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Projectile Motion
Simulation for the TI-83+ and TI-84+ Family of Graphing Calculators
By Daniel Blanchard

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Introduction
This simulation is designed to allow students to explore the various projectile paths given different initial conditions. The simulation allows for a change in vertical position as well as a change in horizontal position.

The Simulation

The projectile motion simulation for the graphing calculator is a program written in TI-basic macro language and is installed in the calculator's RAM. **PLEASE NOTE THAT DOING A GLOBAL RESET OF THE CALCULATOR'S MEMORY WILL ERASE EVERYTHING IN RAM INCLUDING THIS PROGRAM**.

The simulation is limited to the resources available on the calculator. The graphic window is only 62 pixels high by 94 pixels wide. The low resolution leads to the projectile path being limited in accuracy.

Running the Simulation

In the remainder of this document, buttons on the calculator will be enclosed in angle brackets <>; for example <ENTER> represents the Enter button in the bottom, right corner of the calculator. When menus appear, items can be selected by either scrolling down to the desired item using the arrow keys and pressing <ENTER> or press the number preceding the desired menu entry.

To start the program, press <PRGM> and select "PROJECTL" off the menu. The line "prgmPROJECTL" appears on the screen. Press <ENTER>. The following title screen appears:
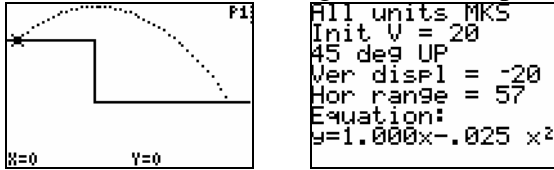
```
********************
*  PROJECTILE    *
*    MOTION      *
*   Copyright    *
* October 2008  *
* D. Blanchard  *
*        <Enter>*
********************
```

Press <ENTER> to continue. You will now be at the main menu:

```
MAIN MENU
1:Run Simulation
2:Set cliff
3:Set init vel
4:Set g
5:Fix Window
6:Back to Graph
7:Exit
```

A default set of values is entered so that the "Run Simulation option can be selected right away. (*Please note that all units in this simulation are MKS – all distances are in metres and all times in* seconds.) Initially, the acceleration due to gravity is 9.8 m/s^2 , the cliff is set to a height of -20 m and is located 20 m from the launch point. The initial velocity is 20 m/s angled 45^0 above the horizontal.

Each simulation displays a graphical results screen followed by a screen of resulting values as in the following two screens produced by the default values:
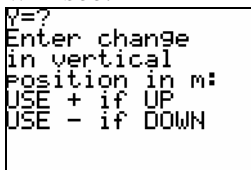

When viewing the graph screen above, the left and right arrow keys can be used to move along the projectiles path. The (X,Y) coordinates of the projectile are displayed as you move along the path. The origin is at coordinates (0,0). The graph screen is rescaled for every problem to make the best use of the screen. No two subsequent simulations are likely to be at the scale.

The vertical change in height is referred to as a "cliff" in the simulation. Its height and location can be changed. The initial speed and angle of the projectile can also be changed.
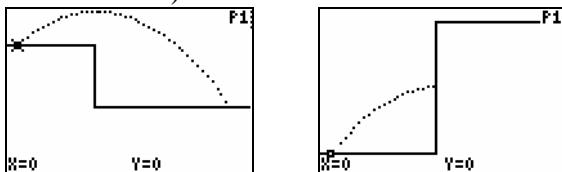
To change the cliff parameters, select the "Set cliff" option off the main menu to get the cliff menu:
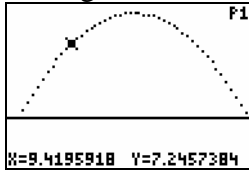

To change the height of the cliff, select option 1 "Set cliff hght" off the cliff menu. You will see:

When entering Y, this value is the vertical displacement you want for the projectile motion. Down is assumed to be negative and up is positive. A downwards cliff looks like the first result below whereas an upwards cliff looks like the second result (note that in the second result below, the projectile did not have sufficient initial velocity to make it over the cliff):

Setting the cliff height to Y=0 will remove the cliff entirely:

X=9.4195918 Y=7.2457384

The horizontal distance of the cliff from the launch point can also be specified by selecting "Set cliff dist" off the cliff menu. This gives the screen

X=?■
Enter horizontal
distance to
cliff edge in m.

You can place yourself right at the cliff edge by setting X=0.

The final option on the cliff menu "Return to main" will return you to the main menu.

The initial velocity of the projectile can be set by selecting "Set init vel" from the main menu. You will be presented first with an information screen that tells you how to enter the velocity and then by two actual entry screens for the speed and angle of launch:

When entering
initial velocity
Use:
Speed unit m/s
Angle unit deg
Angle + is UP
Angle - is DOWN
          <Enter>

V=?
Speed in m/s

Q=?
Angle in deg

Speed is entered in m/s. The launch angle (represented by Q) is entered as positive if the initial angle is above the horizontal and negative if it is below the horizontal.

If you want to experiment with different accelerations due to gravity, you can change the value of g by selecting the "Set g" option from the main menu.

G=?■
Enter new g
currently g=9.80

In some experiments, you might want to see the paths produced for various trials without the window scale changing. You can fix the window parameters by setting the window limits using the "Fix Window" option on the main menu. You will have to set the minimum and maximum values for X and Y that will be displayed in the graphing window.

Performing an Experiment

A typical experiment would be to determine how the maximum height or the horizontal distance changes for a given set of initial values. Students are free to experiment with the initial values to see the effects on the results. Teachers can designate certain initial conditions and ask the students to perform an experiment. Most of the useful results are displayed on the output screen following every simulation. However, if a more details set if data for a given projectile path is needed, the student can exit the program and access the data in the appropriate lists. The X data for the projectile is stored in List 1. Press <2nd><1> to view L1. The Y data is in L2 (<2nd><2>).

Transferring the Program to the TI Graphing Calculator

The projectile motion program file is named "projectl.8xp" for the TI-83+ and TI-84+ family of calculators. To transfer the program to the calculator, you will need a cable, and a software application available from the TI website.
Cables:
TI-84+:
>	Use a USB cable, or a TI Silver Graph-Link cable (USB).
TI-83+:
>	Use the TI Silver Graph-Link cable in a USB port or the TI black or grey Graph-Link cable in a serial port (9 pin or 25 pin).
Software:
TICONNECT:
>	If you are using any of the USB cables, download the TICONNECT application from Texas Instruments (education.ti.com). Install the TICONNECT application and run it. Plug your calculator into the USB port and it should be detected automatically. The projectile motion program can be installed by "dragging and dropping" it into the TICONNECT main window.
TI Graph-Link:
>	If you are using a serial port connection with either the black or grey Graph-Link cable, download the appropriate Graph-Link application from Texas Instruments (at education.ti.com) and install it. Run the application with the calculator attached. Use the "Link" menu item to select the proper Com port and cable. Use the file menu to load the projectl.8xp program. Click on the "Send to RAM" button to send it to the calculator. Though this software has been mostly supplanted by the TICONNECT software, the TI Graph-Link software includes an editing application that allows you to easily change the program. Editing can also be done on the calculator itself. Even if you communicate with your calculator using TICONNECT, it is still recommended that you get the Graph-Link software for the editing abilities.

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