Projectile Motion Lab

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1 Introduction

In this lab, you will analyze the motion of a tennis ball tossed in a high arc between two partners. The goal is to measure the velocity in the x-direction and the acceleration due to gravity in the y-direction by analyzing the ball's trajectory. You will use a custom-built software, `ProjectileMotionGUI02`, to process the video data you collect.

2 Materials

- Tennis ball
- Meter stick
- Whiteboard or any plain background
- Smartphone with video recording capability
- Tape

3 Procedure

3.1 Step 1: Setting Up the Experiment

- Tape the meter stick vertically against a whiteboard or any plain background. Ensure that the meter stick is stable and the entire length is visible in the video frame.

- Position the whiteboard so that it fills as much of the vertical extent of the video frame as possible.
- One partner should stand just outside the left hand side of the frame and the other just outside the right hand side of the frame.
- Toss the tennis ball in a high arc from one partner to the other. It is crucial that the tennis ball does not go above the top of the video frame during its flight.
- Have the third partner record the toss using a smartphone. Try to keep the camera still during the recording.
- Repeat this process to record a total three separate videos.

3.2 Step 2: Download and Install the Software

- Download the installation file `ProjectileMotionGUI02Setup.exe` from the course website.
- Run the setup file and follow the on-screen instructions to install the software. Note that this software is only available for Windows; unfortunately, there is no version for macOS or linux.
- Once installed, launch the program `ProjectileMotionGUI02.exe`.

3.3 Step 3: Importing the Video

- Open `ProjectileMotionGUI02.exe`.
- Click on the `Load Video` button.
- Navigate to the location of your recorded video and select it.
- The first frame of the video will appear on the canvas within the software.

3.4 Step 4: Calibrating the Spatial Dimension

- Click on the `Calibrate` button.
- Using the mouse, click on one end of the meter stick in the video frame. The pixel position should appear in the console window.
- Click on the other end of the meter stick. The software will calculate the scale factor based on the meter stick's length.
- The calculated scale factor (in meters per pixel) will be displayed in the data console.

3.5 Step 5: Capturing the Flight of the Ball

- Click on the `Collect Data` button.
- Use the slider at the bottom of the screen to move through the video frame by frame.
- For each frame where the ball is visible, click on the center of the ball in the video. A red "X" will mark the spot, and the x, y coordinates along with the corresponding time will be recorded.
- If you make a mistake, you can click the `Undo` button to remove the last point or `Clear All` to start over.
- Continue this process by moving the slider slightly until the entire flight of the ball is captured.

3.6 Step 6: Plotting the Data

- After capturing all necessary data points, click on the `Plot Data` button.
- The program will display two plots:
  - **X-Position vs. Time:** The x-coordinates of the ball over time, with a linear fit.
  - **Y-Position vs. Time:** The y-coordinates of the ball over time, with a quadratic fit.
- The equations of the best-fit lines will be displayed on the graphs.

3.7 Step 7: Analyzing the Data

- **X-Direction Analysis:** From the equation of the linear fit on the X-Position vs. Time graph, determine the velocity of the ball in the x-direction. The slope of the line represents the constant velocity.
- **Y-Direction Analysis:** From the equation of the quadratic fit on the Y-Position vs. Time graph, calculate the acceleration due to gravity. The coefficient of the t^2 term in the equation represents half of the acceleration, so multiply this coefficient by 2 to find the gravitational acceleration.

4 Conclusion

By following this procedure, you should be able to accurately determine the velocity in the x-direction and the acceleration due to gravity for a tennis ball tossed in an arc. This experiment reinforces the principles of projectile motion and the use of video analysis in physics.