Graphing Calculator Workshop

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POWER ON/OFF

• Press ON to turn on calculator.
• Press 2nd OFF to turn off calculator.

SCREEN CONTRAST

• Press 1 7
• Press 2nd △ to make screen darker.
• Press 2nd □ to make screen lighter.

KEY STRUCTURE

• Press 2nd LOG to get $10^x$ on the screen.
• Press [ALPHA] LOG to get N on the screen.
• Press CLEAR.

MODE

• Press MODE. The selected items are the highlighted ones. To select a specific item, use arrow keys to highlight the item. To activate the selection, press ENTER.
HOME SCREEN/SCIENTIFIC CALCULATOR

- Press 2nd QUIT to arrive at the Home Screen.

- Calculate: 
  
  \[ -e\sqrt{17} + \pi^3 - \left| \frac{17.2^2 - 296}{3.4} \right| \]

- Press \((-)\) 2nd e 2nd \(\sqrt{17}\) 1 7 + 2nd \(\pi\) \(\wedge\) 3 \(-\) \(\text{MATH}\) NUM abs 1 1 7 3 \(\div\) ( 3 \(\times\) 4 ) \[\text{ENTER}\).

What you should see on the home screen:

\[ -e\sqrt{17} + \pi^3 - \left| (17.2^2 - 296)/(3 \times 4) \right| \]

- Your answer should be 19.78518025. NOTE: \((-)\) is for negation and \((-\) is for subtraction.

ALGEBRAIC EXPRESSIONS and FUNCTIONS

PROBLEM: Let \(f(x) = x^3 - 4x^2 + 4x + 2\). Find \(f(\pi^2)\).

- Press \(\text{Y=}\) to go to the Function Screen. Note that your cursor is at the \(Y_1\) = line. Press \(\text{CLEAR}\) if necessary.

- Enter the expression \(x^3 - 4x^2 + 4x + 2\), i.e. key in \(Y_1 = X^3 - 4X^2 + 4X + 2\).

- Press 2nd QUIT to return to the Home Screen. Press \(\text{CLEAR}\) to erase the Home Screen.

- Enter \(Y_1\) variable on the Home Screen by pressing \(\text{VARS Y-VARS Function} Y_1 \[\text{ENTER}\).

- Evaluate \(Y_1\) at \(\pi^2\) by typing \(Y_1(\pi^2)\). Press \(\text{ENTER}\).

- Answer: 613.231247

GRAPHING FUNCTIONS

PROBLEM: Graph: \(f(x) = x^2 + 2\) and \(g(x) = (f(x))^{1/3}\).

- Press \(\text{Y=}\) to go to the Function Screen.

- Key in \(Y_1 = X^2 + 2, Y_2 = (Y_1)^{(1/3)}\).

- Press \(\text{ZOOM ZStandard (or press ZOOM 6)}\). Set the window size and graph.
• \( \text{ZOOM Zstandard} \) sets \( X \)-values and \( Y \)-values as \( X_{\text{min}} = -10 \) and \( X_{\text{max}} = 10 \), i.e., \(-10 \leq X \leq 10 \) and \( Y_{\text{min}} = -10 \) and \( Y_{\text{max}} = 10 \), i.e., \(-10 \leq Y \leq 10 \).

**USING THE TRACE FEATURE**

• Using the same function in \( Y_1 \) as above, press \( \text{TRACE} \). Move cursor to the right and left using the right and left arrow keys. Move from the graph of one function to another by using the up and down arrow keys. The function being traced is indicated by the number in the upper-right corner. (1 = \( Y_1 \), 2 = \( Y_2 \), etc.).

• Move cursor until \( X = 14893617 \).

• \( Y = 4.2181983 \) corresponds to \( Y_1(14893617) \).

• Press \( \text{ZOOM ZDecimal} \) (or \( \text{ZOOM 4} \)).

• You have changed the WINDOW to \(-4.7 \leq X \leq 4.7 \) and \(-3.1 \leq Y \leq 3.1 \).

• Press \( \text{TRACE} \). Move cursor until \( X = .6 \) to find that \( Y_1(.6) = 2.36 \).

**FINDING ROOTS, INTERSECTIONS AND EXTREMA**

PROBLEM: Graph: \( Y_1 = X^{3.1} + 1.5X^{1.9} - 3X^{0.7} \). Find the roots.

1. Change Window to \( 0 \leq X \leq 1.88 \) and \(-3.1 \leq Y \leq 3.1 \) \( \text{GRAPH} \).
2. Press \( \text{2nd CALC zero} \) (or \( \text{2nd CALC 2} \)).
3. Move cursor to the left of the root; press \( \text{ENTER} \).
4. Move cursor to the right of the root; press \( \text{ENTER} \).
5. Move cursor close to the root; press \( \text{ENTER} \).
6. The bottom of the screen should read \( X = 1.113302 \) \( Y = 0 \).
7. (The \( X \) value may be accurate to only 5 decimal places.)

PROBLEM: Graph: \( Y_1 = X^{3.1} + 1.5X^{1.9} - 3X^{0.7} \) and \( Y_2 = X - 1 \). Find the intersection points.

1. Press \( \text{2nd CALC intersect} \) (or \( \text{2nd CALC 5} \)).
2. Press \( \text{ENTER} \) to indicate the first curve.
3. Press \( \text{ENTER} \) to indicate the second curve.
4. Move cursor to the left most intersection point; Press [ENTER].

5. The bottom of the screen should read $x = .17462943$, $y = -.8253706$ for the left most intersection point. Repeat the same process to find the second intersection point.

PROBLEM: Graph: $y_1 = x^3(3.1) + 1.5x^2(1.9) - 3x^0(0.7)$. Find the minimum point.

- **Method 1: Using [ZOOM]**
  1. Change Window to $0 \leq x \leq 1.88$ and $-3.1 \leq y \leq 3.1$.
  2. Use [ZOOM] key to get approximate answer. Zoom again and again until answer with the desired accuracy is obtained.

- **Method 2: Using [2nd] CALC**
  1. Change Window to $0 \leq x \leq 1.88$ and $-3.1 \leq y \leq 3.1$.
  2. Press [2nd] CALC minimum (or [2nd] CALC [3]).
  3. Move cursor to the left of the minimum point; press [ENTER].
  4. Move cursor to the right of the minimum point; press [ENTER].
  5. Move cursor close to the minimum point; press [ENTER].
  6. The bottom of the screen should read $x = .54532248$, $y = -1.335785$.

- **Method 3: Using the TABLE**
  1. [2nd] TblSet Set TblStart = 0 and $\Delta$Tbl = .1. (Note that for the TI-83, TblStart is called TblMin.)
  2. [2nd] TABLE Use up and down arrow keys to check through the $y_1$-values. Note that the minimum occurs for $0.54 \leq x \leq 0.55$.
  3. [2nd] TblSet Set TblStart = .5 and $\Delta$Tbl = .01.
  4. [2nd] TABLE Use up and down arrow keys to check through the $y_1$-values. Note that the minimum occurs for $0.54 \leq x \leq 0.55$.
  5. [2nd] TblSet Set TblStart = .54 and $\Delta$Tbl = .001.
  6. Continue until you get the accuracy that you need.

**FINDING THE GRAPH: DETERMINING THE WINDOW**

PROBLEM: Graph and find minimum value of $y_1 = .0045e^x - 89x + 987$ for $0 \leq x \leq 20$.

- Press [WINDOW]. Change the window to $0 \leq x \leq 20$, $-10 \leq y \leq 10$. 
• Press **(GRAPH)** and we get a blank screen! What to do?
• Use **(TRACE)** to get $Y_1 = 196.1190961$. Now we have a ball-park idea of the range.
• Change window to $100 \leq Y \leq 300$, $Y_{\text{sc1}} = 0$.
• Find minimum value using **(2nd) CALC**.
• Answer: $X = 9.892312$, $Y = 195.58403$.

**GRAPHS WITH HOLES**

• Graph: $f(x) = \frac{x^2 - 1}{x - 1}$ using **(ZOOM) ZDecimal**.

• Screen Display:

![Graph of $f(x) = \frac{x^2 - 1}{x - 1}$](image)

• Use **(TRACE)** to obtain the $Y$-value when $X = 1$.

• Comment: This illustrates that $f(x) = \frac{x^2 - 1}{x - 1}$ and $g(x) = x + 1$ are **not** the same function because $f(1)$ is undefined and $g(1) = 2$ is defined. This shows that the two functions have different domains.

• Another approach is to use the table feature. Key in **(2nd) TblSet**. Set TblStart = 1 and $\Delta \text{Tbl} = .01$. Note that at $X = 1$ the $Y_1$ value is shown as ERROR. Use the up and down arrow keys to analyze the behavior of $Y_1$ near $X = 1$.

**GRAPHING PIECEWISE-DEFINED FUNCTIONS**

**PROBLEM:** Graph the piecewise-defined function

$$f(x) = \begin{cases} 
.3e^{x^2} & x < 1 \\
2x - \frac{5}{2} & x \geq 1
\end{cases}$$
• In \[\underline{Y} = \text{graph } Y_1 = (0.3e^{-X^2})/(X < 1) \text{ and } Y_2 = (2X - 5/2)/(X \geq 1)\] using \textit{ZDecimal} window.

• Use \textit{TRACE} and \textit{TABLE} to obtain the \(Y\)-values for \(X = -1, 0, 1, 2\).

**PROBLEM:** Graph

\[
f(x) = \begin{cases} 
3x^2 - 1 & -2 \leq x < 2 \\
5 - x & 2 \leq x \leq 5 
\end{cases}
\]

• Where is the function increasing/decreasing? What is the largest value on \(-2 \leq x \leq 5\)?

• Hint: Graph \(Y_1 = (3X^2 - 1)/((-2 \leq X)(X < 2))\) and \(Y_2 = (5 - X)/(2 \leq X)(X \leq 5)\) on \(-3 \leq X \leq 6, -5 \leq Y \leq 15\).

**SOLVING INEQUALITIES**

**PROBLEM:** Solve \(.3e^{x^2} - 2 \leq 2x - 1\).

• Graph \(Y_1 = .3e^{-X^2} - 2\) and \(Y_2 = 2X - 1\) using \textit{ZDecimal} window.

• Screen Display:

• Find the coordinates of the left intersection point using \underline{2nd} \textit{CALC} \textit{intersect}. The answer: \(X = -0.3324686\) and \(Y = -1.664937\). Find the coordinates of the right intersection point. The answer: \(X = 1.6286884\) and \(Y = 2.2573769\).

• Solution to inequality: \(-0.3324686 \leq X \leq 1.6286884\). How does one check the answer?

• Shade between the two functions \(Y_1 = .3e^{-X^2} - 2\) and \(Y_2 = 2X - 1\). Key the \underline{Shade} entry under \underline{2nd} \textit{Draw} to get \textit{Shade} \((Y_1, Y_2)\) on the Home Screen. Press \underline{ENTER}.

• Screen Display:
• Do not erase the two equations in $Y_1$ and $Y_2$ from above. Another method to solve the
inequality is to graph $Y_1 = (.3e^{X^2}) - 2 - (2X - 1)$ using the ZDecimal window or graph $Y_3 = Y_1 - Y_2$.

• Screen Display:

![Graph of $Y_1$ and $Y_3$]

• Find the left root. Key the Zero (or Root) entry under CALC. Move cursor to left of
left root and press ENTER. Move cursor to right of left root and press ENTER. Move
cursor close to left root and press ENTER. Left Root: $X = -0.3324686, Y = 0$.

• Repeat above to find right root. $X = 1.6286884, Y = -4E - 13$.

• Answer: $-0.3324686 \leq X \leq 1.6286884$.

• EXERCISE: Write the solution of $|3x + 2| < 5$ in interval notation. Graph
$Y_1 = |3X + 2| < 5$ on ZDecimal Window. Look for where the graph is above the
x-axis. The answer: On the interval with approximate end points $(-2.4, 1)$.

• EXERCISE: What is the domain of $g(x) = \sqrt{4 - 6x + x^2}$? Hint: Graph
$h(x) = 4 - 6x + x^2$ and solve $4 - 6x + x^2 \geq 0$. 
COMPUTING A DERIVATIVE

PROBLEM: Compute the derivative of \( f(x) = \pi^{3x} \) at \( x = 1.9 \).

- Method 1:
  1. Graph \( Y_1 = \pi^{0.3x} \) using the zDecimal window.
  2. Press \( \text{2nd CALC 6} \) to get \( dy/dx \).
  3. Type in the number 1.9. Press \( \text{ENTER} \) to get \( dy/dx = 0.65947709 \).

- Method 2:
  1. Type \( Y_1 = \pi^{0.3x} \) into the \( Y= \) menu.
  2. Return to the Homescreen. Press \( \text{Math 8} \) so that \( \text{nDeriv(} \) appears on the screen.
  3. Type \( \text{nDeriv(} Y_1, X, 1.9) \).
  4. Press \( \text{ENTER} \) to get \( 0.6594770885 \).

TANGENT LINES

PROBLEM: Let \( f(x) = \sqrt{x+3} \). Find an equation of the line tangent to the graph of \( f \) at \( x = -1 \).

- Graph \( Y_1 = \sqrt{x+3} \) using the zDecimal window.
- Press \( \text{2nd DRAW 5} \) to select Tangent (). This will return you to the graph.
- Enter \(-1\) and press \( \text{ENTER} \).
- The calculator will draw the tangent line at \( x = -1 \) and give the equation of the tangent line in the form \( y = mx + b \) at the bottom of the screen.

COMPUTING A DEFINITE INTEGRAL

PROBLEM: Compute \( \int_{1.2}^{1.8} \pi^{3x} \, dx \)

- Method 1:
  1. Graph \( Y_1 = \pi^{0.3x} \) using the zDecimal window.
  2. Press \( \text{2nd CALC 7} \) to get \( \int f(x) \, dx \).
3. Type in $-1.2$ as the lower limit and press $\text{ENTER}$. Then type the upper limit $1.8$ and press $\text{ENTER}$ again.

4. The calculator will shade in the area under the graph between $x = -1.2$ and $x = 1.8$ and give the numeric value of the integral at the bottom of the screen.

\[ \int f(x)dx = 3.4746004 \]

• Method 2:

1. Enter $Y_1 = \pi \cdot (0.3x)$.
2. Press $\text{MATH} \{7\}$ to get $\text{fnInt(}$ on the screen.
3. Then type $\text{fnInt(}Y_1, x, -1.2, 1.8\text{)}$.
4. Press $\text{ENTER}$ to get $3.474600363$.

REGRESSION

PROBLEM: Consider the following population (in millions) data of the world.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>1650</td>
<td>1750</td>
<td>1860</td>
<td>2070</td>
<td>2300</td>
<td>2520</td>
<td>3020</td>
<td>3700</td>
<td>4450</td>
<td>5300</td>
<td>6100</td>
</tr>
</tbody>
</table>

Graph as a scattered plot. Use regression to find an exponential model and cubic model for population growth.

- To enter the data in the lists, press $\text{STAT EDIT Edit}$. Enter the years in L1 and the populations in L2. Press $\text{2nd STAT PLOT ENTER}$. Turn on plot; select the scatter plot from the pictures, L1 for $X$-list, L2 for $Y$-list, and a square for the mark. Key $\text{ZOOM } \text{ZoomStat}$ to get a scatter plot of the population growth in the world for the last century.
For the TI-83 Plus and TI-84: Press $\boxed{Y=}$. Clear $Y_1$ and $Y_2$. To find an exponential model, key the $\text{CALC}$ entry under $\boxed{\text{STAT}}$. Now key in $\text{ExpReg}$ (which sends you back to the Home Screen); press $L_1 \ (\rightarrow) \ L_2 \ (\rightarrow) \ Y_1$. The Home Screen should look like this:

$\text{ExpReg} \ L_1, L_2, Y_1$

Press $\boxed{\text{ENTER}}$.

The Home Screen should read:

$y = a \times b^x$

$a = 7.7913892E - 9$

$b = 1.01374896$

$r^2 = .9693660871$

$r = .984563907.$

Press $\boxed{Y=}$. Note that $Y_1 = (7.7913892195333E - 9)(1.0137489599052) \times X$. The equation for the regression line has automatically been entered into $Y_1$. Press $\boxed{\text{GRAPH}}$ and note how closely the exponential model reflects the data.

For the TI-83: Press $\boxed{Y=}$. Clear $Y_1$ and $Y_2$. To find an exponential model, key the $\text{CALC}$ entry under $\boxed{\text{STAT}}$. Now key in $\text{ExpReg}$ (which sends you back to the home screen); press $L_1 \ (\rightarrow) \ L_2$. Your Home Screen should read

$\text{ExpReg} \ L_1, L_2$

Press $\boxed{\text{ENTER}}$.

The Home Screen should show the same information as above.

To graph the regression equation on the TI-83, go to $Y_1$; press $\boxed{\text{VARS}}$ Statistics EQ $\text{RegEq}$. Press $\boxed{\text{ENTER}}$. The regression equation will be automatically entered into $Y_1 = \cdot$. Press $\boxed{\text{GRAPH}}$ and note how closely the exponential model reflects the data.

To find a cubic model, key the $\text{CALC}$ entry under $\boxed{\text{STAT}}$. Now key in $\text{CubicReg}$ (back to the home screen) then repeat the above.

Be sure to turn plots off after graphing a statistical plot so that your calculator is returned to function graphing mode. This can be accomplished by pressing $\boxed{2nd} \ Y= \ \text{STATPLOT} \ \boxed{\text{ENTER}}$. Select the plot that is on, select off with the arrow key, then press $\boxed{\text{ENTER}}$. 

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