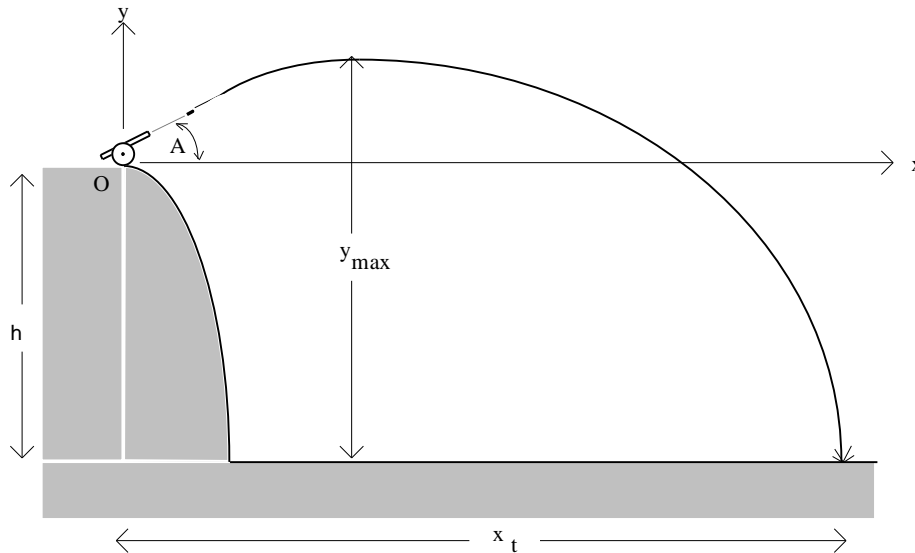


Programming Assignment #3: Projectile Trajectory

A typical problem encountered in the study of dynamics is the trajectory problem. In the situation illustrated below, a projectile is fired from the edge of a cliff with an initial velocity, V_o , and a firing angle, A . The cliff has a height, h . It is desired to:

1. determine the distance, x_t , to the target
2. determine the highest elevation reached, y_{max}
3. determine the time to reach the target, t_t
4. generate a table of (x,y) points to use in plotting the trajectory



Background:

If V_o = initial velocity
 and A = firing angle (in degrees), then
 V_{xo} = initial horizontal velocity = $V_o \cos(A)$
 V_{yo} = initial vertical velocity = $V_o \sin(A)$

If $g = -9.81 \text{ m/s}^2$ = acceleration due to gravity, then solving for t in the quadratic equation (the positive root)

$$-h = V_{yo}t + 0.5gt^2$$

will give the time to reach the target, t_t (i.e., $t = t_t$). Using this value of t_t , the distance to the target is

$$x_t = V_{xo}t_t$$

and the maximum height reached is

$$y_{max} = h - \frac{V_{yo}^2}{2g}$$

Background (continued):

In order to generate a table of 21 (x, y) values, the final distance, x_t , can be divided into twenty even increments, (i.e., $x = 0.0, 0.05x_t, 0.1x_t, 0.15x_t, \dots, 0.95x_t, x_t$) and the corresponding y value can be found by

$$t = x/V_{x0}$$

$$y = V_{y0}t + 0.5gt^2$$

Program Requirements:

1. The user of the program should be prompted to input three values from the keyboard: h, V_o , and A. The following restrictions should apply: $h > 0$, $90^\circ > A > 0$, and $V_o > 0$ (allow the user to re-enter erroneous inputs).
2. Use functions for at least the following:
 - a) to convert an angle from degrees to radians
 - b) to find the two real roots of the quadratic equation when given the coefficients. The function might be called as:
RealRoots(A,B,C,Root1,Root2);
3. Use arrays to store the values of t, x, and y. The arrays should be dimensioned for 21 points.
4. Give the user the option of:
 - A) Displaying a table of values on the computer screen
 - B) Sending the values to a data file so that they can be graphed using Excel

If option A is selected, the output to the screen should include a brief program description, the input values, and calculated values for x_t , y_{max} , and t_t , and a table of (t,x,y) values. All outputs should be formatted and include units. The table might look as follows (lines are not required, but could be added for extra credit):

time, t (s)	distance, x (m)	height, y (m)
0.000	0.0	0.0
1.134	283.6	91.7
.	.	.
.	.	.
.	.	.
22.673	5672.6	-150.0

If option B is selected, only the values of t, x, and y should be sent to the data file. Put commas between each value so that the file can be opened in Excel as a “commas delimited file”. Also prompt the user to enter the name of the output data file. The data file might look as follows:

```
0, 0, 0
1.134, 283.6, 91.7
.
.
.
22.673, 5672.7, -150.0
```

5. Give the user the option of re-running the program.
6. Include a printout of the program and run the program for the following test cases:
 - A) Example 1 below with output to screen. Include a printout of the screen output.
 - B) Example 1 below with output to a data file. Open the data file with Excel and graph the trajectory (y versus x). Include a printout of the data file, and the Excel worksheet (both the table and the graph). The graph should be nicely formatted and labeled.
 - C) Repeat 6A using the inputs indicated corresponding to your last name in Table 1.
 - D) Repeat 6B using the inputs indicated corresponding to your last name in Table 1.

Table 1: Input parameters:

Last Name begins with	V_o (m/s)	A (degrees)	h (m)
a-b	180	20	110
c-d	180	30	115
e-f	180	40	120
g-h	220	20	125
i-j	220	30	130
k-l	220	40	135
m-n	260	20	140
o-p	260	30	145
q-r	260	40	150
s-t	300	20	155
u-v	300	30	160
w-x	300	40	165
y-z	340	20	170

Example 1:

You can test your program with the following data:

Inputs:

$$V_o = 180 \text{ m/s}$$

$$h = 150 \text{ m}$$

$$A = 30^\circ$$

Outputs:

$$t_t = 19.9 \text{ s}$$

$$x_t = 3100.0 \text{ m}$$

$$y_{\max} = 562.8 \text{ m}$$

Extra Credit Suggestions: (for a maximum of 10 additional points on the program grade)

1. Allow the user to select the units that he or she wishes to work with (e.g., V_o could be in m/s, ft/s, or mph). The output should print the appropriate units.
 2. Allow the user to specify the number of lines in the table (from 5 to 100). Repeat step 6D using 95 points.
 3. Allow the user to specify the number of lines in the table (any number greater than 5). Use vectors from the Standard Template Library to store the values of t , x , and y . Repeat step 6D using 95 points.
 4. Put the values from Table 1 in an input data file. Prompt the user to enter their last name and then search the data file for the correct values to be used in steps 6C and 6D.
 5. Modify the program so that it will also allow the user to determine one or both of the following (for students who enjoyed Dynamics!):
 - a) Given V_o , h , and a desired target distance, x_t , find A .
 - b) Given A , h , and a desired target distance, x_t , find V_o .
- Reference: Beer and Johnson, *Vector Mechanics for Engineers*
6. Use your imagination!