EN

Diff-Eq Program

(Differential Equation Graph for Python App)

for fx-CG100
GRAPH MATH+
fx-1AU GRAPH

User's Guide

CASIO Worldwide Education Website

https://edu.casio.com

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Contents

Getting Started

Diff-Eq is a program that runs in the Python app on CASIO scientific calculators. It is used to graph differential equations.

Note

- There are three files that make up the Diff-Eq program: DEQmessage.py, DEQresource.py, and DEQexe.py. Of these files, do not make any changes to DEQmessage.py and DEQresource.py. Also, do not modify DEQexe.py except as explained in this manual.

To use the Diff-Eq program, first follow the steps below to transfer its configuration files (DEQmessage.py, DEQresource.py, DEQexe.py) to the calculator.

1. Use a USB cable*1 to connect your computer to the calculator and establish a USB connection between them.
   - For more information, see “Connecting the Calculator to a Computer” in your calculator’s Software User’s Guide.
2. On the computer, copy all three py files to the root directory of the calculator drive*2.

*1 Use of a genuine CASIO USB cable is recommended. If you plan to use a commercially available USB cable, be sure to use a cable that can transfer data.

*2 Your calculator’s storage memory mounted on the computer as a USB drive.

Using the Diff-Eq Program

You can run the Diff-Eq program in the calculator's Python app to perform the operations described below.

- Draw the slope field for the first-order differential equation $y' = f(x, y)$.
- After drawing the slope field, you can specify an initial condition (x, y) for the differential equation to draw the solution curve corresponding to that initial condition. You can simultaneously draw solution curves for up to three initial conditions.

Note

- This program supports only first-order differential equations in the form $y' = f(x, y)$. Attempting to input a second-order or higher, or differently structured differential equation will result in an error or the graph may not be drawn.
- The program solves differential equations using the Runge-Kutta method to draw graphs.

Graphing a Differential Equation

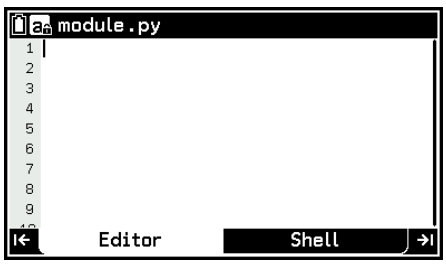
The Diff-Eq program draws a graph based on user input in response to prompts displayed when the program is run. The required input items are shown in the table below.

	In response to this prompt:	Enter this:
①	Y' =	Differential equation in the form of $f(x, y)$
②	x Minimum =	Graphing range minimum x-value
③	x Maximum =	Graphing range maximum x-value
④	y Minimum =	Graphing range minimum y-value
⑤	y Maximum =	Graphing range maximum y-value
⑥	x =	Initial condition x-coordinate
⑦	y =	Initial condition y-coordinate

- Completing the input from ① to ⑤ causes the slope field representing the general solution of the differential equation to be drawn on the display.
- Afterward, entering ⑥ and ⑦ will draw the solution curve representing the particular solution, overlaid on the slope field.

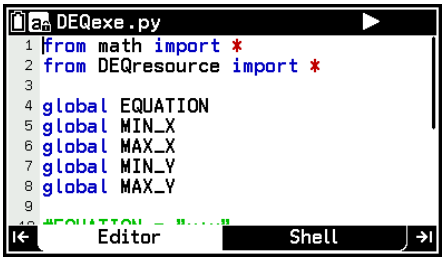
Example: To draw a slope field for $y' = y^2 - x$ and then graph three solution curves for the initial conditions $(x, y) = (0, 0), (0, 0.5), (0, 1)$. Set the graphing range to $-2 \le x \le 2$ and $-2 \le y \le 2$ (x Minimum = -2, x Maximum = 2, y Minimum = -2, y Maximum = 2).

1. On the calculator, start up the Python app (⌂ > Python).
   - This displays Editor.

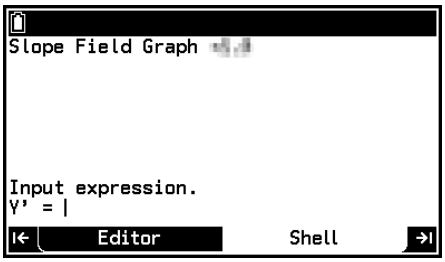


2. Select ⋯ > [File] > [Open].

3. On the dialog that appears, select “DEQexe.py” and then press [OK].
   - This opens “DEQexe.py” and displays the screen shown on the right.

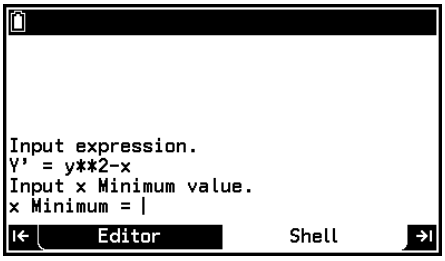


4. Press [⇥].
   - This runs “DEQexe.py” (Diff-Eq program) and causes the calculator to switch to Shell.
   - At this point, the “Y’ =” prompt appears at the bottom of the screen, telling you to enter the differential equation.



5. Enter $y^2 - x$.

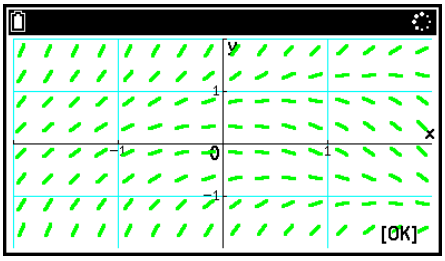
[ALPHA] [−] (Y) [■²] [−] [X] [EXE]



   - This displays the “x Minimum =” prompt, telling you to enter the graphing range minimum x-value.

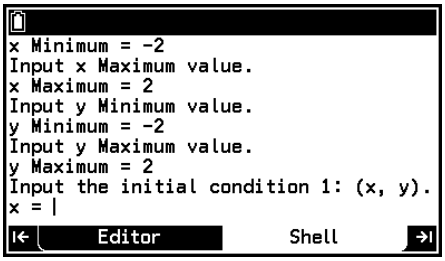
6. Enter the values for the graphing range ($-2 \le x \le 2$, $-2 \le y \le 2$) as prompted.

[−] 2 [EXE] 2 [EXE] [−] 2 [EXE] 2 [EXE]



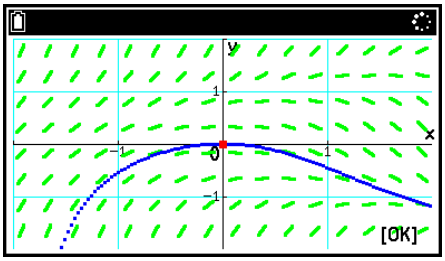
   - Entering the value for the “y Maximum =” prompt, causes the slope field for y’ = $y^2 - x$ entered in step 5 to be drawn.

7. Press [OK].
   - This returns to Shell and causes “x =” to appear, prompting you to input the initial condition x-coordinate.



8. Enter values as prompted to specify the first initial condition: (x, y) = (0, 0).

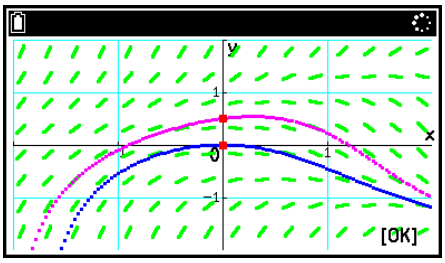
0 [EXE] 0 [EXE]



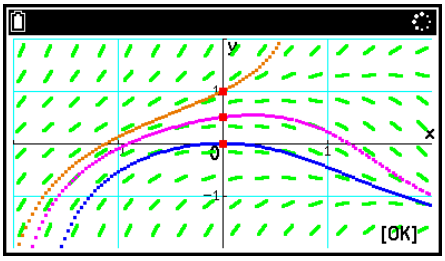
   - Entering a value for the “y =” causes the solution curve for the first initial condition to be drawn.

9. Repeat steps 7 and 8 to specify the second and third initial conditions: $(x, y) = (0, 0.5)$, $(x, y) = (0, 1)$.

[OK] 0 [EXE] 0 [.] 5 [EXE]

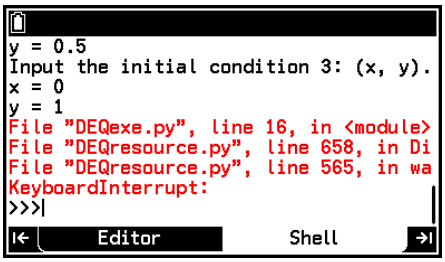


[OK] 0 [EXE] 1 [EXE]



- This causes the solution curves for the three initial conditions to be drawn overlaid on each other.

10. To stop the Diff-Eq program, press [AC].
    - This causes ">>>" to appear at the left edge of Shell, and resumes normal Shell operations.



Note

- As explained above, you can draw up to three solution curves on the same screen by repeating steps 7 and 8. Repeating these steps four times or more will cause the three most recent curves to be displayed.
- When entering an expression for the "Y' =" prompt, use only lowercase x and y. If you enter any other characters, an error occurs, the program stops, and the slope field is not drawn.
- Since the expression format follows Python syntax, you cannot omit multiplication signs between numbers and letters. For example, entering Y' = 2x results in an error, because you should have entered Y' = 2*x.
- For the initial condition, be sure to specify values within the graphing range (x Minimum ≤ x ≤ x Maximum, y Minimum ≤ y ≤ y Maximum). Entering a value outside the range causes the input prompt to reappear.
- Specifying an initial condition that does not satisfy the entered differential equation (such as entering Y' = x/y and specifying $(x, y) = (0, 0)$) causes an error to occur and the program to stop.
- If the solution curve goes outside the specified graphing range during drawing, the drawing operation will stop at that point. Even if continuation of the curve would return to within the drawing range, that subsequent portion will not be drawn.
- To return to the Editor from the Shell while the program is running, press [AC] to stop the program and then press [⇥].

Specifying Default Values Applied When Prompt Input Is Omitted

By editing specific lines in DEQexe.py, you can specify default values to be applied when input for prompts is omitted.

Example: To specify the default values below in DEQexe.py and use them to draw the slope field:
Y' = x+y, x Minimum = -5, x Maximum = 5, y Minimum = -5, y Maximum = 5

1. Use the Python app to open DEQexe.py.

2. Scroll down in the window until lines 10 to 14 are visible.
   - By default, lines 10 to 14 contain comment strings* like those shown to the right.
   - Removing the hash symbol (#) at the beginning of a comment line changes it into a statement that defines the default values for each input field.
   - Only the characters and values shown in blue below can be changed by you.

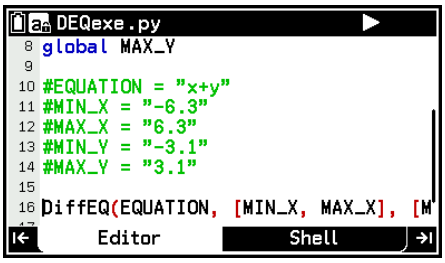
   #EQUATION = "x+y"

   #MIN_X = "-6.3"

   #MAX_X = "6.3"

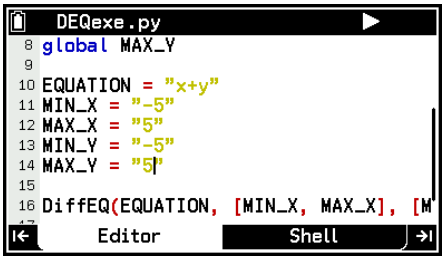
   #MIN_Y = "-3.1"

   #MAX_Y = "3.1"

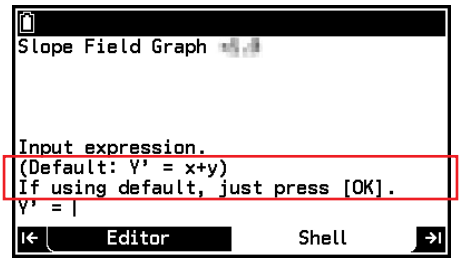
   

   * A string that begins with a hash symbol (#) is treated as a comment that is ignored during execution. In the Python app Editor, comment lines are displayed in green.

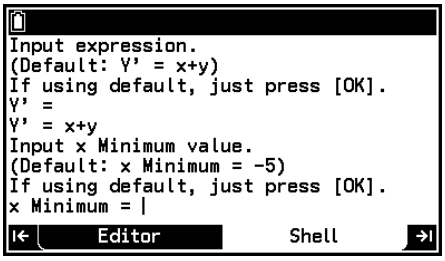
3. Edit lines 10 through 14 as required.
   (1) Remove the hash symbols (#) at the beginning of all the comment lines.
   (2) Modify the values on lines 11 to 14 as shown in the screen on the right.

4. Press ⇥.
   - On the "Save this file?" dialog that appears, select [Yes]. This runs the Diff-Eq program and transitions to Shell.
   - This causes the "Y' =" prompt to appear at the bottom of the screen. Since we wrote default values into DEQexe.py, the display will show the message enclosed in the red box on the screen shown to the right.

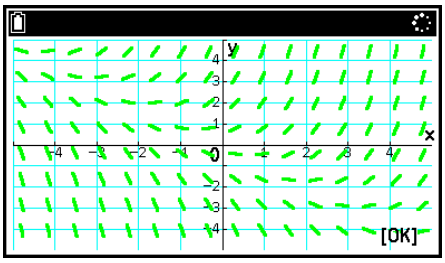
   

5. Press OK to use the default values.
   - This displays the prompt "x Minimum =".

6. Since we will use default values for x Minimum, x Maximum, y Minimum, and y Maximum, press [OK] for all the prompts that appear.

[OK] [OK] [OK] [OK]



- This draws the slope field for $y' = x + y$.
- Next, you can specify the initial conditions to draw the solution curves using the same procedure as that described starting from step 7 of the example under “Graphing a Differential Equation” (page 4).

7. To stop the Diff-Eq program, press [AC].

Note

- To return DEQexe.py to its initial default state (so default values do not appear in the prompts during execution), add hash symbols (#) at the beginning of lines 10 to 14 to make them comment lines again.
- You cannot use DEQexe.py to specify default values for the initial conditions.

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