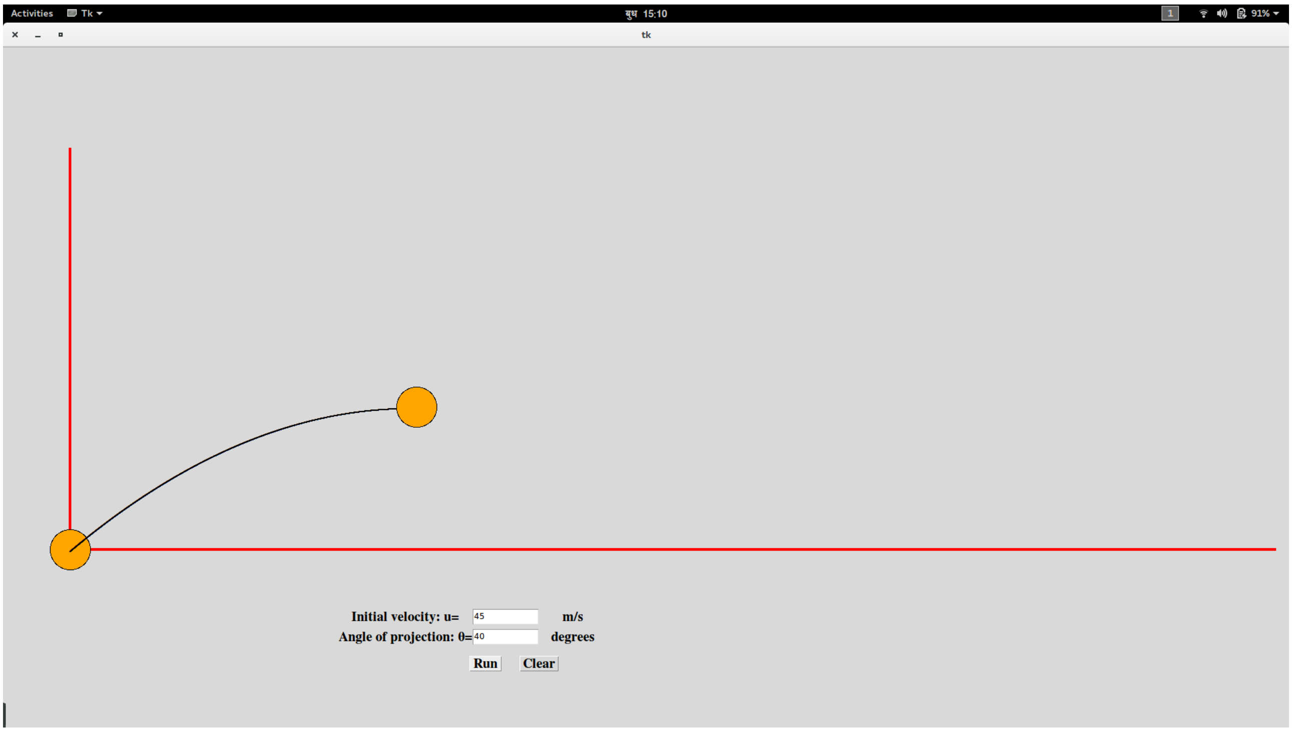

Fig 4.4: Motion of the ball at midway

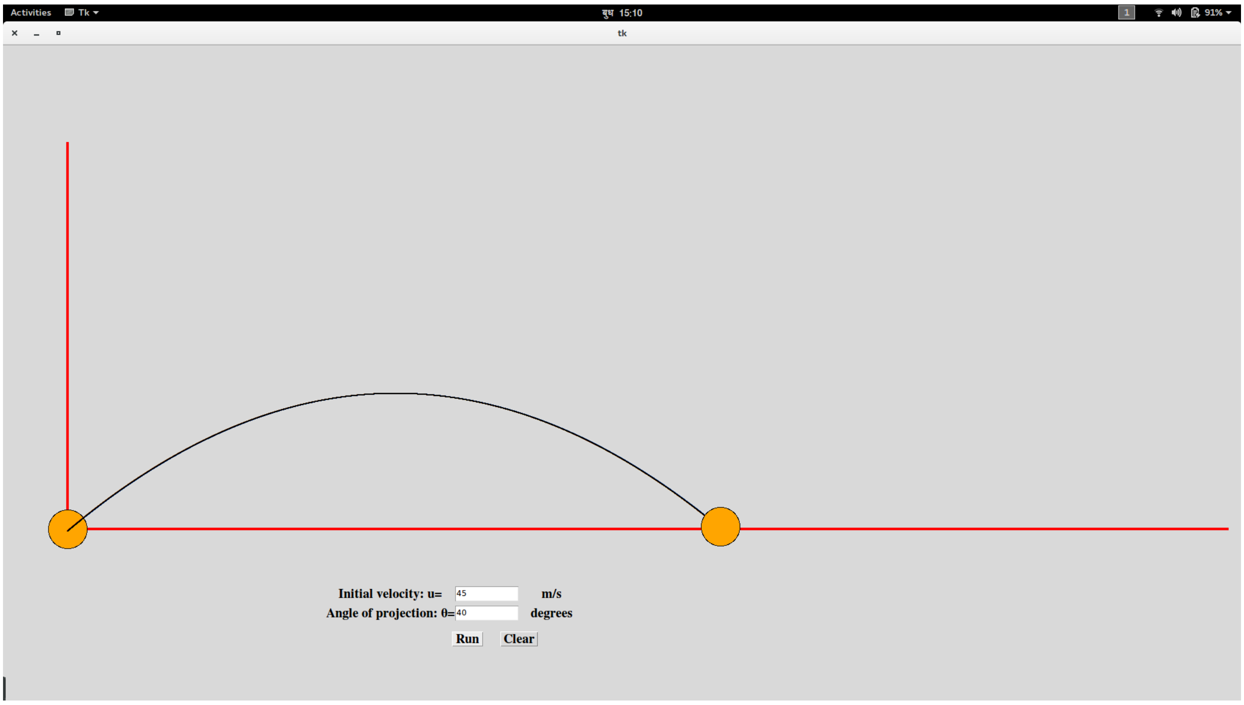

Fig 4.5: Complete motion of the ball

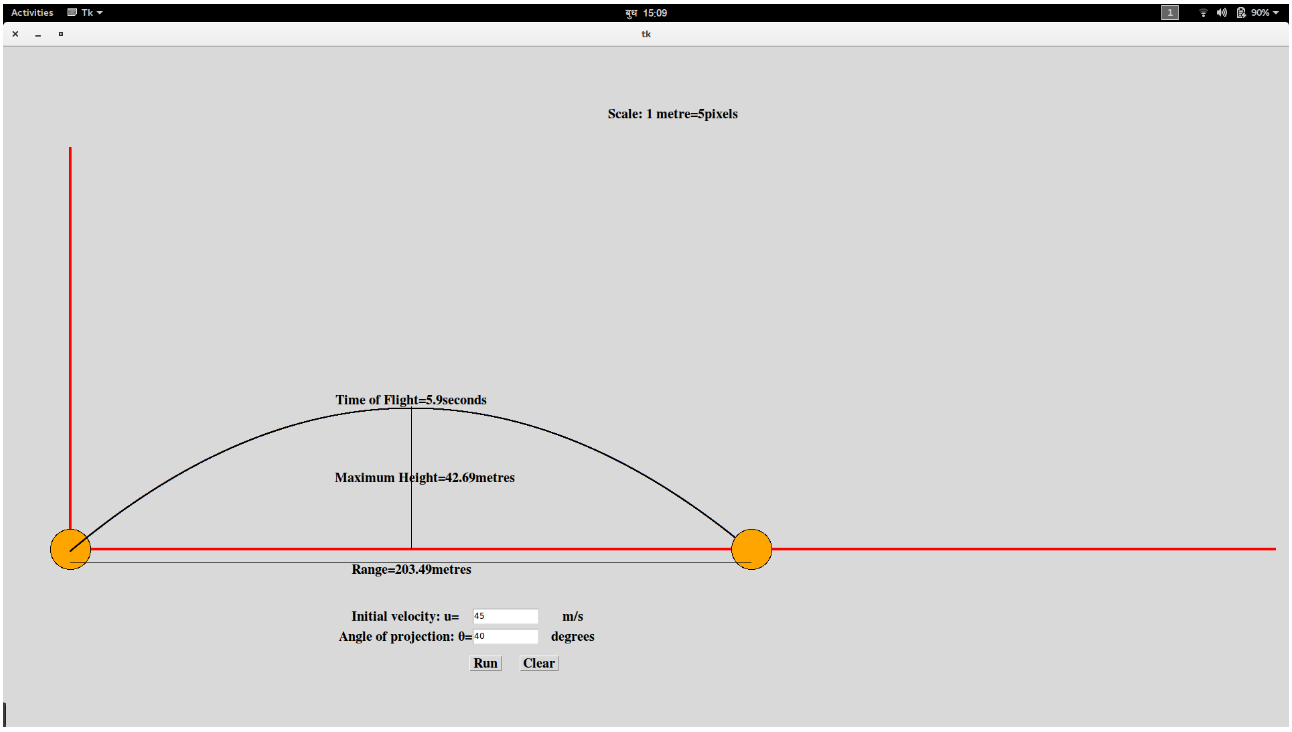

Fig 4.6: Final output

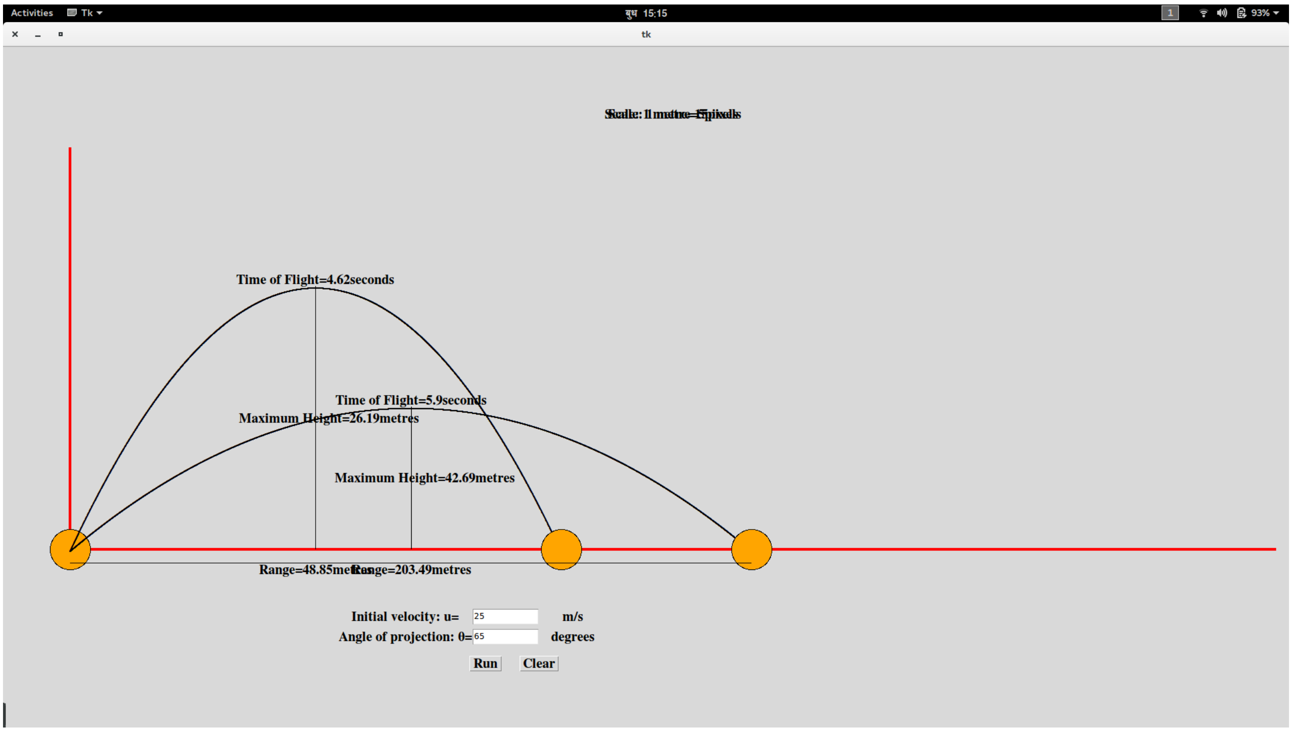

Fig 4.7: Final output for two different input values

Chapter 5: Conclusion

Thus, the simulation of projectile motion was done and the output parameters were also displayed along with the parabolic path of the object using Tkinter graphics library and the mathematical formulas involved in projectile motion.

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