Using the Graphing Calculator on the AP Exam

Every AP Calculus student is required to bring a graphing calculator to the AP Exam. The calculator must have the following four capabilities:

1. Find the zeros of a function.
2. Graph in an arbitrary viewing window.
3. Approximate a definite integral.
4. Approximate a derivative at a point.

Students, in working the first three free-response questions which require the calculator, may only use the calculator for the above four operations.

Features on the calculator that perform may not be used by the student on on the AP test.

- If students must find a maximum value they must use calculus techniques to find the location of the maximum (or minimum) value. Work must be shown that supports how the maximum (or minimum) value was found.
- If the student is asked to approximate a definite integral using the trapezoidal rule, the student must show the numbers that he/she is putting into their calculations to arrive at their answer.
- If a student uses a built in feature or any program in their calculator to calculate an answer the student will receive no credit unless he/she shows all their work.
- If a student is solving an equation, the student must show the equation on their paper. After that the calculator may be used to calculate the solution to an equation.

On the first three calculator active questions if a student is going to use the calculator to approximate a derivative at a point or the definite integral of a function the student, the student must first record the calculus statement in their answer booklet and then they can use the calculator to find the approximation. Remember decimal answers must be either 3 or more decimal places.

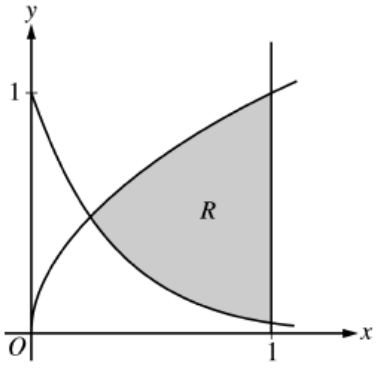
The first twenty-eight multiple choice questions (Part A) are answered without the use of a calculator. In the next seventeen questions (Part B of the multiple choice), a calculator is required but, in many of these questions, the use of a calculator in inappropriate and the student will be wasting time if they try to use the calculator for the entire Part B of the multiple choice. For the free-response, only parts of the first three questions require the calculator. At the conclusion fo 45 minutes the calculator must be turned off and put away. At that point the student can work on any of the six free

response questions. But if a student determines they need their calculator after the time limit, it is not possible to re-use the graphing calculator.

Teachers and students should be alert that sophisticated technology with sophisticated programs will afford the student no advantage when taking the exam. The programs and capabilities of the calculator can and should enhance the teaching and learning of the course. **There is not a single topic that cannot better be understood by using the power of visualization.** I taught calculus and worked the problems for many years without truly understanding what I was doing. Because of technology my students had a better understanding of the concepts in calculus that I ever had as both a student and a teacher.

In using the technology the student should be aware of some places where they could lose points through carelessness or by not saying enough. Consider the following example:

2003 AB1/BC1



Let R be the shaded region bounded by the graphs of $y = \sqrt{x}$, $y = e^{-3x}$, and the vertical line x = 1, as shown in the figure.

A. Find the area of R.

B. Find the volume of the solid generated when R is revolved around the horizontal line y = -1.

C. The region R is the base of a solid. For this solid, each cross section perpendicular to the base is a rectangle whose height is 5 times the length of its base in region R. Find the volume of the solid.

A student should attempt to produce a picture on their calculator similar to the given figure. This would mean the window should be set for $0 \le x \le 1$ and $0 \le y \le 1$. The students then needs to calculate the intersection of the equations. Surveying the questions it appears that only the x value of the intersection point will be need. Once the intersection point is found the x-value should be stored in the calculator for a variable and identified on the test solution. For example A = 0.238734.

The student needs to set up an integral for the area of region R:

$$\int_A^1 \left(\sqrt{x} - e^{-3x}\right) dx$$

Using the calculator the student then calculates this value by entering FnInt(Y1-Y2,x,A,1). This calculator language should not be recorded on the test. It will receive no credit. The answer is 0.44263. Therefore the answer 0.442, 0.443, and 0.44263 are all acceptable values.

To find the volume in part B the student will need to once again set up an integral to find the volume.

$$\pi \int_A^1 \left(1 - e^{-3x}\right)^2 - \left(1 - \sqrt{x}\right)^2 dx$$

The A has already been identified and stored in the calculator. Once this integral has been recorded the student can then again use the calculator to find an approximation for the integral. The student would enter πFnInt(((1-Y2)^2-(1-Y1)^2),x,A,1). The answer produced for this integral is 1.42356. Therefore the student may record that answer or 1.423 or 1.424.

For part C the student needs to record a third integral that can be used to find the volume.

$$\int_A^1 5\left(\sqrt{x} - e^{-3x}\right)^2 dx$$

Again since A has been identified and stored the student need to only use their calculator to find an approximation for the integral. The student would enter 5FnInt((Y1-Y2)^2,x,A,1). The student is responsible for the answer correct to 3 decimal places, either rounded or truncated, and the student should use all the digits for the coordinates of the point of intersection and only round off to 3 decimal places in the answer. The acceptable answers are 1.554354405 or 1.554.