The University of the State of New York
**The State Education Department**
Albany, New York 12234

# 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 to support conceptual understanding and solve real world mathematics problems. The connections between graphical and algebraic representation can be enhanced through the use of graphing calculators and other technological tools, while algebraic and analytical approaches (i.e., pencil and paper techniques) to solving problems should still be stressed.

This document provides guidance to schools and districts to determine whether the use of a particular graphing calculator is allowed on a Mathematics Regents Examination or if it provides an unfair or inappropriate advantage to a student and, therefore, is not allowed.

The graphing calculator should only function as a tool to help students demonstrate their knowledge and understanding of the Learning Standards being assessed on the Mathematics Regents Examinations. The graphing calculator should **not** remove the need for students to demonstrate their knowledge and understanding of algebraic and geometric properties and relationships that are being assessed in the particular course.

## Restricted Features/Prohibited Functions

Educators should work collectively to determine if a graphing calculator adheres to the guidelines and does not contain restricted features.

- The calculator must **not** make use of a Computer Algebraic System (CAS). These calculators are capable of doing symbolic algebra or symbolic calculus (for example, factoring, expanding, or simplifying given variable output).
- The calculator must **not** have measuring capabilities (e.g., segment lengths and area of polygons), perform transformations, or be able to make geometric constructions.
- Students may **not** use calculators that can communicate through infrared sensors, nor may students use operating manuals, instruction or formula cards, or other information concerning the operation of calculators.

For questions in which the graphing calculator can be used, students should be instructed to show sufficient work so that their approach to problem-solving can be easily followed. For students to be awarded the maximum points allowable for a constructed-response question, they should 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.

Please note that schools must make a graphing calculator available for the exclusive use of each student while taking Regents Examinations in mathematics, and that students are allowed only one calculator.

The memory of any graphing 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.

## Frequently Asked Questions

1) Can I use a graphing calculator that can simplify radicals such as $\sqrt{18}$ or give exact trig values?
*-Yes. These features will be allowed.*

2) Is there a list of approved calculators that can be used on the Math Regents Exams?
*-No. It is the responsibility of each district to make sure any graphing calculator to be used on a High School Mathematics Regents Exam adheres to the guidelines.*

3) A company representative told me a specific calculator model can be used on Math Regents Exams. Can I assume the calculator is approved?
*-No. Although representatives may be helpful in providing explanations of the range of capabilities for a brand of calculator, it is the responsibility of each district to make sure any graphing calculator to be used on a High School Mathematics Regents Exam adheres to the guidelines.*

4) My calculator has a Computer Algebra System (CAS). May I use this calculator for the Math Regents Exams?
*-You may **not** use this calculator unless there is a way to restrict the CAS features that are prohibited by the guidelines.*

5) If I put my calculator in a test mode, does this ensure it is ready for the Math Regents Exams?
*-Not necessarily. Although this is generally a good practice, districts must make sure the final calculator mode adheres to the guidelines.*

6) Do the applications (apps) on my calculator need to be removed or turned off for the Math Regents Exams?
*-It is the responsibility of each district to make sure any graphing calculator apps to be used on a High School Mathematics Regents Exam adhere to the guidelines.*

7) My calculator is prompting me to turn off features that I have been using all year when I put it in test mode. Do I have to turn them off?
*-Possibly. It is the responsibility of each district to make sure any graphing calculator features to be used on a High School Mathematics Regents Exam adhere to the guidelines.*

8) I can draw lines and segments on my calculator without using equations. Is this acceptable on the Math Regents Exams?
*-Yes, as long as the lines and segments are drawn by the student. The graphing calculator must not draw what a student would otherwise need to construct or locate themselves either algebraically or graphically. For example, the perpendicular bisector of a line segment must be drawn by the student and not be a result of a graphing calculator function. Please note that performing calculator regressions and the resulting line of best fit are permissible.*

9) My calculator will reflect a figure over the *y*-axis. Is this allowed on the Math Regents Exam?
*-No. Graphing calculators must not perform transformations. This function must be turned off in order to use this graphing calculator.*

10) Our district would like to use graphing calculator software other than a traditional handheld calculator. Is this allowable?
*-Districts may submit requests to the Test Administration Unit within the Office of State Assessment for consideration. Please call 518-474-5902 or email emscassessinfo@nysed.gov for more information.*

11) Can a student use multiple calculators on a Math Regents Exam?
*- No. Each student is allowed only one calculator.*

## Calculator Tasks

When taking Mathematics Regents Examinations, some of the tasks students will be expected to perform using a graphing calculator are:

- Graphing functions in an appropriate viewing window
- Determining key features of functions
- Observing the table of values for a graphed equation
- Solving systems of equations
- Exploring changes and effects on the graph of parent functions
- Performing trigonometric calculations
- Determining a regression equation
- Determining a correlation coefficient
- Determining the standard deviation of a set of data
- Determining population percentages for a normal curve

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)
- To show the curvature of nonlinear functions, at least three points should be indicated on the graph or represented as a table of coordinate values
- Key features are correctly shown
- Scale is stated if not 1 to 1
- Use the full extent of the graph or provide arrows unless a domain is specified

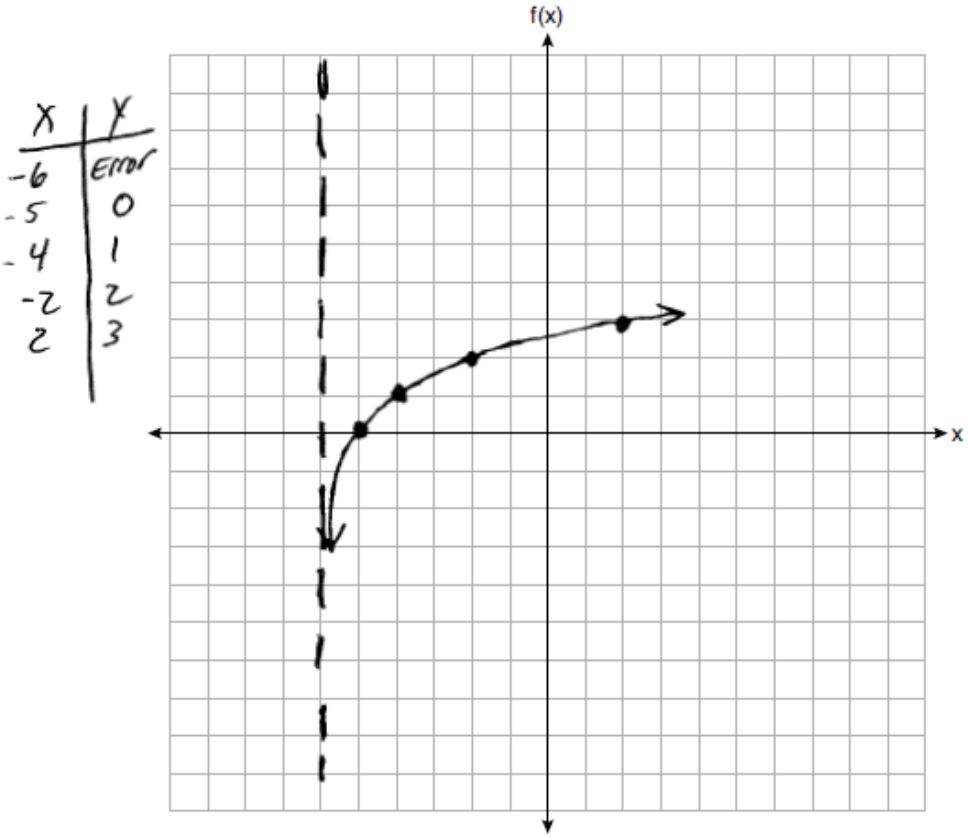
If a student sketches a graph when a grid is not provided, the above criteria for sketches and graphs still apply.

## 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.

**F-IF** Analyze functions using different representations.

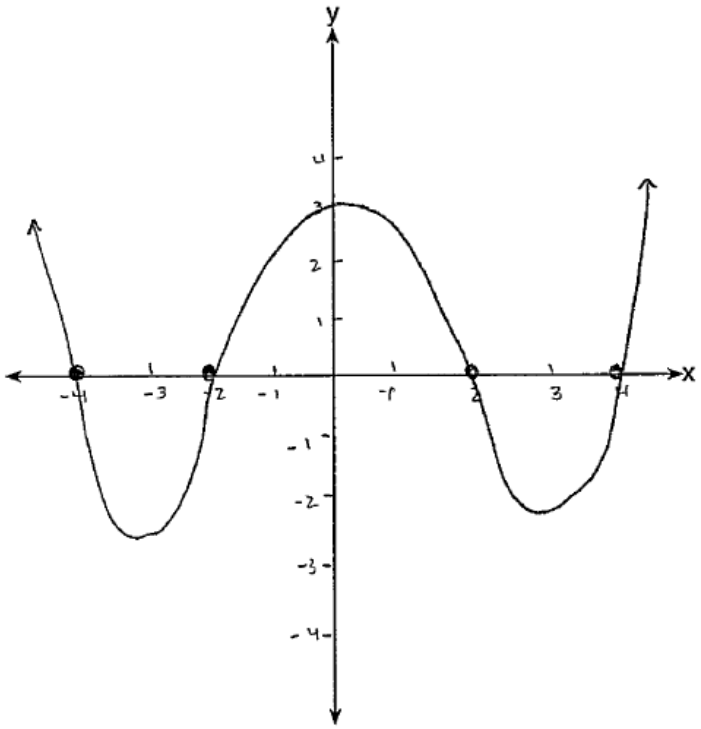
27 Graph $f(x) = \log_2(x + 6)$ on the set of axes below.




The student entered the equation into the graphing calculator, drew the function and asymptote, and provided a table of values. The student plotted at least 3 points, provided arrows, and showed appropriate end behavior. Full credit would be awarded for this accurate graph without the asymptote or table of values, but these additional features clearly indicate to the rater that the points were plotted correctly and better indicates that as $x$ approaches $-6$, $f(x)$ decreases to infinity.

**A-APR** Understand the relationship between zeros and factors of polynomials.

**26** The zeros of a quartic polynomial function are 2, $-2$, 4, and $-4$. Use the zeros to construct a possible sketch of the function, on the set of axes below.




The student explored graphs of the form $y = a(x - 2)(x + 2)(x - 4)(x + 4)$ on the graphing calculator and drew a sketch of a quartic function with zeros at 2, $-2$, 4, and $-4$. The student plotted 4 points, provided a correct shape for a quartic, and showed appropriate end behavior. The minima may be roughly drawn and the graph misses $-2$ and 4 slightly, but credit should not be deducted for this sketch.

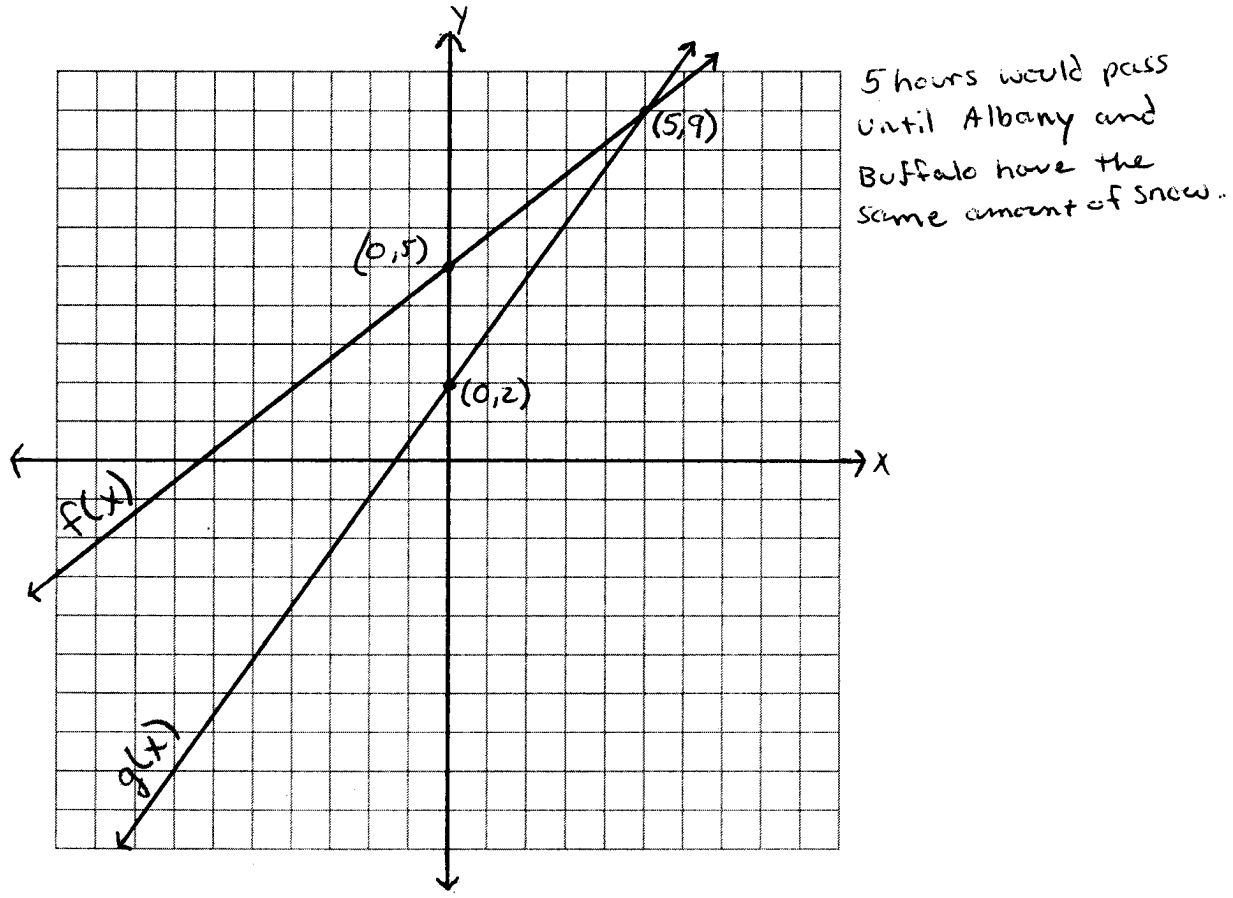
**A-REI** Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

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.]




The student entered both equations into the graphing calculator and drew the graphs of 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** Identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $kf(x)$, $f(kx)$, 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 $g(x) = f(x - 5)$.

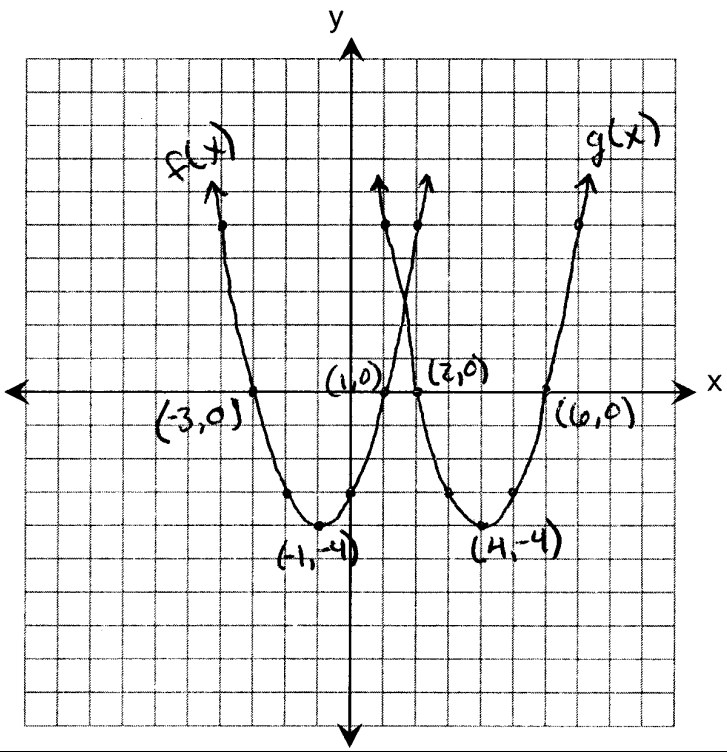
The graph f(x) moves five units to the right.

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 drew the graphs of $f(x)$ 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.

**F-IF** 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.

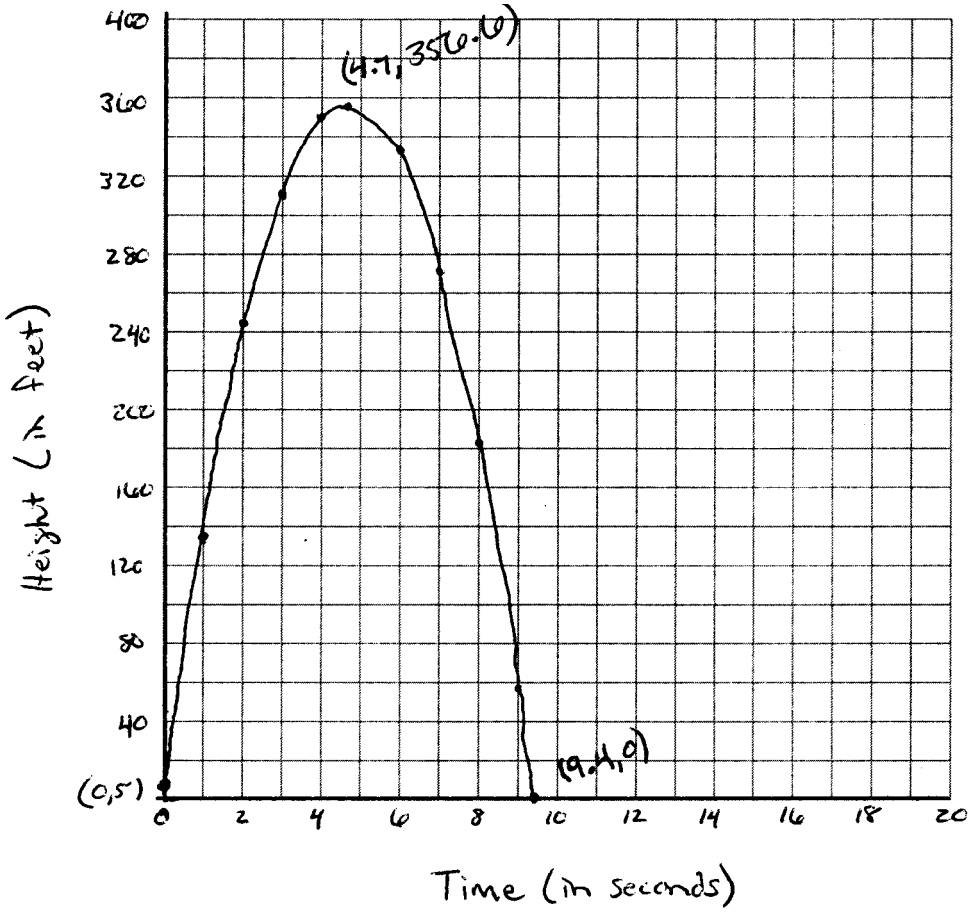
A model rocket is launched from a platform in a flat, level field and lands in the same field. The height of the rocket follows the function, $f(x) = -16x^2 + 150x + 5$, where $f(x)$ is the height, in feet, of the rocket and $x$ is the time, in seconds, since the rocket is launched.

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 the graphing calculator and then drew the graph of 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** 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.

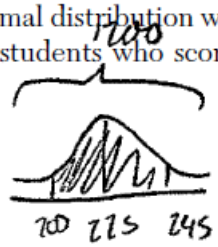
$y = 3.96(8) - 12.03$

$y = 19.65$

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

**S-ID** Summarize, represent, and interpret data on a single count or measurement variable.

28 The scores of a recent test taken by 1200 students had an approximately normal distribution with a mean of 225 and a standard deviation of 18. Determine the number of students who scored between 200 and 245.




normalcdf(200, 245, 225, 18) = .7843

.7843 × 1200 = 941

941 students

The student showed correct work in determining 941 students. While the item could be solved primarily using a graphing calculator feature, the student provided a sketch and listed calculations which clearly demonstrate the student's understanding of the problem to the rater.