

# Advanced Graphics in Microsoft Word

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Isaac Greenspan is the lead editor for *Precalculus and Discrete Mathematics*, the final book in the University of Chicago School Mathematics Project series. He is also the head coach of the Chicago ARML teams, competing in the national American Regions Math League competition. He previously taught at the Illinois Mathematics and Science Academy in Aurora, Illinois and at Evanston Township High School in Evanston, Illinois, where many of the techniques described in this document were developed and honed.

# Shortcut Keys

## General Shortcut Keys

Cut	<b>Ctrl / ⌘ + X</b>
Copy	<b>Ctrl / ⌘ + C</b>
Paste	<b>Ctrl / ⌘ + V</b>
Select All	<b>Ctrl / ⌘ + A</b>
Undo	<b>Ctrl / ⌘ + Z</b>
Redo	<b>Ctrl / ⌘ + Y</b> or <b>⌘ + Shift + Z</b>
Application Switching	<b>Alt + Tab</b> (hold <b>Alt</b> to display list of apps) <b>⌘ + Tab</b> (hold <b>⌘</b> to display list of apps)
Close Window	<b>Alt + F4</b> or <b>Ctrl + F4</b> (depending on context) <b>⌘ + W</b> (or <b>⌘ + H</b> hides an application)
Misbehaving Programs	<b>Ctrl + Alt + Delete</b> (Task Manager, "End Process") <b>⌘ + Cmd + Esc</b> ("Force Quit")
	<b>Windows</b> a Macintosh

## Word Shortcut Keys

Bold	<b>Ctrl / ⌘ + B</b>
Italics	<b>Ctrl / ⌘ + I</b>
Underline	<b>Ctrl / ⌘ + U</b>
Center Align	<b>Ctrl / ⌘ + E</b>
Hanging Indent	<b>Ctrl / ⌘ + T</b>
Move to Beginning of Line	<b>Home</b>
Move to End of Line	<b>End</b>
Move Forward One Word	<b>Ctrl / ⌘ + →</b>
Move Back One Word	<b>Ctrl / ⌘ + ←</b>
Move Down One Paragraph	<b>Ctrl / ⌘ + ↓</b>
Move Up One Paragraph	<b>Ctrl / ⌘ + ↑</b>
Move to Top of Document	<b>Ctrl / ⌘ + Home</b>
Move to End of Document	<b>Ctrl / ⌘ + End</b>
New Page (not new section)	<b>Ctrl / ⌘ + ↵</b>
Page Setup	<b>Alt + F, U</b> (Windows only)

## MathType Shortcut Keys

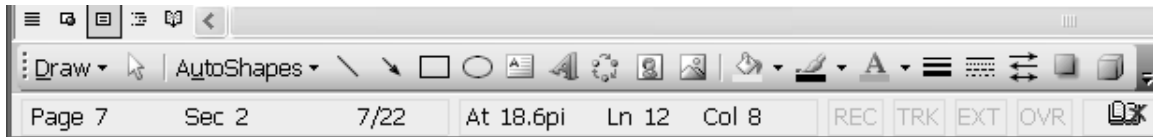
Parentheses	$\text{Ctrl} / \text{⌘} + \text{[9]}$
Absolute Value	$\text{Ctrl} / \text{⌘} + \text{[T]}, \text{[I]}$ (vertical bar)
Exponent/Superscript	$\text{Ctrl} + \text{[H]}$ or $\text{⌘} + \text{[E]}$
Subscript	$\text{Ctrl} / \text{⌘} + \text{[L]}$
Fraction (full-size)	$\text{Ctrl} / \text{⌘} + \text{[F]}$
Fraction (small)	$\text{Ctrl} / \text{⌘} + \text{[T]}, \text{[Shift]} + \text{[F]}$
Square Root	$\text{Ctrl} / \text{⌘} + \text{[R]}$
Less Than or Equal To	$\text{Ctrl} / \text{⌘} + \text{[K]}, \text{[.]}$
Greater Than or Equal To	$\text{Ctrl} / \text{⌘} + \text{[K]}, \text{[.]}$
Not Equal	$\text{Ctrl} / \text{⌘} + \text{[K]}, \text{[+]}$
Approximately Equal	$\text{Ctrl} / \text{⌘} + \text{[~]}$
Congruent (Modulo)	$\text{Ctrl} / \text{⌘} + \text{[K]}, \text{[=]}$
Plus or Minus	$\text{Ctrl} / \text{⌘} + \text{[Shift]} + \text{[K]}, \text{[=]}$
Minus or Plus	$\text{Ctrl} / \text{⌘} + \text{[Shift]} + \text{[K]}, \text{[+]}$
Multiplication-type Dot	$\text{Ctrl} / \text{⌘} + \text{[Shift]} + \text{[K]}, \text{[.]}$
Angle Symbol	$\text{Ctrl} / \text{⌘} + \text{[Shift]} + \text{[K]}, \text{[A]}$
Degree Symbol	$\text{Ctrl} / \text{⌘} + \text{[Shift]} + \text{[K]}, \text{[D]}$
Thin Space	$\text{Ctrl} / \text{⌘} + \text{[ ]}$
Em Space	$\text{Ctrl} / \text{⌘} + \text{[K]}, \text{[4]}$
Baseline Horizontal Ellipsis	$\text{Ctrl} / \text{⌘} + \text{[.]}, \text{[ ]}$
Centered Horizontal Ellipsis	$\text{Ctrl} / \text{⌘} + \text{[.]}, \text{[ ]}$

	$\text{[A]}$	$\text{[B]}$	$\text{[C]}$	$\text{[D]}$	$\text{[E]}$	$\text{[F]}$	$\text{[G]}$	$\text{[H]}$	$\text{[I]}$	
	A	B	X	$\Delta$	E	$\Phi$	$\Gamma$	H	I	
Greek Letters (Uppercase)	$\text{Ctrl} / \text{⌘} + \text{[G]}, \text{[Shift]} +$	$\text{[J]}$	$\text{[K]}$	$\text{[L]}$	$\text{[M]}$	$\text{[N]}$	$\text{[O]}$	$\text{[P]}$	$\text{[Q]}$	$\text{[R]}$
	$\vartheta$	K	$\Lambda$	M	N	O	$\Pi$	$\Theta$	P	
	$\text{[S]}$	$\text{[T]}$	$\text{[U]}$	$\text{[V]}$	$\text{[W]}$	$\text{[X]}$	$\text{[Y]}$	$\text{[Z]}$		
	$\Sigma$	T	Y	$\zeta$	$\Omega$	$\Xi$	$\Psi$	Z		
	$\text{[A]}$	$\text{[B]}$	$\text{[C]}$	$\text{[D]}$	$\text{[E]}$	$\text{[F]}$	$\text{[G]}$	$\text{[H]}$	$\text{[I]}$	
	$\alpha$	$\beta$	$\chi$	$\delta$	$\epsilon$	$\phi$	$\gamma$	$\eta$	$\iota$	
Greek Letters (Lowercase)	$\text{Ctrl} / \text{⌘} + \text{[G]},$	$\text{[J]}$	$\text{[K]}$	$\text{[L]}$	$\text{[M]}$	$\text{[N]}$	$\text{[O]}$	$\text{[P]}$	$\text{[Q]}$	$\text{[R]}$
	$\varphi$	$\kappa$	$\lambda$	$\mu$	$\nu$	$\omicron$	$\pi$	$\theta$	$\rho$	
	$\text{[S]}$	$\text{[T]}$	$\text{[U]}$	$\text{[V]}$	$\text{[W]}$	$\text{[X]}$	$\text{[Y]}$	$\text{[Z]}$		
	$\sigma$	$\tau$	$\upsilon$	$\omega$	$\omega$	$\xi$	$\psi$	$\zeta$		

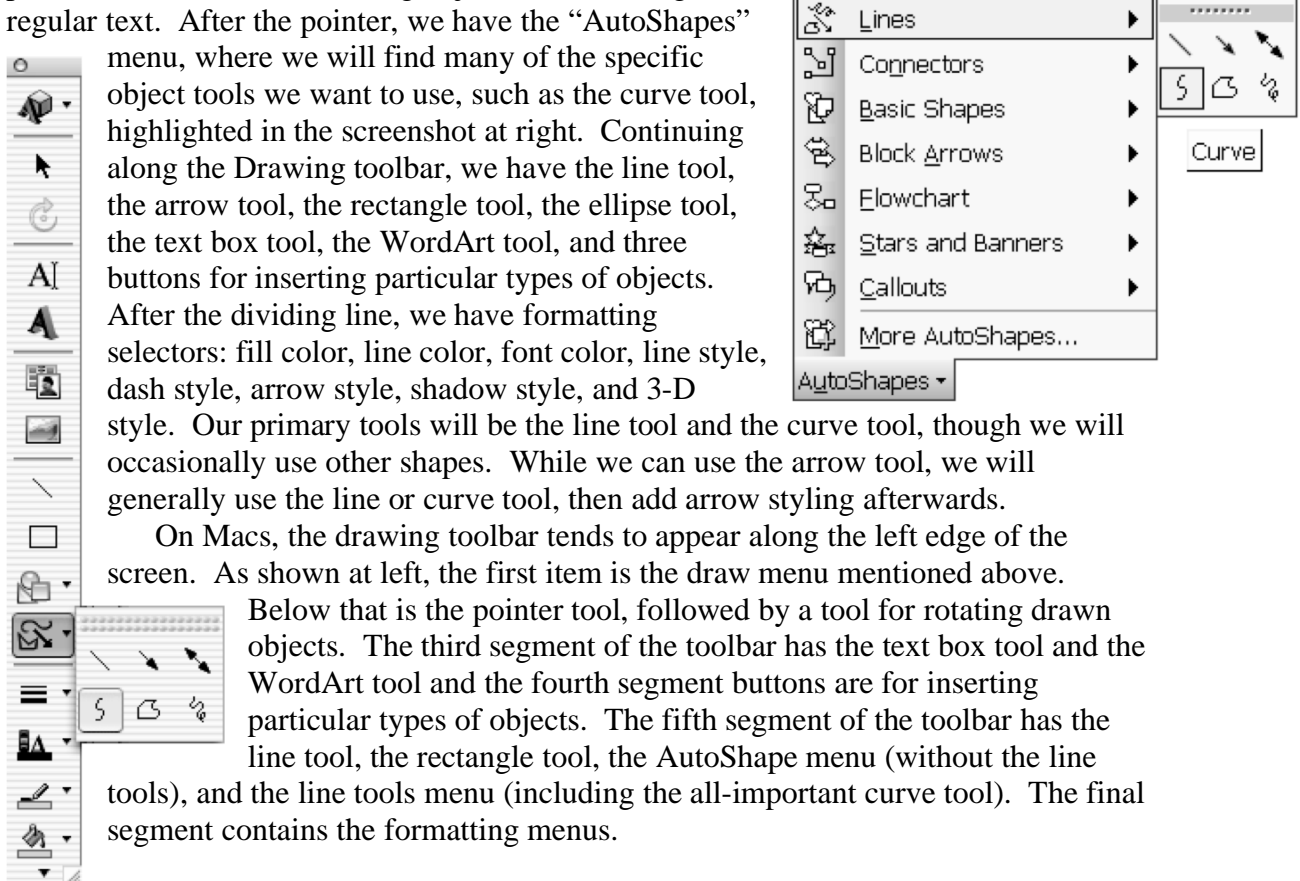
I generally find Word to be a hateful program, but it is by far the dominant program for word processing, especially in secondary schools, so we're pretty much stuck with it. Let's make the best of it.

## The Drawing Tools in Microsoft Word

We will be primarily working with the Word drawing tools. In the "View" menu, in the "Toolbars" submenu, make sure the "Drawing" item is checked so that the drawing



toolbar will appear. On Windows machines, the toolbar often defaults to appearing at the bottom of the window. As shown above, the "Draw" menu item on the toolbar contains a few key features we'll be using—grouping and ungrouping, order modification (which objects are on top of which), and transformations (rotation/reflection). Next over is the pointer tool, useful for selecting objects and avoiding regular text. After the pointer, we have the "AutoShapes"



menu, where we will find many of the specific object tools we want to use, such as the curve tool, highlighted in the screenshot at right. Continuing along the Drawing toolbar, we have the line tool, the arrow tool, the rectangle tool, the ellipse tool, the text box tool, the WordArt tool, and three buttons for inserting particular types of objects.

After the dividing line, we have formatting selectors: fill color, line color, font color, line style, dash style, arrow style, shadow style, and 3-D style. Our primary tools will be the line tool and the curve tool, though we will occasionally use other shapes. While we can use the arrow tool, we will generally use the line or curve tool, then add arrow styling afterwards.

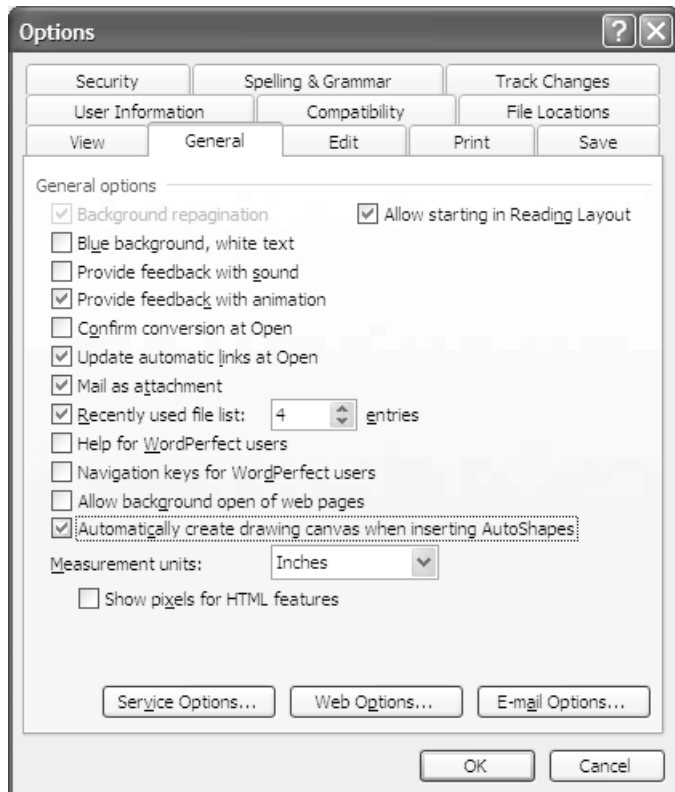
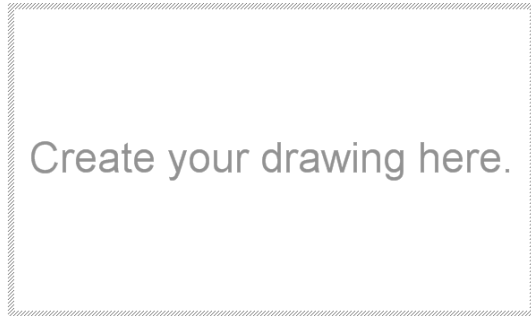
On Macs, the drawing toolbar tends to appear along the left edge of the screen. As shown at left, the first item is the draw menu mentioned above.

Below that is the pointer tool, followed by a tool for rotating drawn objects. The third segment of the toolbar has the text box tool and the WordArt tool and the fourth segment buttons are for inserting particular types of objects. The fifth segment of the toolbar has the line tool, the rectangle tool, the AutoShape menu (without the line tools), and the line tools menu (including the all-important curve tool). The final segment contains the formatting menus.

For creating a drawing of any complexity, working in a document with text or anything else just complicates the work on the drawing. It is far simpler to work in a new, blank document. With the entire page blank, we are also free to use more space if we want and we can always scale down our drawing later. When we begin to draw, newer versions of Word present us with the “Create your drawing here” annoyance shown at left—the “canvas” object. While this does actually have some advantages, we aren’t going to use it, so if it pops up, we need to make sure we

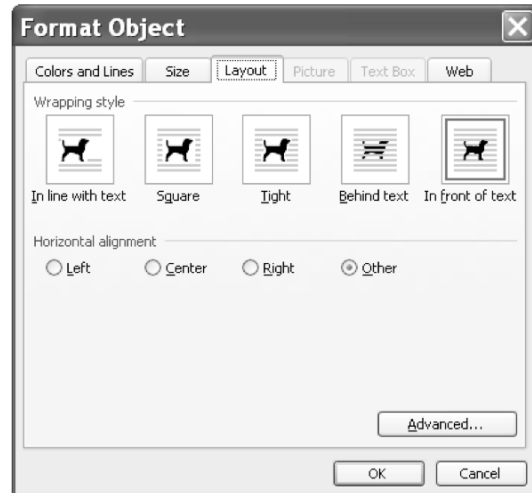
don’t draw in it. We can either draw outside of it or press **[Esc]** to make it go away (but we will still have our current tool). We can also prevent Word from automatically creating the canvas object by going to “Options” in the “Tools” menu, going to the “General” tab, and un-checking “Automatically create drawing canvas when inserting AutoShapes” (see the dialog at right). Once we begin drawing, there are a few key things to keep in mind. First, Word has an underlying grid and has a default setting of “Snap to Grid,” which causes all objects to naturally move (and be drawn) in jumps, as if every point and edge were drawn to lattice points in the plane. We can take advantage of this to help us align and uniformly space objects. When we have one or more objects selected, we can move them with the arrow keys—this will move them in uniform steps, so a counted-out number of presses of the arrow keys will yield repeatable spacing. When we want to escape the limitations of the grid, we can “nudge” objects using the arrow keys while holding down **[Ctrl]** (on Windows) or **[⌘]** (on Mac), moving them in very small increments.

When we are drawing two-dimensional objects, like rectangles and ellipses, holding down **[Shift]** will force the aspect ratio to be 1, forming squares and circles. Holding down **[Shift]** while drawing a line will force it to be horizontal, vertical, or at a 45° angle. When resizing an object, **[Shift]** will maintain the aspect ratio of a 2-D object and maintain the direction of a line.

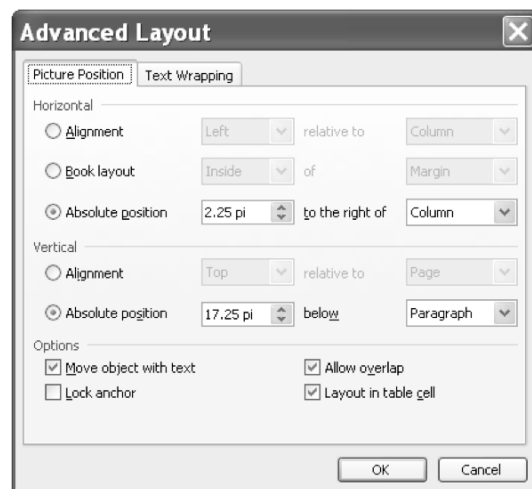
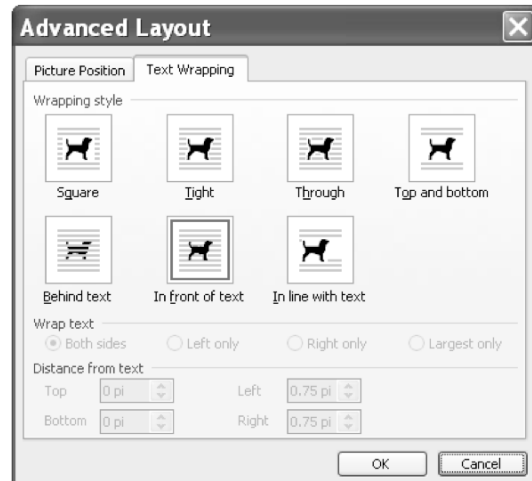




When we create a drawing composed of multiple objects, we will usually want to group those objects together so that they stay positioned properly and can be safely moved and resized. Grouping makes the collection of objects behave as a single object. For a group in particular, as well as for individual objects, we will often need to format it to behave in a particular way with respect to the rest of our Word document. While many people place their graphics in tables to position them, it is far better to use formatting to make the graphic interact well with the rest of your document. Key to this is the “Layout” part of an object’s formatting. The “Layout” tab of the “Format Object” dialog is shown at right. There are five basic wrapping styles, as shown in the dialog. “In line with text” is the default, though perhaps the least useful for any large object. “Square” and “Tight” cause the object to carve out space and force the text around the object with “Square” keeping the text out of a rectangular region containing the object and “Tight” allowing the text to come closer and mold around the shape of the object. “Behind text” and “In front of text” don’t wrap the text at all; these are most useful for our intermediate work when creating drawings. From this tab, we can also set the horizontal alignment of the object.



The “Advanced” button provides a number of additional options. To begin with, the “Text Wrapping” tab gives us more wrapping options. “Through” is tighter than “Tight,” allowing the text to take up empty space nestled in the object. “Top and bottom” provides a more classical interjected figure, where text is above and below the object, but not exactly wrapped around it. For the styles that actually allow wrapping, we also have the added option of keeping the wrapped text to only one side of the object and of specifying how much space to leave between the object and the text being wrapped around it. The “Picture Position” tab gives us a number of choices as to how exactly the object will be positioned on the page. Though all these position settings can be useful, the most noteworthy is the “Move object with text” check box toward the bottom of the window. This is checked by default, causing objects to



move up or down as you edit text around them. Most of the time, this is a good behavior, but it can be helpful to know how to turn it off when you want an object to stay put regardless of what edits you make to the surrounding text.

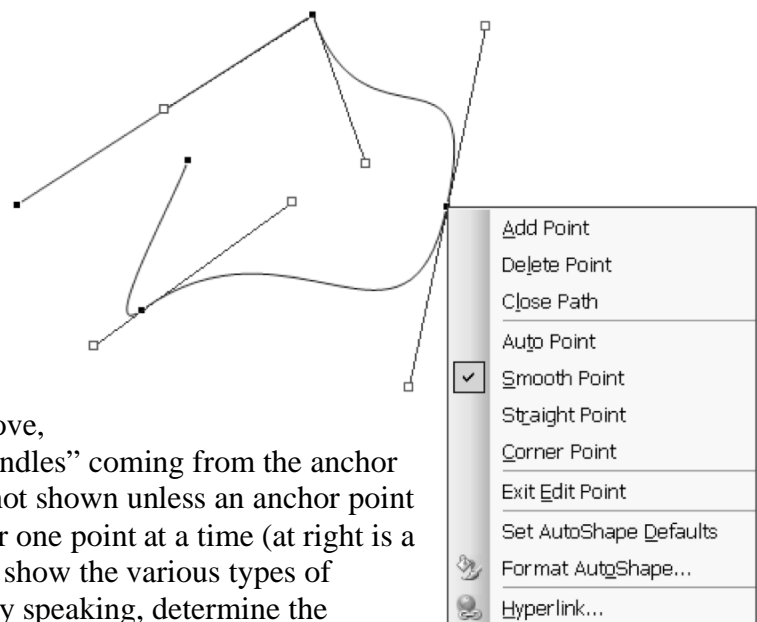
## The Evils of Text Boxes

While Word has a “Text box” tool, it is best to avoid it entirely. The default settings for a text box include a border, a white background (that covers other objects), and a fairly large internal margin. These are all fixable, but there is a more fundamental flaw: though you can resize text boxes (particularly when they are grouped with other objects), the text inside them will not scale with the box, nor will the margins scale. The result is that if you use a text box grouped with other objects and attempt to resize the grouped objects, the text may be cut off or vanish, generally making the drawing harder to maintain.

Fortunately, MathType allows us to type anything we could have typed into a text box and MathType objects are better behaved. By default, MathType objects are transparent and have no border. While MathType objects that are pasted in have the default layout setting of “In line with text,” this is easily fixed (setting the layout to “In front of text” allows the object to move freely and be easily placed into drawings). In fact, when we need many MathType elements in a drawing, we can duplicate a properly-formatted one and edit the contents rather than having to repeat the formatting. These MathType objects can be grouped with other drawing objects and behave just like any other drawing object. In particular, MathType objects can be resized and their contents will scale properly. Because of all these advantages, it is greatly preferable to exclusively use MathType objects for labeling drawings in Word.

## The Curve Tool

The curve tool is one of the most powerful tools in Word. Curves are based on anchor points and behavior at those anchor points. In the composite screenshot at right, we have a curve with five anchor points (black boxes). Once a curve is drawn (or, rather, roughed in), we can fine tune it using the “Edit Points” feature, where we are presented with the anchor points to move, select, and modify. Normally, the “handles” coming from the anchor points and ending in white boxes are not shown unless an anchor point is selected and then are only shown for one point at a time (at right is a composite of several screen images to show the various types of anchor points). These handles, roughly speaking, determine the



direction of the curve at the anchor point and how far away from the anchor point the effect lasts.

Beginning from the leftmost point and moving clockwise, the first point is an “Auto Point” and has no handle, so the behavior of the curve at that point is largely governed by the surrounding points. The segment joining that point to the second point is set as a “Straight Segment,” as opposed to the rest of the segments which are set as “Curved Segment.” The second anchor point is a “Corner Point,” so the two handles move completely independently from one another, allowing a sharp corner in the curve. The third anchor point, as shown in the menu, is a “Smooth Point,” so the handles are always the same length and in opposite directions, leading to a smooth curve. The fourth point is a “Straight Point,” similar to the “Smooth Point” but allowing the handles to have different lengths. The final point, like the first, is an “Auto Point.”

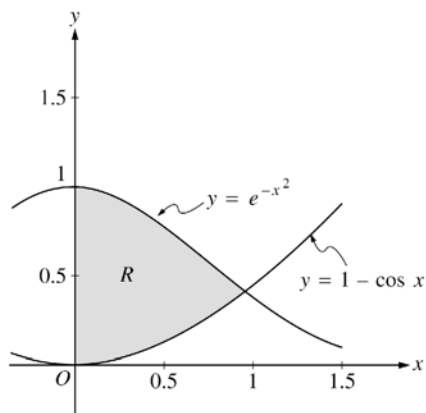
## **Sketchpad & Graphs**

Sketchpad is likely the most readily available tool for graphing functions (among other things) for most teachers. While it is very flexible in many ways, the way that its graphics copy and paste into Word (at least, with the default settings) render them virtually unusable—the lines are too thin, the scale numbers are hard to read and the tick marks are hard to see, and getting exactly the part of the graph you want is difficult. These graphs do, however, provide an easy template for us to create better-looking curves using Word’s drawing tools.

To get a graph from Sketchpad into Word, create the graph in Sketchpad (use “Plot New Function,” repeat for multiple graphs together), adjust the window and the scale (move the point at the origin and/or the point at one on the axis/axes) so that what shows in the window is what you want to copy to Word, then select only the axes and the curves you want to bring into Word and copy/paste into Word. By default, we will end up pasting an image that is formatted to be in line with text. In order to trace over it, we need to format it to be “Behind text” so that it is behind anything else we’re working on and can move freely. It is generally best to create your axes before copying in the Sketchpad graph, then take the Sketchpad graph and move it into alignment with your axes. This can take several cycles through nudging it into place (matching the origins) and resizing so that the scales match (this may need to be done through the object formatting in order to get fine enough control over the size). Once the Sketchpad graph is lined up with your axes, you can use the Word drawing tools to create your graph directly on top of the Sketchpad graph, using it as a template. When you are done, select the Sketchpad graph and delete it.

## Examples or Exercises (depending on your point of view)

**2000 AP<sup>®</sup> CALCULUS BC FREE-RESPONSE QUESTIONS**



1. Let  $R$  be the shaded region in the first quadrant enclosed by the graphs of  $y = e^{-x^2}$ ,  $y = 1 - \cos x$ , and the  $y$ -axis, as shown in the figure above.

- Find the area of the region  $R$ .
- Find the volume of the solid generated when the region  $R$  is revolved about the  $x$ -axis.
- The region  $R$  is the base of a solid. For this solid, each cross section perpendicular to the  $x$ -axis is a square. Find the volume of this solid.

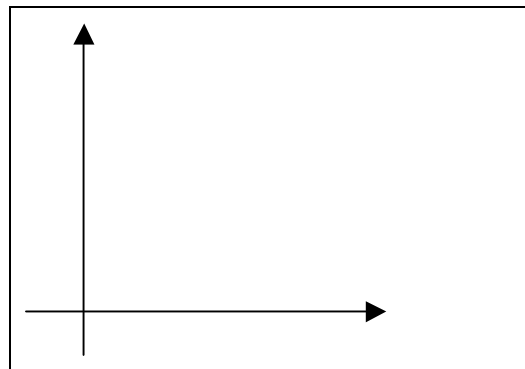
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AP is a registered trademark of the College Entrance Examination Board.

Let's begin with question 1 from the 2000 AP Calculus BC Exam. This graph has a few challenging features to recreate—we have curved graphs, they are specific functions so they should have a specific shape, and we have a shaded region bounded by curves. We'll be using the curve tool heavily here.

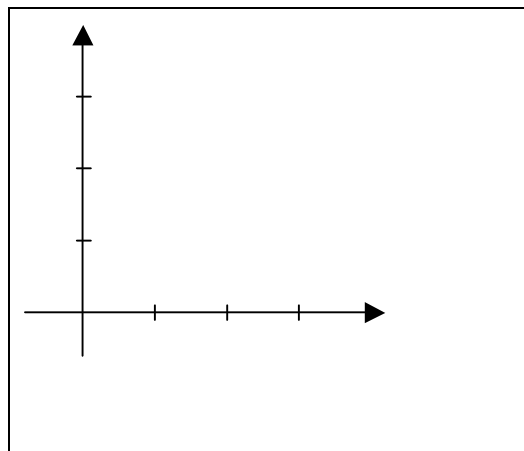
### Create the Axes.

Don't worry about length—we'll fix that when we do the tick marks. To put the arrowheads on, you may end up guessing which end is the "left" and which is the "right" (it depends on where you started and ended the line).



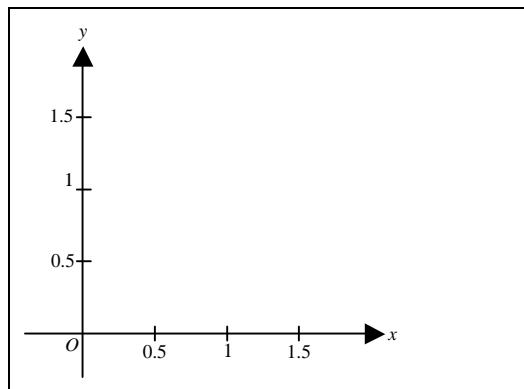
### Tick Marks.

Make a vertical segment as short as you can and position it against the horizontal axis (not across it yet), move it directly on top of the vertical axis, then press  $\square$  three times. Duplicate this short segment, move the copy directly on top of the first, and again press  $\square$  three times. Repeat this to get a third tick exactly  $3 \times \square$  away. Select all three tick marks and use  $\text{Ctrl} + \uparrow / \downarrow$  to nudge them over the axis. Repeat all this starting with a short horizontal segment and moving  $3 \times \square$  away each time for the vertical axis ticks. If need be, adjust the length of your axes to get the tick marks to fit.



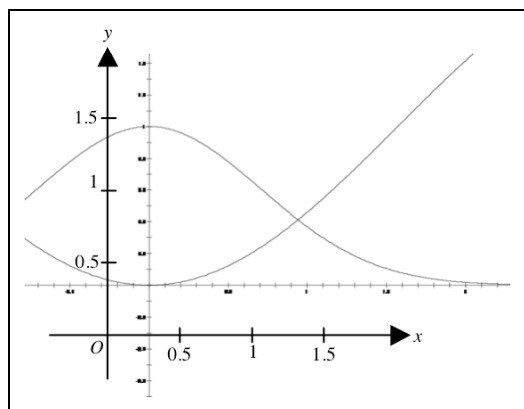
### Label the Axes.

Copy/paste in a MathType object with just an “O” for the origin. Format this MathType object to make it “In front of text” and move it to the right place. Duplicate it and edit the copies for the rest of the labels (this preserves the object formatting).



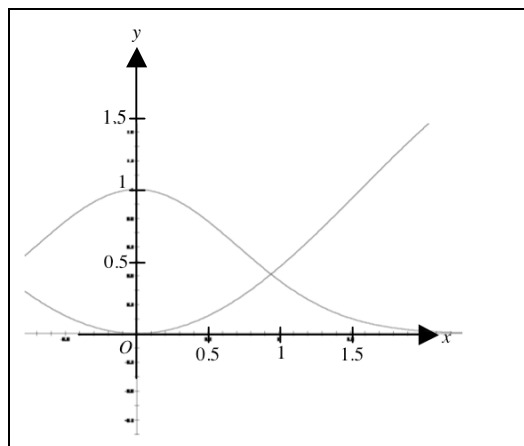
### Use Sketchpad to Graph the Functions, Copy into Word.

Plot the functions in Sketchpad, then manipulate the graph so that the part we want fills the window (roughly). Select the axes and the two curves, copy/paste into Word.



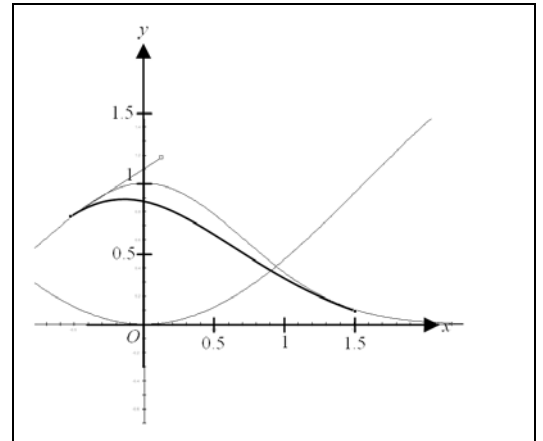
### Align the Sketchpad Graph with the Axes.

Format the Sketchpad graph to be “Behind text” (this is different from the usual, but helpful in keeping the Sketchpad graph under our own graphics). Move it so that the axes are close to aligning and resize it so that the units match up—this may take several cycles of moving (and nudging) and resizing to get the two to match up, but we want to ensure the graph is in the right location and has the proper scale.



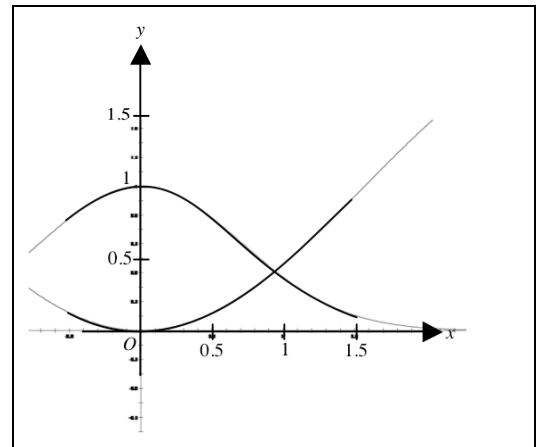
**Use the Curve Tool to Trace the First Graph.**

With the curve tool, single-click at one end of the graph and double-click at the other end. This will create a straight line between the points. Now, edit the points, changing each endpoint to a "Straight Point," moving the point as needed, and adjusting the handles on each end until the curve is exactly on top of the Sketchpad curve. Repeat for the second function.



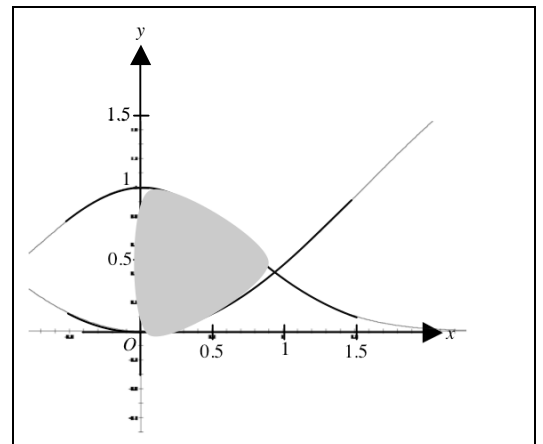
**Use the Curve Tool to Trace the Second Graph.**

Repeat for the second function.



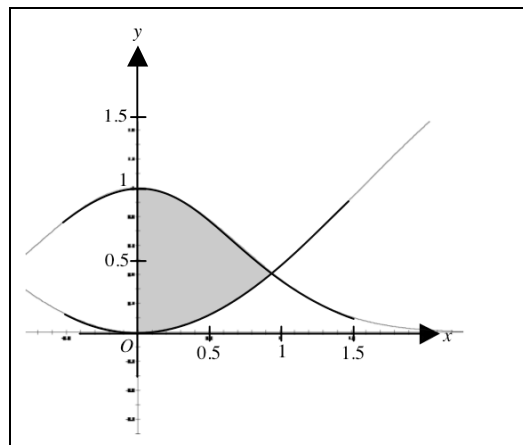
**Use the Curve Tool to Create the Shaded Region.**

With the curve tool (or the closed curve tool), single-click at each vertex of the shaded region, then double-click on the initial vertex to close the region. Format the object to be filled with gray and have no border.



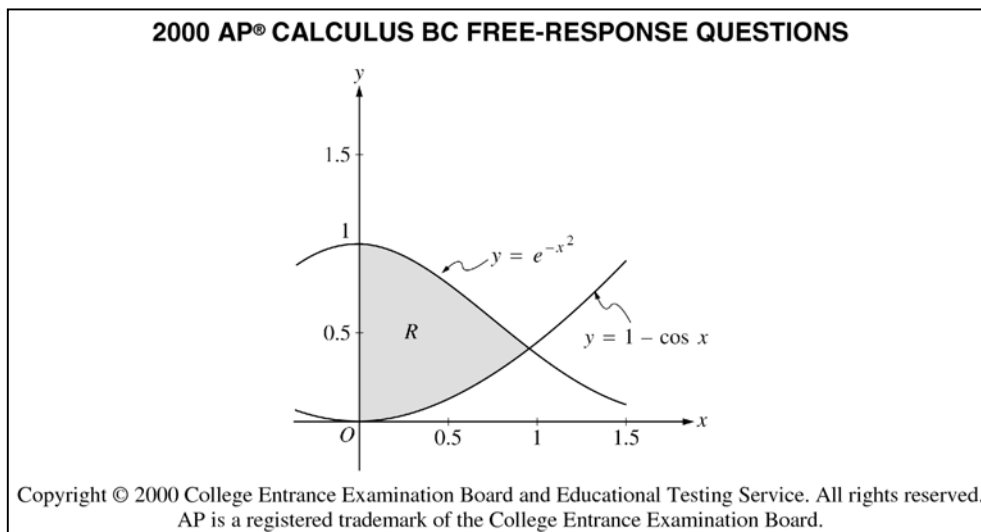
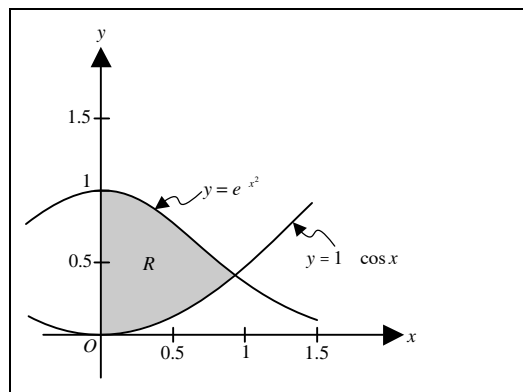
### Reposition and Reshape the Shaded Region.

Edit the points of the shaded region, changing the segments to straight or curved as appropriate and moving the points as necessary. Set each point to be a “Corner Point” and adjust the handles at each vertex until the curve is exactly on top of the Sketchpad curve. You may want to send the shaded region backward (behind other drawing objects) until the drawn-in curves are on top of it.

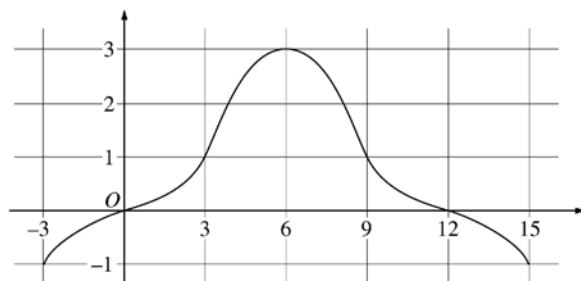


### Remove the Sketchpad Graph, Label Graphs and Region.

Delete the Sketchpad graph since it is no longer needed. Use MathType objects to label the graphs and the region. You can create the S-curve arrows using the curve tool.



2002 AP<sup>®</sup> CALCULUS BC FREE-RESPONSE QUESTIONS (Form B)



Graph of  $f$

4. The graph of a differentiable function  $f$  on the closed interval  $[-3, 15]$  is shown in the figure above. The graph of  $f$  has a horizontal tangent line at  $x = 6$ . Let  $g(x) = 5 + \int_6^x f(t) dt$  for  $-3 \leq x \leq 15$ .

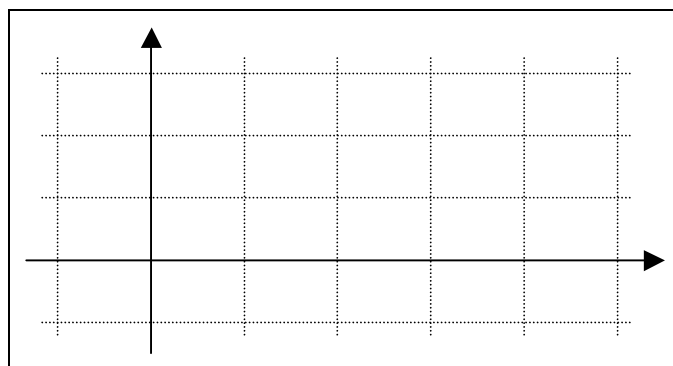
- Find  $g(6)$ ,  $g'(6)$ , and  $g''(6)$ .
- On what intervals is  $g$  decreasing? Justify your answer.
- On what intervals is the graph of  $g$  concave down? Justify your answer.
- Find a trapezoidal approximation of  $\int_{-3}^{15} f(t) dt$  using six subintervals of length  $\Delta t = 3$ .

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Now let's try question 4 from the 2002 AP Calculus BC Exam (Form B). Here, we are using gridlines, we aren't given a formula, and our graph has symmetry. Because there isn't a formula, we only need to replicate the general shape, not trace a specific curve and we can take advantage of the symmetry and Word's transformational tools to simplify our work.

**Create Axes and Gridlines.**

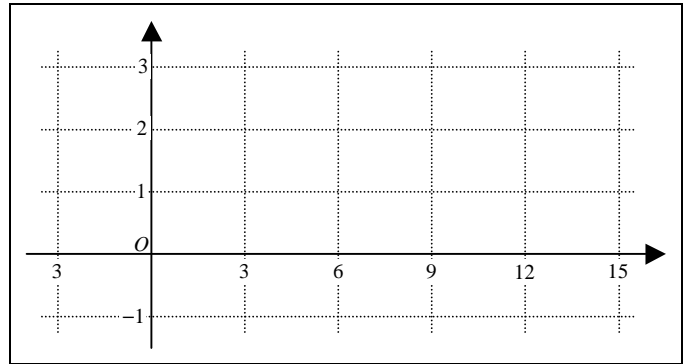
When drawing the gridlines, use the technique for tick marks to make the spacing equal.





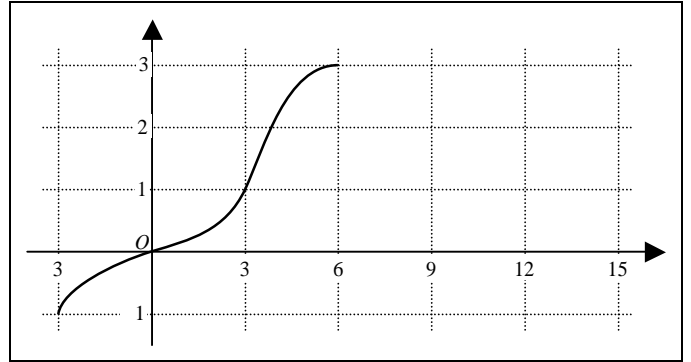
**Label the Axes.**

Format the MathType objects to be filled white so that they cover up the gridlines.



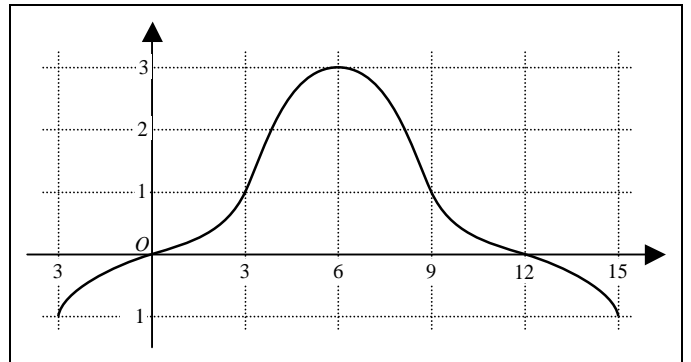
**Create Half of the Curve.**

No need for helping lines since we've got the grid. Place anchor points at all four grid-intersections through which the curve passes, then set the point types (perhaps try straight or smooth) and adjust the handles until you have the appropriate shape.



**Use Symmetry for the Other Half.**

Duplicate the half just drawn, flip horizontally, and align with the first half.



**2002 AP<sup>®</sup> CALCULUS BC FREE-RESPONSE QUESTIONS (Form B)**

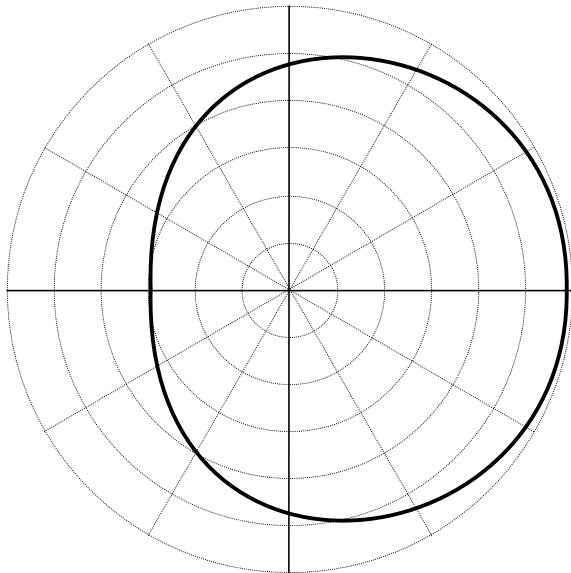
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## Additional Exercises

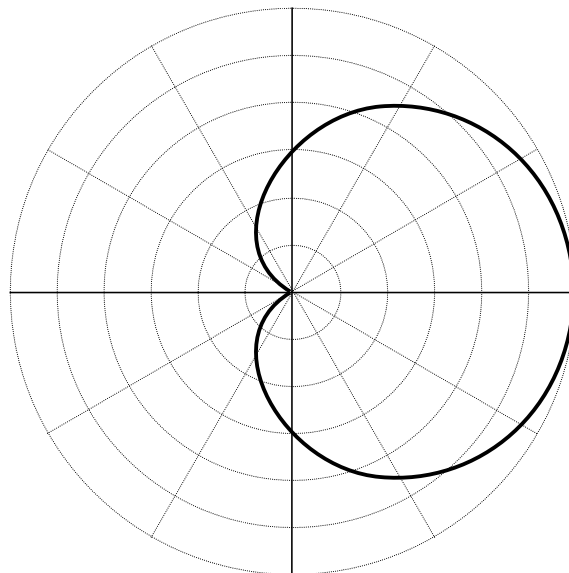
(more practice with the curve tool)

Recreate each of the following standard polar graphs. A good place to start would be creating a blank polar grid (lots of circles and lines, changing the line styles here and there, and an opportunity to try out the rotation and alignment mechanisms in the drawing menu). For the graphs of each, you will probably want to use a Sketchpad graph as a template and it ~~save~~ time if you make use of symmetry.

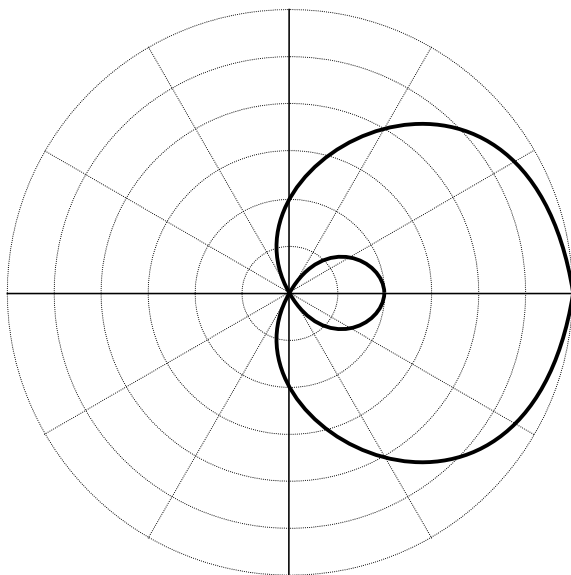
$$r = 4.5 + 1.5 \cos \theta$$



$$r = 3 + 3 \cos \theta$$



$$r = 2 + 4 \cos \theta$$



$$r = 5 \cos 2\theta$$

