L E B A N E S E A M E R I C A N U N I V E R S I T Y
Electrical and Computer Engineering Dept

COE 312
Data Structures

Fall 2013
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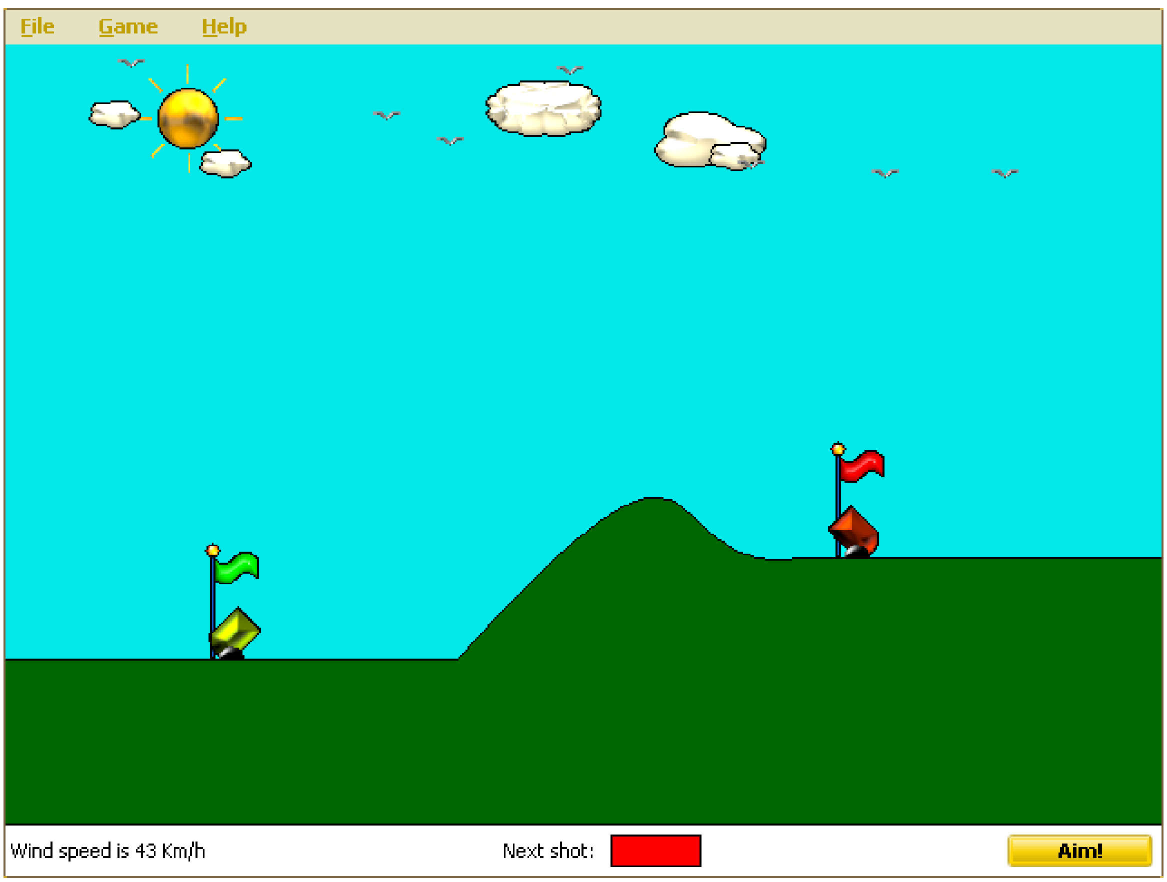
Project III

Due date: MondayJanuary 20, 2014

I. Objective

In this project, you will be reviving "**Bang! Bang!**", one of the most popular classic games for Windows. "**Bang! Bang!**" is a simple multi-player artillery game where each player owns a cannon and the players take turns shooting at each other as demonstrated in the figure below until one of the players is hit and destroyed.

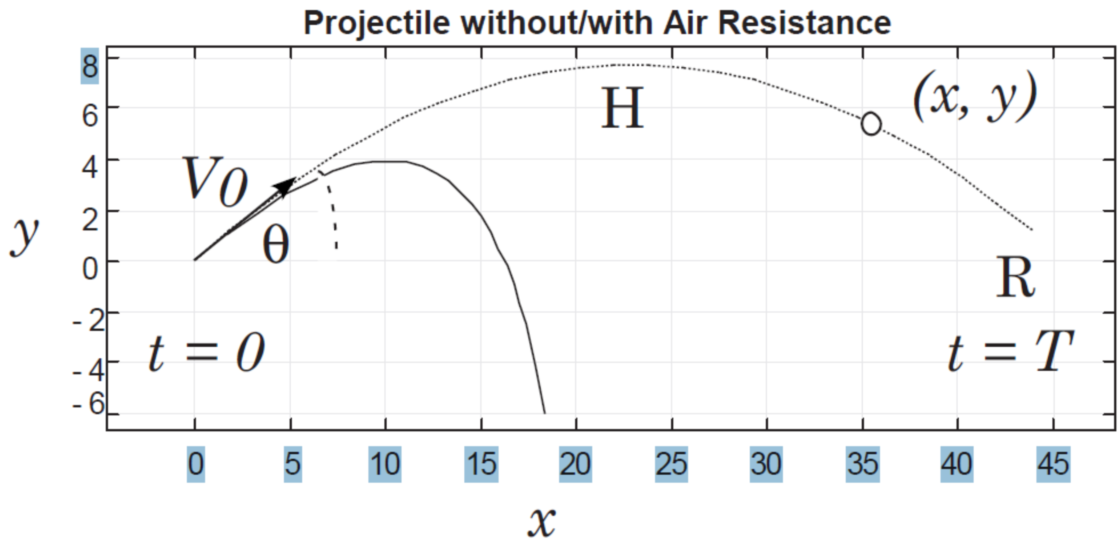


More specifically, playing against a human opponent or the computer, the two cannons take turns selecting an angle and a velocity with the purpose of firing a cannonball at each other. The figure given next shows the user interface allowing a player to set the values of these parameters for one of the two cannons, in particular the red cannon. The angle parameter is used to aim the cannon while the velocity parameter defines the initial speed of a cannonball. When youfire the cannonball using the “Fire!” button, the game plays a firing sound and when a cannonball hits its target, an explosion sound plays and the opponent’s cannon disappears from the screen.

Your job is to develop this “Bang! Bang!”-style game.While the premise of the project is very appealing, simulating the motion of a cannonball is somewhat a challenging task. Building on this observation, the rest of this document is devoted to describing how one can accomplish this task.

II. Simulating the motion of the cannonball

A trajectory is the path that a moving object follows through space as a function of time. The object of interest in this project is clearly the cannonball. The trajectory followed by the cannonball will depend on the **angle of throw θ relative to the horizon**, the **initial velocity V_0**, the force due to gravityF_g, andthe friction force due to air resistanceF_{resist}.



A program that **simulates the motion of a cannonball** has to go through the following steps:

1. Determine the values of θ and V_0
2. Setup the "equations of motion" that govern the evolution of the position of the cannonball
3. Vary the position of the cannonball as a function of time based on the equations of motion developed in (2)

Note that in this project and unlike the project assigned last year, you will be dealing with the case in which the projectile is subject to air resistance.

III. Setting up the equations of motion

In the context of a **friction-fullcannonball motion scenario** such as the one we are considering in this project, the force associated with air resistance is opposite in direction to the velocity vector corresponding to the cannonball. In addition to the force associated with the air resistance, there is the force pertaining tothe uniform gravitational field acting on the cannonball. The force of gravity causes the cannonball to fall towards the center of the earth with a constant acceleration $g=9.8m/s^2$.

The equations of motions are given as follows:

$$x(t) = \frac{mv_0 cos\theta}{b}\left(1 - e^{\frac{-bt}{m}}\right) \textbf{(1)}$$

And

$$y(t) = \frac{m}{b}\left(\frac{mg}{b} + v_0 sin\theta\right)\left(1 - e^{\frac{-bt}{m}}\right) - \frac{mgt}{b} \textbf{(2)}$$

At any time t, the instantaneous components of the velocity can be expressed as:

$$v_x(t) = v_0 cos\theta e^{\frac{-bt}{m}}$$

And

$$v_y(t) = -\frac{mg}{b} + \left(\frac{mg}{b} + v_0 sin\theta\right) e^{\frac{-bt}{m}}$$

An explicit equation for the trajectory of the cannonball can be derived by using equations (1) and (2). Particularly, by eliminating the time "t" from both of these equations we obtain:

$$y = \frac{x\left(v_0 sin\theta + \frac{mg}{b}\right)}{v_0 cos\theta} + \left(\frac{m}{b}\right)^2 g \ln\left(1 - \frac{bx}{mv_0 cos\theta}\right) \mathbf{(3)}$$

Where b is some **constant positive** value of your choice.

At this point, you are armed with all the **necessary information**that is required to adequately simulate the motion of the cannonball and as such complete the implementation of the "Bang! Bang!" game.

IV. Test-driving the application

You should be able to verify that your game is functioning properly by validating some of the properties of the trajectories followed by your cannonballs via the equations provided next.

Time to Maximum Height:

The time to maximum height should be:

$$t_H = \left(\frac{m}{b}\right) \ln\left(\frac{b\left(\frac{mg}{b} + v_0 sin\theta\right)}{mg}\right)$$

Coordinates of Maximum height:

The x-coordinate and y-coordinate of the maximum height should be:

$$x_H = \frac{mv_0^2 cos\theta sin\theta}{mg + bv_0 sin\theta}$$

And

$$y_H = \frac{m}{b^2}\left(mg \ln\left(\frac{mg}{mg + bv_0 sin\theta}\right) + bv_o sin\theta\right)$$

What to turn in?

This project is due at the beginning of class on the due date. You have to turn inthe following material in both**hard**and **soft** copies.

Criteria	Percentage
HTML Documentation of your code.In addition, provide explanations and illustrations in one or two pages along with a short write-up of questions and/or problems that you encountered while doing this assignment.	2pts (10%)
Source code that contains an appropriate amount of comments. Well-organized and correct code receives 16pts, messy yet working code receives 8 pts, code with bugs receives 2pts, and incomplete code receives 1 pt.	16pts (80 %)
Execution output such as a snapshot of the contents of standard output. A correct output receives 2pts, the one with minor errors receives 1pts, and an incomplete output receives 0 pt.	2pts (5%)
Total	20pts (100%)

Good Luck!