Project 1: Find Launch Angle to Hit Target with Projectile

Introduction

The goal of this project is to find the angle at which a water balloon should be launched such that it hits our enemy mocking us at 25 m away. A simple model of the water balloon's dynamics is represented by the following differential equations

$$M\frac{d^2x}{dt^2} + \beta\frac{dx}{dt} = 0 \tag{1}$$

$$M\frac{d^2y}{dt^2} + \beta\frac{dy}{dt} + mg = 0 \tag{2}$$

where

- t is time assumed to start at $t = 0$ s,
- x is the horizontal position of the water balloon with an initial position $x|_{t=0} = 0$ m and initial velocity $\frac{dx}{dt}|_{t=0} = V_o\cos(\theta)$ m/s,
- y is the vertical position (height) of the water balloon with an initial position $y|_{t=0} = 0$ m and initial velocity $\frac{dy}{dt}|_{t=0} = V_o\sin(\theta)$ m/s,
- θ is the angle at which the water balloon is launched relative to the x- (horizontal) axis,
- V_o is the initial velocity of the water balloon assumed to be 30 m/s,
- M is the mass of the water balloon assumed to be 1.0 kg,
- β is the coefficient of air resistance (drag) assumed to be 0.7 kg/s, and
- g is the earth's acceleration of gravity assumed to be 9.8 m/s^2.

The solutions of the differential equations (1), (2) for time $t \geq 0$ s are

$$x(t) = \frac{MV_o}{\beta}\cos(\theta)\left(1 - e^{-\frac{\beta}{M}t}\right) \tag{3}$$

$$y(t) = \frac{M}{\beta}\left(V_o\sin(\theta) + \frac{Mg}{\beta} - gt - \left(\frac{Mg}{\beta} + V_o\sin(\theta)\right)e^{-\frac{\beta}{M}t}\right). \tag{4}$$

Problem Statement

The goal of the project is to find the launch angle θ (to within 1°) that results in the water balloon hitting our enemy. To solve the problem, develop a C program that

1. varies the launch angle θ from 1° to 90° in increments of 1°;
2. solves for x, y from equations (3), (4) using time $t \geq 0$ s in increments of 0.005 s (hint: $y <= 0$ m corresponds to the balloon hitting the ground);
3. finds and displays the launch angle (θ to the nearest °) that results in the water balloon hitting the enemy;
4. creates a simple, informative and labeled plot of the trajectory with the location of the water balloon shown by a character every meter in the x-direction (see example plot below noting standard width of terminal is 80 characters, each horizontal character corresponds to $\frac{1}{3}$ m in the y-direction, and each new line corresponds to 1 m in the x-direction);
5. makes appropriate use of functions (there should be at least one in addition to *main()*);
6. has parameters that can be easily varied for other scenarios; and
7. is neatly coded, i.e., has appropriate variable names, nice formatting and comments.

Items to Turn In

- Hand in a printed document that includes memo (see sample with guidelines below), C program, and results (launch angle and simple plot of trajectory).
- Email C program to instructor such that program can be readily compiled and executed, and alternate values entered for parameters to test other scenarios. Put "EE 251 Project 1" in the subject line of the email.

Information on Memo's Content and Format

MEMORANDUM

TO:	Kevin Wedeward, Professor
	(readers' names and job titles)
FROM:	Your Name, Student
	(your name and job title; sign or initial by your name)
DATE:	October 3, 2014
	(complete and current date)
SUBJECT:	EE 251 Project 1 - Launch Angle Found via C Program
	(what memo is about - short and informative)

Writing a technical memo can be more challenging that a full report as key information must be conveyed clearly within one page of normal text (not counting supporting attachments such as documents, data, figures, calculations, programs, etc., that are referenced in the text). This makes it similar to a project's abstract/summary, and should contain the following (each as its own sentence or paragraph for clarity):

Objective/purpose. State the problem that was addressed and for what reason.

Means. Provide summary of approach used to address the problem.

Results. Report the results along with interpretation, details of experiment/scenario that affected answer, and accuracy.

Conclusion. State how well you met your objective/purpose, and make recommendations if appropriate.

Make sure to sign or initial your memo by your name to make it official, refer to attachments in the memo, and note attachments at the bottom in a manner similar to that shown below.

Attachments: (Number and list by name)
Attachment 1: proj1.c - C program
Attachment 2: proj.txt - Output (angle and plot) of C program

Sample Plot of Trajectory (a Miss) using Characters