TI-89 Clinic

Preliminaries

Let's first set up our calculators so that we're all working in the same mode.

- From the home screen, select F6 – *new problem*. Hit *enter* to execute that command. This erases previous calculations, clears variables *a*-*z*, and clears the home screen.

- Push the mode button.
  From page 1: *graph: function*
  display digits: float
  angle: radians
  From page 2: *exact/approx: auto*
  Remember to hit *enter* a second time to store these selections.

Numeric Calculations

- On the home screen, evaluate these expressions:

$$\frac{4}{7}\ ,\ \frac{4.0}{7}\ ,\ \frac{15}{20}\ ,\ \sqrt{32}\ ,\ \frac{w^2}{w^5}\ ,\ \frac{5}{0}\ ,\ \frac{2}{\infty}\ ,\ \cos(\tfrac{\pi}{6})$$

  Notice that your calculator provides exact, simplified answers. Wow!
  If *you* introduce a decimal, though, your calculator returns a decimal approximation.

- A second way to get approximate answers is to use ≈ located above *enter*.
  Evaluate the above expressions again with ≈
  Don't retype the expressions! Instead, grab and paste them on the entry line.
  Grab & paste will save you a lot of time in this clinic.

- If at any time you wish to clear the home screen: F1, 8.
  Notice that you may also cut, copy, and paste items.

Managing Folders and Files

Similar to a computer, your TI-89 has folders and files.

- To see your folders, select *var-link*, located on the right-hand side of your keypad.
  Create a folder called "practice." Do that in F1. We'll soon place an item in there.

- Look across the bottom of your screen.
  It shows you your mode selections and how much history you have in the home screen.

Algebra

F2 contains much of what you learn in algebra.

- Would you like to **factor**?
  Try: *factor* (126) *factor* $(x^2+7x+12)$ *factor* $(x^2+2xh+h^2)$
  Be sure to include a multiplication symbol between *x* and *h*.
  Otherwise, your calculator views *xh* as a new variable.

- Would you like to **FOIL**?
  Try: *expand* $((x+3)\cdot(x+4))$ *expand* $((x+h)\cdot(x+h))$
  Don't retype. Just grab the expressions. Wow!

- Let's **solve equations**.
  Try: *solve* $(3x+7=12, x)$ *solve* $(t^2=9, t)$ *solve* $(a\cdot x+b=c, x)$
  You can solve for any variable. For example, replace the final *x* with *b*. What results?

- Does your calculator know the **quadratic formula**?
  Try: *solve* $(ax^2+bx+c=0, x)$
  Remember to include a multiplication symbol between multiplied variables.

- Shall we solve a **system of equations**?
  Try: *solve* $(2x+y=10\, and\ y-x=1, x)$
  Find *and* in *math-test* or from the catalog.
  Imagine the possibilities here!

Trigonometry

- How does your calculator handle **periodic solutions**?
  Try: *solve* $(\cos(x)=1, x)$
  Notice the @n1 symbol. It represents an integer constant, like *n*.

- Suppose we want only those solutions in a **specific domain**.
  Try: *solve* $(\cos(x)=\frac{1}{2}, x) \mid 0 \le x\, and\ x \le 2\pi$
  Find the | symbol on your keypad.

- We can create our own **custom operations**.
  Let's create a new operation: $\cos(x)\cdot\sin(x) \to fun(x)$. Type the letters f-u-n.
  You'll now find your new fun operation in *var-link* in the main folder.

- Just for fun, move this new operation to your *practice* folder.
  Put a check mark by it (F4), then move it (F1).
  Then, from your home screen, select it in *var-link* to evaluate $fun(\frac{\pi}{3})$.
  Is the result correct?

Limits

- Does your calculator recognize the limit at a hole? You bet it does.
  To evaluate $\lim_{x\to 5}\frac{x^2-3x-10}{x-5}$, type: $\text{limit}((x^2-3x-10)/(x-5),x,5)$
  Find the limit command in F3.
  Confirm the answer by hand. You *do* know how to simplify the quotient, don't you?

- Does your calculator recognize vertical asymptotes?
  Evaluate: $\lim_{x\to -1}\frac{x^2-3x+2}{x+1}$

- What about limits as x approaches infinity (horizontal asymptotes)?
  Try: $\lim_{x\to\infty}\frac{3x^2-5x+7}{8x^2+11}$ $\quad\lim_{x\to\infty}\frac{4x+8}{e^x}$ $\quad\lim_{x\to\infty}\frac{e^x}{x^2}$

Piecewise-Defined Functions

In Y=, notice that you have one hundred available functions!

- To graph $f(x)=\begin{cases}4\cos x & x\le 0\\ 4-x & x>0\end{cases}$ type: $y_1 = when(x\le 0, 4\cos x, 4-x)$
  Get *when* from the catalog.

  What your calculator reads is "when $x \le 0$, graph $4\cos x$; otherwise graph $4 - x$."
  Zoom standard provides a good viewing window.

- From your home screen, evaluate: $y1(-\frac{\pi}{4})$ $\quad y1(7)$ $\quad\lim_{x\to 0} y_1(x)$
  You can also do this quickly *without* your calculator. Try!

Geometric Series

Your calculator can evaluate *finite* and *infinite* series.

- To evaluate $\sum_{n=1}^{10}(\frac{1}{2})^n$ type: $\sum((1/2)\wedge n, n, 1, 10)$
  Find $\sum$ in F3.

- What value are we approaching as we add more and more terms?
  Evaluate $\sum_{n=0}^{\infty}(\frac{1}{2})^n$. Wow!

Derivatives

- Your calculator knows the **definition of the derivative**.
First, store $x^2 + 3x$ as $f(x)$.

- Evaluate: $\lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$.
Remember to wrap your numerator in parentheses. What results?

- Your calculator knows how to **differentiate.**
Try: $d(f(x), x)$ $d(\sin(5t), t)$ $d(w^2 \cdot e^{3w}, w)$ $d((t+1)/\sin(t), t)$
The derivative symbol *d* is in F3 and also above the 8.

- Would you like the **second derivative**?
Try: $d(f(x), x, 2)$.
Remember, you can grab an edit previous entries.

- You can **evaluate derivatives** at any location along a function.
Try: $d(f(x), x) \mid x = 4$

  Let's locate where the derivative of a function equals zero on a closed interval.
Try: $solve(d(\sin x, x) = 0, x) \mid \pi \le x\, and\; x \le 2\pi$

  Now use the second derivative to determine whether you are at a maximum or minimum:
Try: $d(\sin x, x, 2) \mid x = \frac{3\pi}{2}$
What can you conclude?

- Do you still have your piecewise function in $y_1(x)$?
Try: $d(y1(x), x) \mid x = -\frac{\pi}{3}$ $d(y1(x), x) \mid x = 3$ $d(y1(x), x) \mid x = 0$ Why?
Try: $d(y1(x), x)$ What do you notice?

- Would you like to see a **graph of the** piecewise function's **derivative**?
In Y=, type: $y_3(x) = d(y1(x), x)$ and use *style* to make it dotted.
Graph it. Wow!

Integrals

Yes, your calculator can **integrate**, too.

- Let's find an anti-derivative. Evaluate $\int x^2 \cdot dx$ by typing $\int(x^2, x)$
  The integral symbol is in F3 and above 7.
- Evaluate a definite integral, such as $\int_1^4 x^2 \cdot dx$ this way: $\int(x^2, x, 1, 4)$
- Can your calculator handle integrating by parts? Try: $\int x^2 \cdot e^x \cdot dx$
- Use your solver to find the *k*-value such that $\int_1^k \frac{1}{x} \cdot dx = 1$.
  Can you confirm your result with calculus? Try!

Many calculus operations are also available when you view a graph. Just look in F5.

Taylor Series

Your calculator can construct a function's **Taylor Series**. Look in F3.

- If you want, for example, the fourth degree series for e^x centered at $x = 0$:
  $taylor(e^x, x, 4, 0)$
  The calculator writes the series backward and simplifies factorials.
- Let's evaluate the error that results from using that series to estimate e^2:
  Try: $e^x - taylor(e^x, x, 4, 0) \mid x = 2$
  Remember that you can grab and paste items, rather than retype them.
- Can your calculator integrate a Taylor Series?
  Try: $\int(taylor(\sin(x^2), x, 11, 0), x)$

$\sin x =$

Confirm your answer by hand: $\sin(x^2) =$

$\int_0^x \sin(x^2) \cdot dx =$

Graphing in Three Dimensions

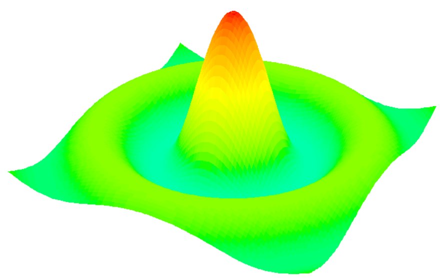
Let's graph some three dimensional surfaces.
First change your graph mode to 3D.

- Let's graph the paraboloid $z = \frac{1}{10}(x^2 + y^2)$. Do it this way:
  Go to Y= and type your function into z_1.
  Notice that the domain is now (x, y) and the range is z.
  Select Zoom Standard. Be patient – the calculator's working hard!

- Play with the graph's format: F1, ninth choice.
  I happen to like hidden surface, with the axes either boxed or off.

- Graph the surface shown below.
  It's a three-dimensional sine wave that dampens as it moves away from the origin:
  Place it in z_2. A good viewing window is: $-3 \le x \le 3, -3 \le y \le 3, -3 \le z \le 3$

$$h(x, y) = \frac{\sin(3\sqrt{x^2 + y^2})}{\sqrt{x^2 + y^2}}$$



- Hit F4 and watch the surface get re-graphed.
  Wow!

- You can rotate surfaces with the arrow buttons. Try it!

- This surface has a hole at $(x, y) = (0,0)$.
  Evaluate that limit from the home screen, by nesting two conventional limits:
  Type: limit(limit$(z2(x, y), x, 0), y, 0)$.

- At any point, this surface has different slopes in different directions.
  Those slopes are known as *partial derivatives*.
  From the home screen, evaluate partial derivatives at $(x, y) = (2,3)$ this way:
  $d(z1(x, y), x) \mid x = 2 \, and \; y = 3$
  $d(z1(x, y), y) \mid x = 2 \, and \; y = 3$
  } The results are two slopes on the paraboloid at the point (2,3)

- This surface captures volume over the *x*,*y* plane.
  Let's capture the volume under the paraboloid over the domain: $1 \le x \le 2$, $3 \le y \le 4$:
  We'll need to evaluate the *double integral*. $\int_{x=1}^{2} \int_{y=3}^{4} z_1(x, y) \cdot dy \cdot dx$
  Type it into your calculator as two nested integrals: $\int(\int(z1(x, y), y, 3, 4), x, 1, 2)$