Laboratory Sessions 5

Task 1: Personalized Materials about Function and a Quiz (20%)

This task includes view/interact with personalized materials on the topic "function", which are presented on the NEWTELP platform based on your media presentation preference choices. Take the quiz which follows the materials. (You should have already viewed/interacted with the materials and taken the quiz on the platform by now).

Task 2: Projectile Problem

The purpose of this task is to calculate the theoretical trajectory of a projectile in a constant gravitational field. In other words, we want to calculate the path followed by, say, a ball thrown in the air or of an artillery shell for example.

We are going to make some simplifications. We will work in just two dimensions (i.e., as if we are looking exactly side on at the path of the ball). We will also neglect air resistance, and will treat the projectile as a point mass. This allows a simple analysis of the motion of the projectile, using Newtonian physics theory.

In our two-dimensional (x and y) coordinate system, x will denote the horizontal position, and y will denote the vertical position. According to physics the movement equation on the x direction and consequently the position x at moment in time t is given by:

$$x = x_0 + v_x * (t - t_0), \text{ where} \quad (1)$$

$$v_x = v_{x0} + a_x * (t - t_0) \quad (2)$$

In equations (1) and (2), we have denoted with x_0 the original position on Ox axis (horizontal) at moment t_0, v_x the horizontal component of the velocity at moment t, v_{x0} the horizontal component of the velocity at moment t_0 and a_x the horizontal component of the acceleration.

Similarly, y denotes the vertical position and according to physics the movement equation on the y direction and consequently the position y at moment in time t is given by:

$$y = y_0 + v_y * (t - t_0), \text{ where} \quad (3)$$

$$v_y = v_{y0} + a_y * (t - t_0) \quad (4)$$

In equations (3) and (4), we have denoted with y_0 the original position on Oy axis (vertical) at moment t_0, v_y the vertical component of the velocity at moment t, v_{y0} the vertical component of the velocity at moment t_0 and a_y the vertical component of the acceleration.

Command Line Redirection

Suppose your program is in a file called "projectile.c". After successful compilation, you will have an executable file called "projectile.exe". Normally you execute this simply by giving the name "projectile" as a command. However, if you want to use command line redirection, you would give a command somewhat like this instead:

projectile > out.txt < in.txt

The "<" serves as the input redirection character in a command. The effect is that the input for "projectile" will no longer be taken from the keyboard, but from the file indicated instead. Similarly, the ">" character in a bash command provides for output redirection, to direct output to the file indicated instead of the screen. With any given command invocation you can choose to use no redirection at all, to use input redirection only, output redirection only, or both.

Sub-task 1: Solving the Problem (40%)

Assuming that the initial time $t_0 = 0$, initial position has $x_0 = 0$ and y = y_0 (representing the height of a man throwing the ball) and knowing that there is no horizontal component of acceleration $a_x = 0$ (there is only the vertical component due to the Earth gravity: a_y = - g = -9.81 m/s^2), equations (1)-(4) become equations (5)-(6):

$$x = v_{x0} * t, \quad (5)$$

$$y = y_0 + v_{y0} * t - gt^2 \quad (6)$$

Write a program that reads the initial height y_0 and initial horizontal and vertical velocity components v_{x0} and v_{y0} of the projectile. These values will be assigned to suitable variables. The output from the program will be a display on the screen of the numerical values of x and y calculated using equations (5) and (6) at successive, small intervals of time.

The program should terminate when y becomes zero again (i.e., the projectile falls back to earth). This display should be captured into a text file and a graph plotted of y versus x using Microsoft Excel. One way of capturing program output in a file is described in detail in the section on Command Line Redirection. Informally, the motion of the projectile is pretty simple: it moves steadily to the right (positive x direction), simultaneously going up for a while (positive y direction), and then coming down again to Earth. Technically, under the various idealizing assumptions we have made, it can be shown that the trajectory will be parabolic. You should test your program carefully. Explain, in your report, what tests you carried out, how the program behaves, and whether it has passed such tests.

Sub-task 2: Functional Decomposition and File Writing (40%)

Use functional decomposition to break your program into smaller, more manageable pieces. This will make it easier to write, test, and debug. For example, you might define a new function of your own, which deals with printing out the results, for one cycle of your calculations. This can then be simply called or invoked from within the while loop of your main() function - which should make the main() function shorter and easier to follow. Note that this function will have to accept two arguments (the current values for the x and y co-ordinates). At least three other functions, apart from main(), are required to be produced.
Two of these functions should be using file-related functions (that enable you to open, read, write and close a file) in order to write directly in a file with no output redirection involved.
Test the program again and record the results.