Graphing Calculators Tutorial

designed for inquisitive M119 students

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Example 2: Numerical integration.

In this example we will consider numerical integration using a TI-83 and TI-86. If you have a TI-82 or TI-85, you can still follow these notes, but you will probably need to make some minor adjustments. I assume that you are already familiar with Example 1 and will not give any details on how to graph functions.

So let's get started. Suppose we need to find the definite integral of the function

$$y = x^3 - 5x^2 + 2x - 1$$

with the lower limit of integration equal to 0 and upper limit of integration equal to 5. At this point you may not know what a definite integral is, but you may think of it as an area bounded by the graph of the function and the x-axis between x = 0 and x = 5 . This is not quite true, since area is always positive and definite integrals can be negative. But let's think about area above the x-axis as being positive and below the x-axis as being negative.

First things first: we need to graph the function. So let's switch to the graphing mode (press `GRAPH` on a TI-86 or `Y=` on a TI-83) and type in the equation. Let's choose the following parameters for the window:

xMin = -10
xMax = 10
xScl = 5
yMin = -15
yMax = 15
yScl = 5
xRes = 1

Now you can graph the function you have just typed in. Looking at the graph you can see what kind of area we need to find. (Remember, the xScl was set to 5, thus, each subdivision on the x-axes is equal to 5.) Most of the area is under the x-axis. Since we agreed that such area would be considered negative, we expect our answer to be negative. Now let's set the upper and lower limits of integration, that is, the left and right bounds for the area we want to find. In TI-86 we need to go to the menu item corresponding to `MATH`. If you don't see the menu on the bottom of the screen, press `GRAPH` again. Then

press MORE, possibly several times until you see the MATH option (should correspond to F1). Press F1 to see even more options. In the lower row of the menu choose $\int$f(x). In TI-83 from the window with the graph of the function press 2nd and then TRACE. This will bring the option corresponding to CALCULATE. Now in the list choose 7:$\int$f(x) by moving the shaded box to that line or by pressing 7 and then hit ENTER.

So what happened? It looks like the calculator is asking for something: Lower Limit? There are two ways to set the lower limit of integration. Let's explore both of them. First move the cursor using the left-right arrow buttons. You should notice that this also changes the x value on the display. That's the lower limit. The other way to do this is even easier: just type in the number corresponding to the limit. This is especially helpful if you want to have .01, for instance, not 0. Once you have happily chosen the lower limit you can press ENTER. What you should notice now is a little arrow on the top of the screen which indicates where the lower limit is set. But wait, the calculator is again asking something: Upper limit? Do the same thing with the upper limit. Remember we need to have the upper limit equal to 5. Once you are ready, press ENTER.

And now comes the most exciting part of the whole process. The calculator actually shades the area we just bounded with lower and upper limits! What is even more important is that we can see the numerical value of the integral/area. I got -32.08333... . This is the approximate value of the integral. We can check our work by doing the following: press CLEAR several times to leave the graphing mode. In TI-86 press 2nd CALC (CALC is located at the division button). If you are using a TI-83, press MATH instead. In any case, you should see a menu. We need to choose fnInt: in TI-86 this corresponds to F5 and in TI-83 this option is on line 9. Go ahead and make the choice. What you should see now is fnInt(on the very first line of the screen. The format of this operator is the following: fnInt(expression, variable-of-integration, lower-limit, upper-limit) . Here expression is the function that you would like to integrate, variable-of-integration is the variable in the expression dx, dt, etc; it's safe to always use x. The meaning of lower-limit and upper-limits is clear. So for our example we will have:

$$\text{fnInt}(\text{x} \wedge 3 - 5\text{x} \wedge 2 + 2\text{x} - 1, \text{x}, 0, 5)$$

Now press ENTER to evaluate the integral. The number that will appear should be exactly the same as the answer we got above. Easy, huh? You may ask: why bother with graphing and shading, when you can do everything without it? Well, firstly, in most problems you will be asked to make a graph and shade the area which corresponds to the definite integral that you need to find. Secondly, it's good to fully understand what exactly you are doing, and where the number (definite integral) comes from. Thirdly, if you suspect that your answer is incorrect, it's easier to figure out the mistake if you see the graph of the function.

Now let's clean up the mess. You don't want to see the area that you just shaded every time you graph a function, do you? In TI-86 press GRAPH and then MORE until you see the option DRAW. Press F2 (or whatever F button corresponds to that option). Now you should see the second row of options. Press MORE again several times to find the option CLDRW. Press F1 and you should be all set. In TI-83 press 2nd and then PRGM (this corresponds to option DRAW). In the menu choose ClrDraw on line 1 and press ENTER. Now you are clean too.

Using this approach, you can approximate almost any definite integral that you might run into in your math class. A more challenging problem is to estimate the area between two graphs. It is possible to do with TI-83 or TI-86, but this is beyond the scope of this example. Consult your calculator's manual or read the book "Getting started with TI-86/85 Graphing Calculator" or "Getting started with TI-83/82 Graphing Calculator" by Carl Swenson.

Good luck!