An exercise in basic graphing on the TI-85

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Propose: To introduce the students who are preparing to teach K-4 to the basic graphing capabilities and procedures of the TI-85, and to explore the properties of linear and quadratic functions both numerically and graphically.

Target: Basic skill in using the graphing package on the TI-85 and an intuitive understanding of the concepts of slope, intercepts, parallelism, perpendicularity; as well as linear versus quadratic growth.

We wish to explore the effect of performing a *linear operation* on a set of numbers. First we will consider the operation of *multiplication by ½*. Fill in the table below where each entry in the right column is the corresponding number in the left column multiplied by .

-.5	-.25
-.4	-.2
-.3	
-.2	
-.1	
0	
.1	
.2	
.3	
.4	
.5	

Symbolically if we let x denote a number in the left column then ( )x would denote the corresponding number in the right column. If we let y denote a number in the right column then we have two notations for each right column number and we could express the double notation symbolically by the *equation* y = ( )x, and we could say that *y is a function of x (in this case a linear function of x)*.

In each of the following tables assume y (right column) is a linear function of x (left column) and fill in the missing data. Plot the corresponding data points, x on the *horizontal axis* and y on the *vertical axis,* on the *coordinate axes* provided to the right of the table. Connecting these data points should produced a *straight line*, hence the use of the term *linear function.*

x	y = x
−.5	
−.4	
−.3	
−.2	
−.1	
0	
.1	
.2	
.3	
	.4
	.5
15	

x	y = 2x
−.5	
−.4	
−.3	
	− .4
−.1	
.1	
.2	
.3	
.5	
15	

x	y = (−)x
−.5	
−.4	
0	
.3	

x	y = −x

x	y =
−.5	1
−.4	.8
−.3	.6
−.2	.4
	0
	−.2

Looking at your plots (*graphs*) which *line* would you say

1. is the *steepest*?
2. is the least steep?
3. is *rising?*
4. is *decreasing?*
5. In #1 how steep is the line?
6. In #2 how fast is the line rising?

7. Suppose in all these graphs we *change* x by 2 units. In each case determine the *amount of change in y*, and whether y gets bigger or smaller.

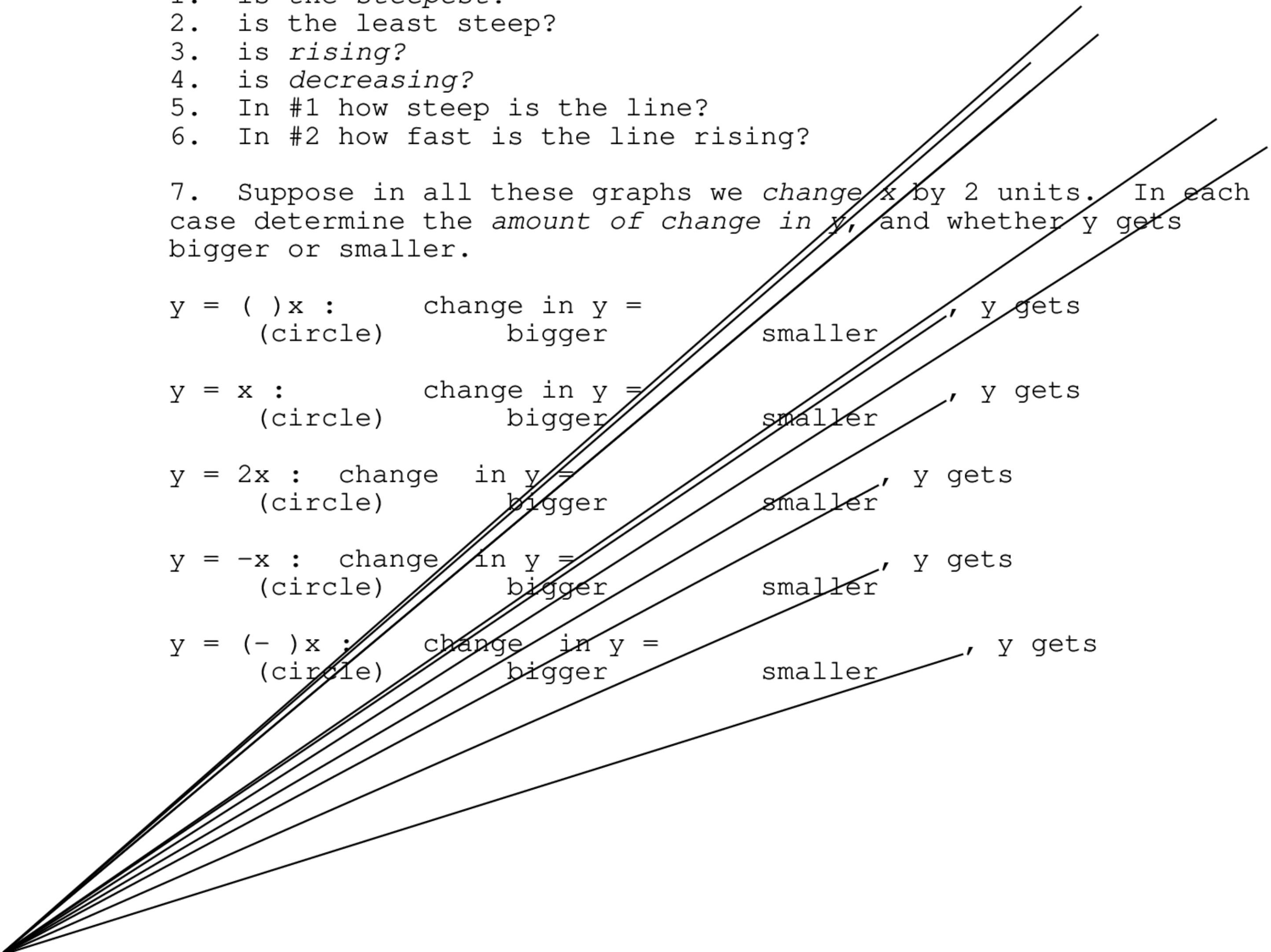
y = ( )x : change in y = , y gets
(circle) bigger smaller

y = x : change in y = , y gets
(circle) bigger smaller

y = 2x : change in y = , y gets
(circle) bigger smaller

y = −x : change in y = , y gets
(circle) bigger smaller

y = (−)x : change in y = , y gets
(circle) bigger smaller



y = – 2x :   change in y =   , y gets
(circle)   bigger   smaller

The change in y compared with the corresponding change is x is a reasonable measure of steepness of a line. In fact we make the following definition:

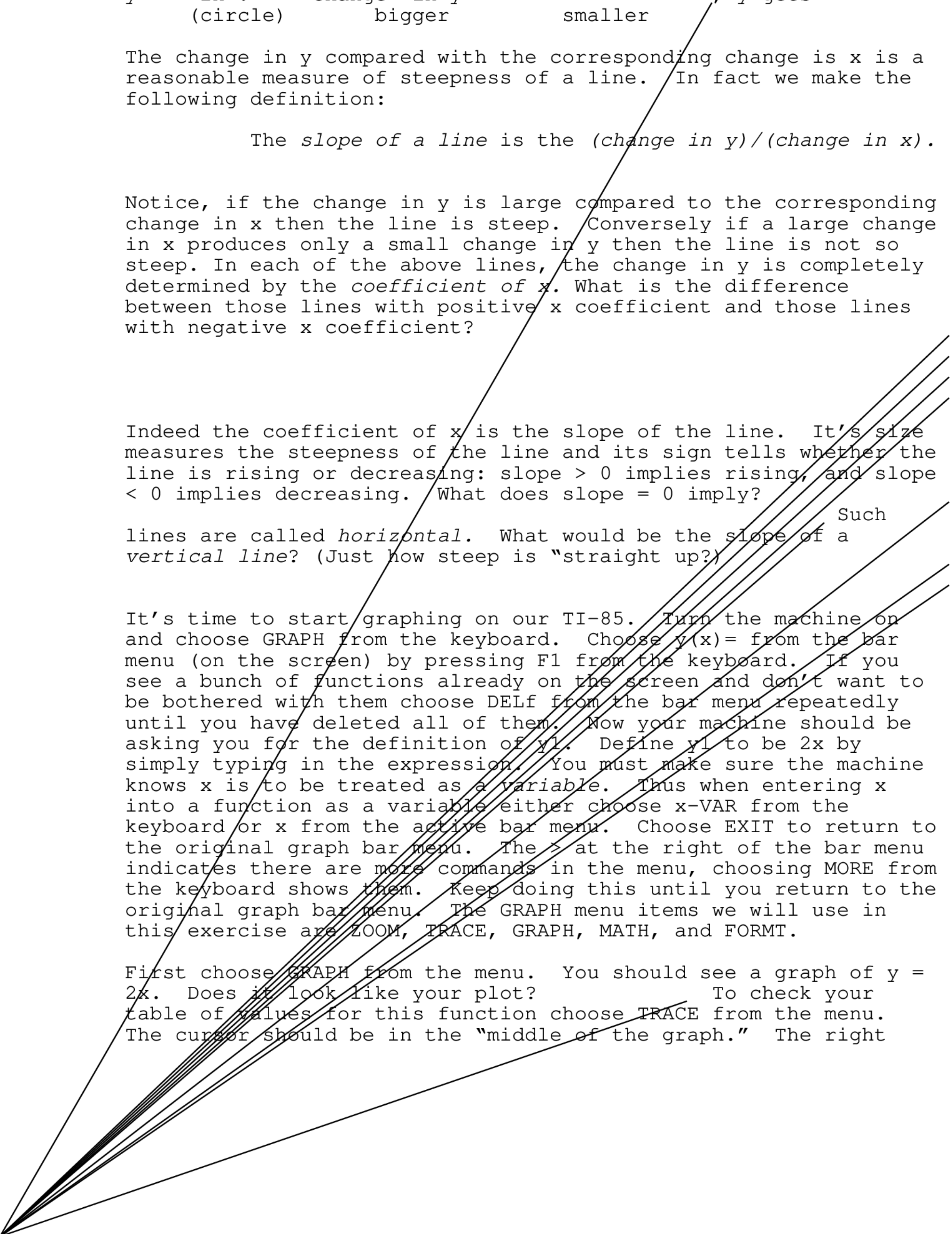
The *slope of a line* is the *(change in y)/(change in x).*

Notice, if the change in y is large compared to the corresponding change in x then the line is steep. Conversely if a large change in x produces only a small change in y then the line is not so steep. In each of the above lines, the change in y is completely determined by the *coefficient of x.* What is the difference between those lines with positive x coefficient and those lines with negative x coefficient?

Indeed the coefficient of x is the slope of the line. It's size measures the steepness of the line and its sign tells whether the line is rising or decreasing: slope > 0 implies rising, and slope < 0 implies decreasing. What does slope = 0 imply?
Such
lines are called *horizontal.* What would be the slope of a *vertical line*? (Just how steep is "straight up?)

It's time to start graphing on our TI-85. Turn the machine on and choose GRAPH from the keyboard. Choose y(x)= from the bar menu (on the screen) by pressing F1 from the keyboard. If you see a bunch of functions already on the screen and don't want to be bothered with them choose DELf from the bar menu repeatedly until you have deleted all of them. Now your machine should be asking you for the definition of y1. Define y1 to be 2x by simply typing in the expression. You must make sure the machine knows x is to be treated as *a variable*. Thus when entering x into a function as a variable either choose x-VAR from the keyboard or x from the active bar menu. Choose EXIT to return to the original graph bar menu. The > at the right of the bar menu indicates there are more commands in the menu, choosing MORE from the keyboard shows them. Keep doing this until you return to the original graph bar menu. The GRAPH menu items we will use in this exercise are ZOOM, TRACE, GRAPH, MATH, and FORMT.

First choose GRAPH from the menu. You should see a graph of y = 2x. Does it look like your plot?   To check your table of values for this function choose TRACE from the menu. The cursor should be in the "middle of the graph." The right



arrow on the keyboard will make the cursor trace the graph to the right and the left arrow will make it trace the graph to the left. Notice that corresponding x and y values appear at the bottom of the screen. Unfortunately they are not the x and y values we used in the above tables. This has to do with the way the machine chooses the x values to put into it's table. We will talk more about this later, perhaps. The ZOOM package let's us change the picture (*viewing window* in computer jargon) of the graph to suit our purpose. This changes the x values the machine uses, in particular, EXIT from TRACE and choose ZOOM from the menu, then choose ZDECM, from the ZOOM menu. (Remember the MORE command.) Now try TRACE again. (Remember EXIT gets you back to the previous screen.) Now you should recover the data in your tables.

Since the y-axis is shorter on the screen than is the x-axis, these pictures are not *square*. That is to say, the length on the y-axis is not the same as the length on the x-axis. However, choosing ZSQR from the ZOOM menu squares up the axis, thus giving a "truer picture of what is happening." Try it. Now the graph should look very close to your plot. TRACE should work just as before.

Next choose FORMT from the graph menu. We will use this to change the format of the picture to suit our purpose. In particular "arrow down" to the "GridOff GridOn line." "Arrow over" to GridOn and press ENTER. Now choose GRAPH from the menu and see the effect of "turning on the grid." Your screen should look more like graph paper. We'll look at all the above graphs in the ZDECM, ZSQR viewing window, and in GridOn format.

Enter all the previous functions into your machine by choosing y(x)= from the graph menu, then arrow down to get the machine to ask for the definition of y2. Enter y2 = x, y3 = ( )x, y4 = (-)x, y5 = -x, & y6 = -2x. Now choosing GRAPH from the menu should show all the graphs drawn at once. This is probably too much information to see at once. We can "turn off" the graph of a function without deleting it from the machine. Choose y(x)= from the graph menu to view all the functions you've entered. If the = is "highlighted" that means the function is "turned on" to "turn it off" "arrow up or down" until the function is highlighted by the blinking cursor and choose SELCT from the menu. This has the effect of turning "on" functions "off" and "off" functions "on."

Turn on y1, y2, & y3 only and graph them. The machine graphs them in order from y1 to y3. Notice how the steepness decreases with each graph. Now graph y4, y5, y6 only and observe the change in steepness from one graph to the next. Now, one at a time, graph the pairs y1 & y4, then y2 & y5, and finally y3 & y6. Do you observe anything special about these pairs?

What? Notice in each case the coefficient of x in one function in the pair equals the negative reciprocal of the coefficient of x in the other function in the pair. This is a general way to determine if two lines are perpendicular by comparing their slopes.

Now graph on the same screen the lines y = 2x, y = 2x + 2, and y = 2x –2. What's special about the relationship between these lines?

Lines with the same slope are called *parallel*. Using TRACE determine where each of these lines crosses the y–axis (*y–intercept)* and the x–axis (*x–intercept,* or *root)*. (Notice the up or down arrow allow you to jump from one graph to the other in TRACE with more than one function graphed.) With these lines graph y = –( )x + 2 and notice it is perpendicular to all three.

It is often important to find where two lines intersect. We'll learn several ways to approach this problem. Two are available to us now. Graph the two lines y = –( )x +2 and y = 2x – 2. Use TRACE to estimate the point of intersection to be at x = and y =

Another way to find then intersection point of two graphs is to choose MATH from the graph menu, then ISECT from the MATH menu. Use the arrow keys to position the cursor close to the the intersection point and press ENTER twice. The machine will find the approximate values to be

x = and y = Now do the problem by hand as shown in the text. What did you get? x = and y = . Are these the same? Explain.

Find all the points of intersection of the three lines y = –( )x + 2 , y = 2x – 2, & y = –x. They are (,) , (,) , & (,).

Often the most important attribute of a function is its *rate of growth.* Linear growth can be thought of as "steady" or "constant " growth. Changing x by a fixed amount always produces the same change in y no matter how big x is. For example let y = 2x – 2. If x changes from 1 to 2 then y changes from 0 to 2, producing a change in y of 2. If x changes from 10 to 11, what is the resulting change in y? If x changes from 500 to 501, what is the resulting change in y?

If the change in x is 1, then the change in y is , independent of the actual value of x. Notice if x changes by 1 then y changes by the slope. This should not be too surprising since, remember, the slope equals (change in y)/(change in x).

In practice the growth rate of something might not be constant. For example if you drop a ball off a building it gains speed as it falls. So it will travel further during the 10 Th second than it did during the first second. In other words, "the change in distance is less when time changes from 0 to 1 than when time changes from 9 to 10; even though the change in time was 1 in both cases." In fact, the distance something falls due to gravity is an example of *quadratic growth.* To "see" this type of growth graph the function y = x^2 – 3. (Pressing CLEAR from the keyboard clears the menu from the graph scree. Of course pressing EXIT will get it back.) Use TRACE to fill in the data in the following table:

old x	new x	change in x	old y	new y	change in y
0	.1	.1	−3	–2.99	.01
.1	.2	.1			
.2	.3				
1	1.1				
3	3.1				
10	10.1				

Which is the better growth rate for your salary as a function of time: linear or quadratic?

Explain.

Which is the better growth rate for the number of aids cases as a function of time?

Explain.