The American University in Cairo
School of Sciences and Engineering
Fall 2019, ENGR 3202 Dr. Elkhayam Dorra

PROJECT

Due Date: December 8th, 2019

Requirement

The goal of firing a projectile is so that it lands on a specific target. If we ignore the effects of air resistance, the differential equations describing its acceleration are very simple:

$$\frac{dv_x}{dt} = 0 \qquad \frac{dv_z}{dt} = -g$$

Here g = 9.81m/s^2, and we can show that these equations result in a parabolic trajectory. Once we know this, we can easily calculate the initial speed v_0 and angle θ_0 above the horizontal necessary for the projectile to reach the target.

However, the effects of air resistance are significant when the projectile must travel a large distance, and if we modify these equations to include a simple model of air resistance, they become:

$$m\frac{dv_x}{dt} = -cv_x\sqrt{v_x^2 + v_z^2} \qquad m\frac{dv_z}{dt} = -mg - cv_z\sqrt{v_x^2 + v_z^2}$$

Here the constant c depends on the shape and density of the projectile and the density of air. Develop a model of estimating v_0 and θ_0 with reasonable accuracy, given the range to the target d. (Use a second order method, and be sure to persuade me that your numerical solution is accurate enough.)

Your model should consider the following:

- Projectiles fired at different altitudes Δz
- External wind forces with various components
- Vertical barriers that might exist
- Projectiles of varying shapes and masses

The model should:

- Calculate the initial speed v_0 and θ_0 needed to reach the target
- Draw the profile of the flight of the projectile
- Calculate the time at which the projectile has reached the target

Bonus: A bonus of 10% will be added for the group that can also incorporate the Magnus effect into their model accounting for the spinning of the projectile.

Write Up

Present the project in a report format, including but not limited to:

1. Introduction and background
    - Presenting background on numerical integration and differentiation methods, illustrating advantages/disadvantages of using such methods

2. Model
    - Flow chart or pseudo code illustrating the algorithm developed
    - Submit a soft and hard copy of your code
    - Code should be accompanied by commentary for ease of review
    - Model should be flexible for use on multiple case studies, and not just tailored to a single case study
    - Results of your test cases

3. Case Study
    - Present background regarding the engineering case study
    - Clearly present all equations that are developed to solve the system
    - Present the solution algorithm
    - Present and discuss results obtained

4. Conclusion
    - Discuss your model and areas in which you believe your model can be improved

Groups

Groups should be 3-4 students