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Guidelines for Graphing Calculator Use for Commencement-Level Mathematics

Introduction

Graphing calculators are instrumental in the teaching and learning of mathematics. The use of this technology should be integrated as an investigative tool at the commencement level. Students' conceptual understanding of mathematics will be increased, and the connections between graphical and algebraic representation will be enhanced through targeted use of graphing calculators and other technological tools. Algebraic and analytical approaches (pencil and paper techniques) to solving problems should still be stressed.

The Standards for Mathematical Practice describe areas of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important processes and proficiencies with longstanding importance in mathematics education. An integral part of the NYS P-12 Common Core Learning Standards for Mathematics at the commencement level is the use of the graphing calculator. The calculator should be used for all types of classroom activities and homework, whenever possible. Mathematically proficient students will determine the appropriate use of a graphing calculator when solving a problem. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. A graphing calculator can help a student make sense of a mathematical problem and persevere in solving it as well as attending to precision.

Please note that schools *must* make a graphing calculator available for the exclusive use of each student while taking Regents Examinations in mathematics. No students may use calculators that are capable of symbol manipulation or that can communicate with other calculators through infrared sensors, nor may students use operating manuals, instruction or formula cards, or other information concerning the operation of calculators during the exam. Symbol manipulation calculators are calculators capable of doing symbolic algebra or symbolic calculus (for example, factoring, expanding, or simplifying given variable output). **The memory of any calculator with programming capability must be cleared, reset, or disabled when students enter the testing room. If the memory of a student's calculator is password-protected and cannot be cleared, the calculator must not be used.**

For questions in which the graphing calculator can be used, students should be trained to show enough of their work so that their approach to problem solving can be easily followed. For students to be awarded the maximum points allowable for a particular constructed-response question, they must be able to communicate the method employed by illustrating their graph, table, or setup (equation), followed by the result of their investigation(s). The answer to the question should also be clearly identified, often by using a sentence or phrase response. Whenever appropriate, complete sentences should also be used to support results so that mathematical reasoning can be easily interpreted. **Teachers should encourage the use of a "rule of three"– setup, method, response (answering in sentence form when appropriate).**

When taking Regents Examinations in mathematics, students will be expected to perform tasks using a graphing calculator as described below:

Algebra I

- Performing basic arithmetic and algebraic operations as found on a scientific calculator
- Graphing algebraic and exponential functions in an appropriate viewing window
- Determining roots of functions and the points of intersection(s) of curves
- Solving linear and quadratic inequalities graphically
- Creating scatter plots and residual plots
- Determining a regression equation: linear, quadratic, exponential, or power
- Determining a linear correlation coefficient, r (Please note that r, r^2 and R^2 cannot be directly compared when calculating certain regression models.)
- Determining the variance and standard deviation of a set of data (population and/or sample)
- Determining the appropriate MODE setting for solving each problem
- Indicating the number of scores, the mean, and the appropriate standard deviation. The standard deviation for a population, σ, is calculated by using "n," whereas the standard deviation for a sample, s, is calculated by using "$n - 1$." Students should be able to differentiate between a population and a sample.
- Using the full potential of the technology by storing all of the digits produced by the calculator during computation. Rounding to the specified degree of accuracy should be done only at the end of all computation when the final answer is found.

Geometry

- Performing trigonometric calculations with right triangles

Algebra II

- Graphing trigonometric and logarithmic functions in an appropriate viewing window
- Finding the inverse of a function
- Determining a regression equation: trigonometric and logarithmic

Expectations for sketches and graphs:

- Same degree equations are labeled when graphed on the same set of axes
(no deduction if the student fails to label only one graphed equation)
- Axes appropriately labeled – variables identified and scale stated if not 1 to 1
- Intercepts noted, where appropriate
- Points of intersection labeled
- In the graphs of nonlinear functions, at least three points should be indicated showing the curvature on the graph or represented as a table of coordinate values.
- Intercepts are acceptable, and when appropriate, the turning point should also be indicated in the graph of the parabola.

If a student sketches a graph not on a grid for problems where grid use is optional, the above criteria for sketches and graphs still apply.

Examples

The problems that follow illustrate what students should show when using a graphing calculator in order to be awarded the maximum points allowable on the scoring rubric for each constructed-response question. Please note that each example shown does not represent the only method that a student may use with his or her calculator to solve the problem.

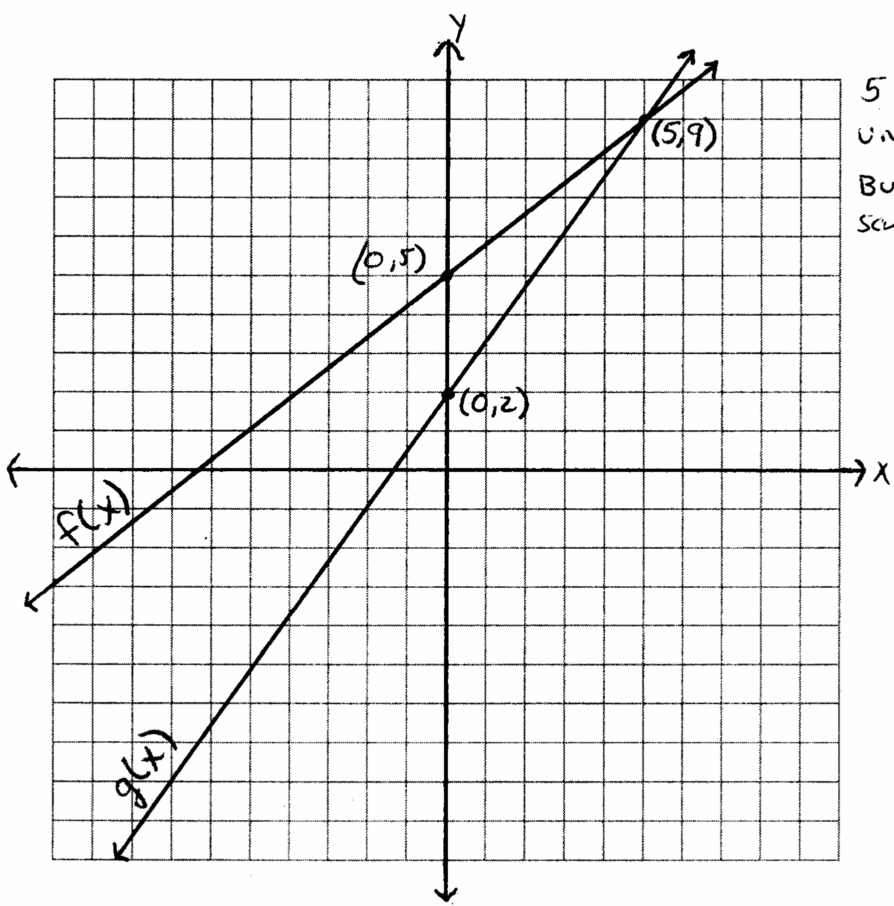
A.REI.6 Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

Albany begins the day with 5 inches of snow on the ground and Buffalo begins the same day with 2 inches of snow on the ground. Two snowstorms begin at the same time in Albany and Buffalo, snowing at a rate of 0.8 inches per hour in Albany and 1.4 inches per hour in Buffalo. The number of inches of snow on the ground in Albany and Buffalo during the course of these snowstorms are modeled by f(x) and g(x), respectively.

$$f(x) = 0.8x + 5$$

$$g(x) = 1.4x + 2$$

Determine the number of hours (x) that would pass before Albany and Buffalo have the same amount of snow on the ground. [The use of the grid below is optional.]



5 hours would pass until Albany and Buffalo have the same amount of snow.

The student entered both equations into a graphing calculator and graphed both equations on the accompanying grid. The functions, intercepts, and intersection were labeled correctly. The student made a statement that 5 hours would pass based on the point of intersection.

F.BF.3 Identify the effect on the graph of replacing f(x) by f(x) + k, k f(x), f(kx), and f($x + k$) for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them.

The function f(x) is given below.

$$f(x) = x^2 + 2x - 3$$

Describe the effect on the graph of f(x), if g(x) = f($x - 5$).

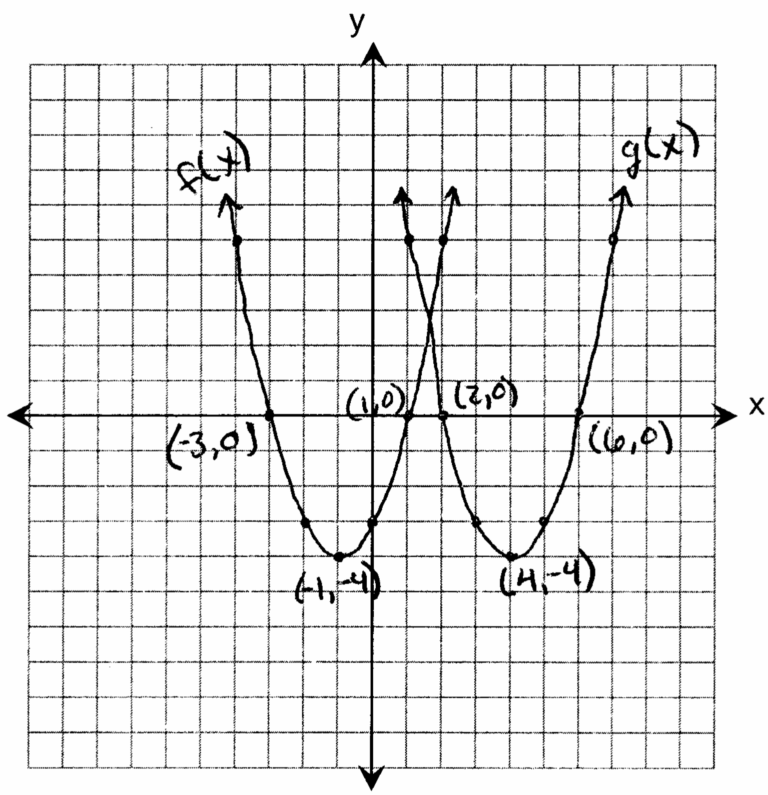
The graph f(x) moves five units to the right.

Show that the vertices of f(x) and g(x) support your description.

[The use of the set of axes below is optional.]

$(-1,-4) \rightarrow (4,-4)$

moves five units to the right

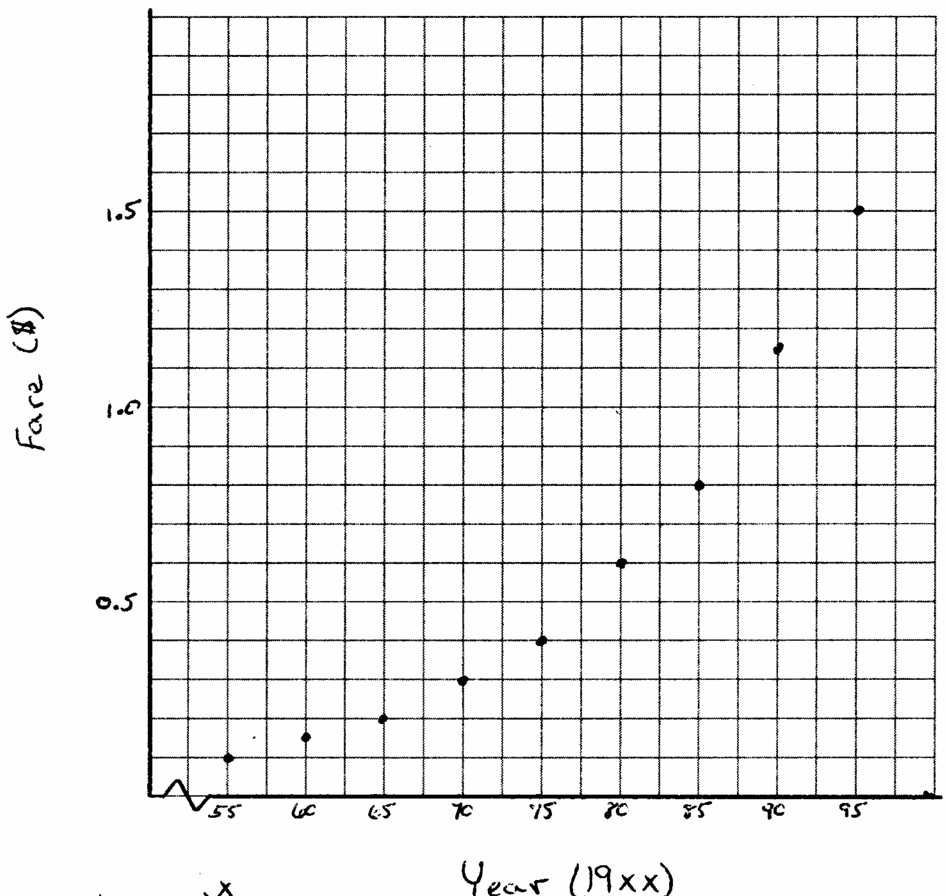


The student entered both functions in the graphing calculator and graphs f(x) and g(x) = f($x - 5$) on the accompanying set of axes. The functions, roots, intercepts, and vertices were labeled. The student made a statement that f(x) has moved five units to the right, and the vertices support this shift.

S.ID.6a Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.

The table below, created in 1996, shows a history of transit fares from 1955 to 1995. On the grid below, construct a scatter plot where the independent variable is years. State the exponential regression equation with the coefficient and base rounded to the *nearest thousandth.* Using this equation, determine the prediction that should have been made for the year 1998, to the *nearest cent.*

Year (19xx)	55	60	65	70	75	80	85	90	95
Fare ($)	0.10	0.15	0.20	0.30	0.40	0.60	0.80	1.15	1.50



$y = 0.002(1.070)^x$

$y = 0.002(1.070)^{98}$

$y = \$1.52$ prediction for 1998

The student used appropriate labels and scales to appropriately graph the given data. The student entered the data into a graphing calculator to obtain the regression equation. The appropriate substitution into the regression equation was shown, producing the predicted value for 1998. The value was rounded correctly.

F.IF.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship.

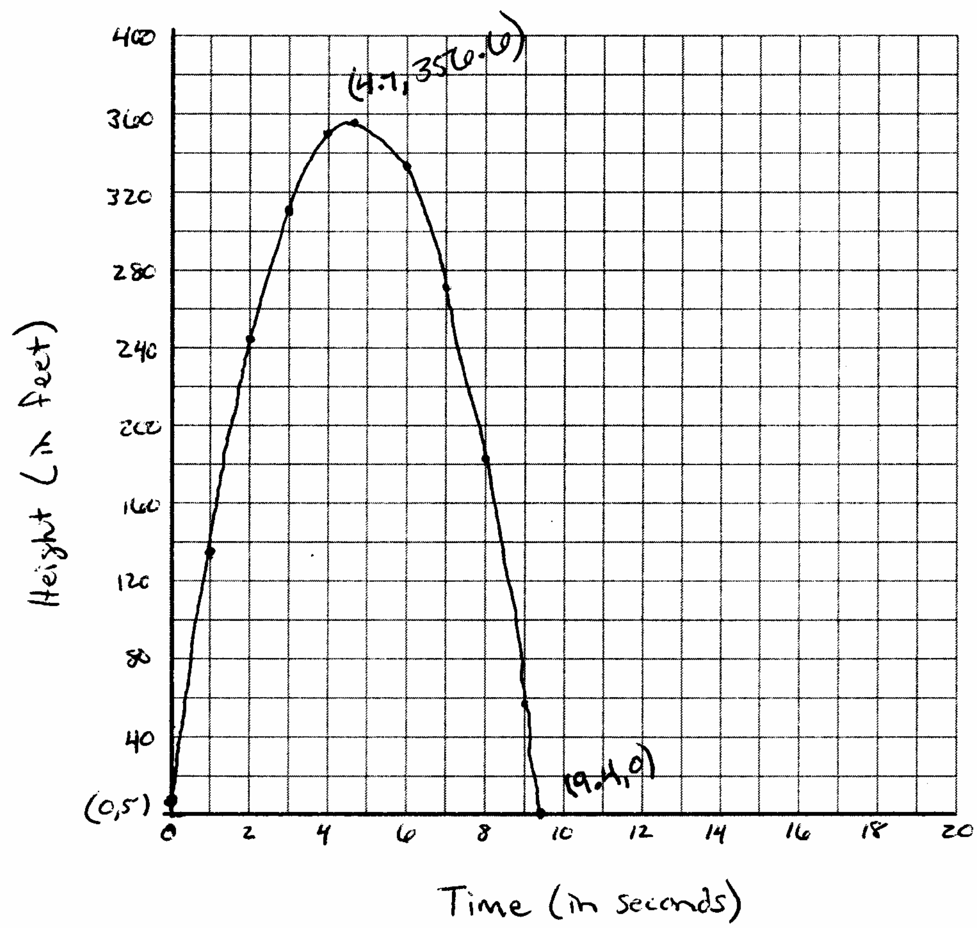
A model rocket is launched from a platform in a flat, level field and lands in the same field. The height of the rocket follows the function, $f(x) = -16x^2 + 150x + 5$, where $f(x)$ is the height, in feet, of the rocket and x is the time, in seconds, since the rocket is launched.

Determine the maximum height, to the *nearest tenth of a foot*, the rocket reaches.

Determine the length of time, to the *nearest tenth of a second*, from when the rocket is launched until it hits the ground. [The use of the grid below is optional.]

Maximum height is 356.6

Time when rocket hits the ground is 9.4



The student entered the function into a graphing calculator and graphed the function on the accompanying grid. The student appropriately labeled the scale on both axes. The intercepts and vertex were found using the graphing calculator and labeled on the graph. The student clearly stated both correctly rounded answers .

S.ID.8 Compute (using technology) and interpret the correlation coefficient of a linear fit.

The table below shows the relationship between the length of a person's foot and the length of his or her stride.

Foot (in inches) (x)	**Stride** (in inches) (y)
9	24
10	27
11.5	33
12	36

Write the linear regression equation for this set of data, rounding all values to the *nearest hundredth.*

$y = 3.96x - 12.03$

Using the linear correlation coefficient, explain how accurate this function is in predicting a person's stride length.

The linear correlation coefficient is 0.99 which means this regression has a strong linear correlation because it is close to 1. Therefore this would be a good predicter of a person's stride length given their foot size

Predict the stride length, in inches, of a person whose foot measures 8 inches.

$y = 3.96(8) - 12.03$

$y = 19.65$

The student correctly entered the table values into the graphing calculator and followed the correct key strokes to obtain the correct linear regression equation. The student then used the graphing calculator to find the correlation coefficient and wrote a correct explanation. The student used the calculator to obtain the correct answer.