CALCULATOR
QUICK REFERENCE GUIDE
and INSTRUCTIONS

TI-89 Titanium

TI-VOYAGE 200

TI-89

BASICS

Green diamond: use for items in <u>green</u> above a key

2nd: use for items in <u>blue</u> above a key(Voyage and 89Titanium) (89-<u>yellow</u>)

alpha: use for items in <u>white</u> above key:89Titanium, <u>purple</u>: 89, (pressing TWICE is
        alpha-LOCK --press again to undo) Voyage: no alpha, use keyboard

White Up Arrow (89 :between 2nd and ESC, Voyage: above ON)-- Capital letters
        (Capital lock on Voyage: use 2nd, Z)

Function keys: F1-F5 below screen, F6-F8 are 2nd F1-F3
        (Voyage—all 8 below screen, —all 8 beside screen)

APPS: Data/Matrix, Numeric Solver, etc. With OS 2.08 or later, screen will look like a
        Windows desktop, with Icons. These are turned on and off in MODE, F3.

←   use for backspace, typing over previous items to left.

DEL (Green diamond ←):   for delete, takes away from right side

INS (2nd ←): toggles between insert mode & type-over mode. If cursor is thin: insert. If
        cursor is a block: type-over.

STO: above ON (Voyage: left of spacebar)
        AVOID storing to one letter, especially x, a, b, n
        NOTE: ab will NOT be interpreted as a times b, but as a variable "ab"
        There is an <u>8 character limit</u>

CLEAR: clears command line, but not home screen

Clear Home screen: F1, 8 (be careful if previous entries are needed later)

Powers: use the ^ key

Roots: use ^(1/n), where n is the index of the root (3 for cube root, etc.) The square
        root key is 2nd of multiply key

Screen Adjustment
        Darken: Green diamond, Add
        Lighten: Green diamond, Subtract

Home Screen
        Key below Green diamond key (Voyage—Green diamond, Q)
        Use for computations, defining functions, solving equations, etc.

Operating System: F1, A (scroll down on TI-89)

Basic arithmetic calculations: calculator uses correct order of operations. You will
        need to put extra parentheses in sometimes (around numerators and
        denominators of fractions, around powers like 1/3 or 5x, etc.)

Quick Edit
        Copy: Green diamond, White Up arrow key (Voyage—Green diamond, C)
        Cut: Green diamond, 2nd   (Voyage—Green diamond, X)
        Paste: Green diamond, ESC (Voyage—Green diamond, V)

TblSet: Green diamond, F4 (Voyage—Green diamond, T)
        tblStart: first x (independent value) Note: works IF Ind=Auto AND Gr<>Tab=Off
        Δtbl: incremental change between successive x values
        Independent=AUTO
                Graph<->Table=OFF: table fills automatically, using all checked y='s
                Graph<->Table=ON: fills based on <u>window settings</u>, using all checked y='s
        Independent=ASK—lets you build the table manually, with specific x values

Table: Green diamond, F5 (Voyage—Green diamond, Y)
        Use TblSet FIRST.   To see more decimal places, highlight y-value (use cursors)
                OR change Cell width (F1, 9—Format)

MODE
    Page 1 (F1)
        Graph: Function (default), and others (Polar, Parametric, etc.)
        Current Folder: main
        Display digits: <u>plain</u> *Float* is best (or you can set specific rounding with Fix)
        Exponential Format: Normal (Engineering is nice for metric)
        Pretty Print: <u>ON</u> (then you will see $\sqrt{\ }$, π, etc.)
    Page 2 (F2)
        Split Screen (nice for Voyage but very small on TI-89)
        Exact vs. Approx: set your calculator in "<u>auto</u>", then use Green diamond, Enter,
            for decimal approximation when desired
        Base: Decimal, hexadecimal and binary are available
    Page 3 (F3)
        Units: SI, English/US, or Custom Available

CATALOG (TI-89—key below APPS, Voyage—2nd, 2)
        Move with cursors to desired entry
              --look at bottom of screen for syntax on most choices
              --press Enter, to bring back to Home, or y =, etc.
              --press Escape, to exit catalog without a selection
        <u>Faster</u> movement through catalog
              --press key with first letter of desired entry (NO Alpha necesssary)
              --2nd up arrow or 2nd down arrow for page

MEMORY MANAGEMENT
        Go to VAR-LINK (2nd of subtract key)
        Check any items to manage first, using F4 (checks and unchecks)
        F1(Manage), 1 (Delete)—eliminates all checked items
        F1, 3 (Rename)—one item at a time
        F1, 6 or 7—lock and unlock checked items
        F6 (Contents)—useful if there is something in the list that you don't
              recognize. Arrow down to item (don't need check) and press F6

TRANSFERRING to another TI-89 or Voyage (go to VAR-LINK—2nd, Subtract)
    Plug link cable between calculators, making sure it is <u>pressed in all the way</u>

    Sender: with arrow keys, move to whatever you want to send, and
                 check it by using F4 (you can send more than one)
    Receiver: press F3, 2(Receive)
    Sender: press F3, 1(Send)

  NOTES: *FLASH APPS* (send by checking in F7, THEN F3 to receive/send)
                  (Polynomial Root Finder, Stats/List package, Finance,
                    Simultaneous Equation Solver, EE200 Demo, …)
                 OPERATING SYSTEM upgrade
                   Warn receiver to backup anything of importance—wipes all
                    Receiver uses F3, 5 (Receive OS or Product SW)
                    Sender uses F3, 4 (Send OS or Product SW)

UPDATING OPERATING SYSTEM and INSTALLING FLASH APPS

A) TI-Connect Software
This is the fastest/easiest way to update operating system and download flash apps. Connect your calculator to the computer, using the USB link cable.
  NOTE: this is NOT the small black link cable that is used to transfer between calculators.

Operating System
- To see which version you have currently installed on your calculator, go to HOME, F1(Tools), A (About) or APPS screen, F1, 3.
- Open TI-Connect (double-click on desktop icon on your computer screen)
- Click on "Updates" button, top right
- Click on "Check for newer operating system", "Continue"
- If you have the most current OS, a message will display—otherwise, click on the newer version of OS that comes up in the display box, click on "download the software to my device", "Continue"
- Log in—if this is your first time, you can set up your account at this time
- Click on "Download"
- You should see: a) your files being backed up b) the new OS loading c) your files being restored

Flash Apps
<u>Getting the File</u>
- Open TI-Connect, click on "Shop" button, at top
- At TI site, click on "United States", "Continue", "English", "Continue", then click on your calculator type, from list at left
- Choose "Apps/Software"
- Look through the list to see what you would like—most are free, including: Polynomial Root Finder, Finance, Stats/List Editor, Simultaneous Equation Solver, Cabri Geometry, Geometer's Sketchpad, Calculus Tools, Organizer (Calendar, Contacts, Planner, Tasks),US Presidents
- "More info" will give you details on the flash app, "download" will let you save the file on your computer (you might want to create a download folder)

<u>Loading the File on your Calculator</u>
- Open TI-Connect, click on "TI-Device Explorer" button at left
- Click on Windows Explorer (far right on icon bar). Locate the flash app program in the folder where it was saved—click to highlight
- Go to FILE (top left), choose Send To, Connected TI Device, RAM
- After searching, you should see the transfer taking place, and when finished, the new icon should be displayed on your calculator applications desktop

B) Between Calculators
See "Transferring…" in the BASICS section of this handbook
OS: requires EXACTLY the same calculator. Programs: some yes, some no

GRAPHING

1. Enter Equation in y=
TI-89: Green diamond, F1. The x key is below the HOME key.
Voyage: Green diamond, W.   Use x from the keyboard.
Note: Even if you are in a mode other than function (3d, polar, etc.), you will still access the equation menu through the y= key.

2. Set Window for viewing the graph
TI-89: Green diamond, F2
Voyage: Green diamond, E
Note: If the resolution (xres) accidentally gets erased or changed, default is 2.

3. To make sure the curve will actually graph:
In y =, make sure there is a check mark beside your equation. F4 is on/off toggle.

4. Graph Equation
TI-89: Green diamond, F3
Voyage: Green diamond, R

5. Zooming
F2 in y = menu and Graph menu
Zoom Box (1)
Nice for looking at a portion of the graph that would fit in a desired rectangle. To use, move the cursor with the left and right arrow keys to the desired upper left corner and press enter. Again, use the arrow keys to move to the desired lower right corner (you should see a box forming) and press enter.
Zoom Square (5)
Corrects distortion from your window setting choices.
Zoom Standard (6)
Basic horizontal and vertical settings from -10 to 10.
Zoom Trig (7)
Useful for a quick trig function window.
Zoom Data (9—arrow down on TI-89)
Very nice when you are working with a data set, so you don't have to set the xmin, xmax, etc. A good window comes up that displays all data points.
Zoom Fit (A—arrow down on TI-89)
Good for helping with the ymin and ymax, when you only know the xmin and xmax that you want to use, but are not sure about the vertical values.
Memory, Zoom Previous (B,1—arrow down on TI-89)
Goes back.

6. Saving a Graphical Database
F1 in y = menu and Graph menu. This feature is nice if you have worked to find a good window for something you want to use in the future. It saves all of the equations currently in the y =, plus the window settings.

7. MATH tab
F5 in Graph menu
After graphing, the following will give more accurate results than tracing:
Value (1) Evaluates the function at a desired x-value.
  Type number, press Enter.
Zero (2) Find x-intercepts, <u>one at a time</u>.
  Move with arrows before intercept, ENTER, move past intercept, ENTER.
Local Minimum (3) Find a relative low point.
  Move with arrows to left of low point, ENTER, to right of low point, ENTER.
Local Maximum (4) Find a relative high point.
  Move with arrows to left of high point, ENTER, to right of high point, ENTER.
Intersection of two curves (5)
  If only two are graphed, press enter twice (yes, 1st curve, yes, 2nd curve). If more are graphed, use up/down arrows and watch equation number in upper right (or where cursor is blinking), then Enter for appropriate choices. Finally, move with arrows to before they cross, ENTER, to after they cross, ENTER.

8. Presentation of Graph Screen
Note: You must <u>press Enter to Save</u> all changes
- In Graph or y = menu, use F1, 9 (Format) —(arrow down on TI-89):
  Coordinates On(Rectangular or Polar) or Off: Usually on Rect.
   Graph Order: When graphing more than one curve, choose one after the other (Seq) or all at once (Simul).
  Grid On or Off: Usually Off. On makes it look like graph paper.
  Axes On or Off: Usually On. "Off" feature nice for polar graphs (roses, spirals, etc.)
- In y = menu, F6:
  Style of curve-- Arrow down to choice and F4 to check:
     Line, dot, square, thick--when graphing several equations, this feature lets you make a distinction between them.
    Animate--to see if one equation is equivalent to another, use Line for one equation and Animate for other—easy to see if one graphs over the other.
    Above or Below—to shade above or below a line

9. Common Problems
- Graph does not appear on screen after pressing the Graph choice.
  a) Is the equation selected? See section 3 above.
  b) Could the graph be outside the window you have chosen?
       Zoom Out (F2, 3) or change the window settings (see section 2)
- Error message when trying to graph
  a) The most common reason is that a Plot is turned on and there may be a problem with the data it is trying to use. If any Plots are checked, uncheck them with F4. (Plots are above y1=)
  b) There may be an error in your formula. Check that:
       i) you are using the appropriate variable (x, for function mode).
       ii) subtract versus negative keys are being used appropriately.
       iii) there are a matching number of right and left parentheses.
  c) There may be a problem with your window— xmin larger than xmax, xmin=xmax, etc. Also, negative key, not subtract. Check and correct.

NUMERIC SOLVER

Numeric Solver Icon (f(x)=0) on the APPS desktop (or APPS, 9)

The numeric solver is most useful for equations that have several variables and/or you will be using the equation repeatedly with different values.

Procedure:
- Type in the equation, without substituting any known values. Make sure you have added any necessary parentheses, multiplication signs between variables, etc., especially between a variable and parentheses (example: x(x + 3) would not be interpreted as a multiplication, but as a <u>function x</u> with x+3 replacing all input variable positions). A list of the variables will come up *after you press enter.* This allows you to answer a variety of questions, by substituting all known values, leaving one that is unknown. Move the cursor to the one that you are looking for and: a) clear the value or b) type in a guess value.
- Press Solve (F2) while the cursor is located at the variable with the unknown value.

Notes:
- On the numeric solver, you will only get one answer at a time. If you think that there are more answers, you must input a guess away from the value that was found. For example, the calculator gives a solution of n = 2.5. You might clear that value and type in a guess of 5 (or –3)…a number that is either larger or smaller than the answer found. For equations with only two variables, the graph can be helpful as a guide to how many solutions are expected.
- If a formula has variables that are similar (say n and N, for example), the numeric solver <u>doesn't distinguish</u> between lower and uppercase. You will need to change one to a different variable, and keep track of the change.

SYMBOLIC SOLVER

At the HOME screen, choose F2, 1. The syntax is: solve(*equation*, *variable*).
- The most common errors are:
    a) entering an <u>expression</u> instead of <u>equation</u>
    b) forgetting the <u>variable to solve for</u> (even if it is obvious, when there is only one)
- The symbolic solver is typically used to:
    a) <u>rearrange</u> an equation to be solved for a different variable
    b) <u>get exact solutions</u> if possible, instead of approximate (from numeric solver)
- To use the solve command, with values assigned to some variables, the "such that" bar is used AFTER the parentheses. (TI-89: below the = key, Voyage: 2nd ,K)

    Example: solve(x+y-z=4,y)| x=3 and z=1

UNITS and CONVERSION

Menu: 2nd, 3 (TI-89)   or Green diamond P (Voyage)
Category: know where the units would be located
    Examples: a) feet would be found under "Length"
                   b) gallons would be found under "Volume"
                   c) hours would be found under "Time"
Abbreviation: recognize what is being used for the units
    Examples: a) feet is represented by   _ft
                   b) gallons is represented by   _gal
                   c) hours is represented by   _hr
Missing Units: can be created
    Examples: a) there is no "feet per second" in the "Velocity" section
                   Find _ft in "Length" and _s in "Time". Using a divide between
                   them, feet per second is represented by _ft/_s
                 b) there is no "square feet" in the "Area" section.
                   Use _ft^2
Typing Directly: without using units menu, use alpha letters with _ symbol, found at
    Green diamond, MODE (TI-89)   or 2nd P (Voyage)
►(**Symbol for Conversion**): 2nd MODE (TI-89)   or 2nd Y (Voyage)
    Example: To convert 5 inches to cm, you would type
$$5\_in \blacktriangleright \_cm \quad \text{Enter}$$

FUNCTIONS

Defining: HOME screen, F4, 1
- type your function on the command line, using correct function notation.
    Example: Define areacirc(r)$=\pi * r \wedge 2$
- "Done" in the window means you can now use your function. Since the
    formula was for area of a circle with radius r, you can find the area of a
    circle with radius 5 by typing: areacirc(5)
- Avoid using x as the input variable, except in the graph (see below)
- Function name is limited to **8** characters
- Multivariable functions can be defined, also
    Example: Define   volucone(r,h)$=(1/3)*\pi*r\wedge2*h$

Graphing
You can graph a function of one variable, just change the input to x. Using the example
above: y1=areacirc(x)

Composition
Notation is the same as if doing by hand. Works for both values and expressions.
    Examples: f(g(m))   h(g(2))   f(h(w+3))

SOLVING SYSTEMS OF EQUATIONS

There are <u>several options</u> for solving systems of equations.
Look at the requirements for each method to see which will be best for a particular system.

Graphically
- 2 equations, 2 variables
- Equations <u>do not have to be</u> LINEAR
- Both equations must be <u>solved for y</u> (or other dependent variable)
- Enter the two equations in y= menu. Set up a good window, where the point of intersection is visible. Use F5 (Math), 5—Intersection. Cursor will blink on one curve—press Enter. Cursor will blink on the other curve—press Enter. Use left/right arrows to move cursor BEFORE the point of intersection and press Enter. Move cursor AFTER the point of intersection and press Enter. The coordinates of the point of intersection will be displayed.

Simultaneous Equation Solver
- This is a Flash Application
- Equations must all be LINEAR and in STANDARD FORM
    Example: $3x + 5y = 14$
                  $5x - 2y = -18$
- Choose 3, New, unless you are working with a system used previously
- Enter number of equations, arrow down, enter number of variables, enter
- Column a1 is for the coefficients on the first variable, column a2 is for the coefficients on the second variable, and b1 is for the constants on the right side of the equations. (b2, b3, etc., let you solve systems with the same variable coefficients but different constants)
- Press F5(solve). If there is a Unique solution, the value for each variable will be displayed. If there is No solution, "no solution found" displays. If there are Infinitely many solutions, a parameterized solution is displayed, using the @ symbol.

Simult command
- In catalog, or Math menu(2nd 5) 4, 5, or type alpha letters
- Equations must all be LINEAR and in STANDARD FORM
- Using the example listed above, at the HOME command line, type:
                simult([3,5;5,-2],[14;-18])
    Notes: a) the square brackets are 2nd, comma key and 2nd, divide key
                b) inside the brackets, note that the semicolon separates rows
                    (TI-89: 2nd 9, Voyage: 2nd M)
- Screen display: $\text{simult}\left(\begin{bmatrix} 3 & 5 \\ 5 & -2 \end{bmatrix}, \begin{bmatrix} 14 \\ -18 \end{bmatrix}\right)$ $\begin{bmatrix} -2 \\ 4 \end{bmatrix}$

- Interpretation: the left display shows the system representation, and the right display means that x = -2 and y = 4

Solve command
- Equations <u>don't have to be Linear</u>
- Equations <u>don't have to be in any particular form</u>
- Using the same example, at the HOME screen command line type:
  solve(3x + 5y =14 and 5x - 2y = -18, {x,y})

  Notes: a) "solve" is the first choice in the F2 Algebra menu
  b) using "and" from the catalog will come with the necessary
  spaces before and after the word
  c) the braces { } are 2nd of the parentheses keys

- Screen display: x = -2 and y = 4   (no interpretation necessary!)

  The system in the example had a Unique solution. If there was No
  solution, "false" would display. If there were Infinitely many
  solutions, a parameterized solution is displayed, using the @ symbol.

Matrix Representation
  (these instructions are for systems with # of Equations = # of Variables)
- Equations must all be LINEAR and in STANDARD FORM
- Data/Matrix Editor on APPS desktop (or APPS,6)
- 3 (New--unless same system used previously):
  Use the right arrow to change from Data to <u>Matrix</u>, 2
  Down arrow to *variable*, name your matrix—something meaningful,
    like Prob4, or something like xyz (faster for TI-89)
  Down arrow to *row*: type in the number of equations
  Down arrow to *col*: type in <u>one more than the row number</u>. Enter twice
  Fill in the coefficients and constant for each equation, as rows.
- Go to HOME screen command line, and type: rref(*matrixname*)
- For the example used previously, the screen would display:

$$\text{rref}\left(\begin{bmatrix} 3 & 5 & 14 \\ 5 & -2 & -18 \end{bmatrix}\right) \qquad \begin{bmatrix} 1 & 0 & -2 \\ 0 & 1 & 4 \end{bmatrix}$$

  Interpretation: x = -2 and y = 4

  Notes: If the last row had been 0   0   0,   this would indicate
          "Infinitely Many Solutions"
          If the last row had been 0   0   *nonzero*   this would indicate
          "No Solution"

MATRICES

Enter Matrix
- Data/Matrix Icon on APPS desktop (or APPS, 6)
- Right arrow to change from Data to Matrix (2, or down arrow and Enter).
  <u>Arrow down</u> to *variable* and type in a meaningful name (up to 8 characters).
  It is best not to use a single letter to name a matrix. <u>Arrow down</u> to type in
  numbers for rows and columns, then Enter. Type in all values, then HOME.
- It is a good idea to take a look at the matrix, to spot any typos. At the home screen,
  type the name of the matrix on the command line and press Enter.
  Inspect the matrix to see if it is correct before using.

Inverse of a Matrix
- Requirements: a) the matrix MUST BE SQUARE, n x n
                 <u>and</u> b) an associated system of equations with those variable
                      coefficients would have a UNIQUE solution
- Syntax: *matrixname*^-1
- If the matrix was not square, error message: "Dimension".
- If a square matrix was not invertible, error message: "Singular matrix".

Determinant of a Matrix
- Requirement: the matrix MUST BE SQUARE, n x n
- Syntax: det(*matrixname*)

Transpose of a Matrix
- Math menu (2nd, 5), 4, 1
- Syntax: *matrixname*^{T}

Row Reduced Echelon Form
- Math menu, 4, 4, or type from keyboard
- Syntax: rref(*matrixname*)

Eigenvalues and Eigenvectors
- Math menu, 4, 9 (for values) or A (for vectors)   (TI-89, arrow down)
- Syntax: eigVl(*matrixname*) or eigVc(*matrixname*)
- The order of the eigenvalues will correspond to the order of the eigenvectors (which
  are the <u>columns</u> of the displayed matrix). The vectors are normalized.

Generate a Random Matrix
- Math menu, 4, E (TI-89, arrow down)
- Syntax: randMat(*number of rows, number of columns*)

PROGRAMMING

To get started: Program Editor Icon (:Prgm) on the APPS desktop (or APPS, 7)
                     New (the first time)

- Arrow down and type in a meaningful name (after *Variable:*) and Enter twice.
  The body of the program will be written between Prgm and EndPrgm.
- Each line will start after a colon (:), which is generated automatically.
- A good way to start is   :ClrIO   this clears the program IO screen (neater)
  Find this in the catalog.
- Disp is used often – for displaying something on the screen. Disp is found in
  F3 (I/O),2. Examples:
              :Disp " "   will give a blank line
              :Disp "hello"   will display **hello** on the screen
              :Disp A   will display the value stored in A, on the screen
- Output can be used to display something at a particular location. Output is
  found in F3 (I/O), 6. Example:
              :Output 20, 30, "Math"   will display **math** at down 20 right 30 position
  NOTE—Limits are approximately
       TI-89: down 65 right 150   Voyage: down 90 right 230
- Input is used to store a value entered from the keyboard.   Input is found in
  F3 (I/O),3. If you want a message to prompt the entry, put it in quotes. Examples:
              :Input P   the user will only see a **?**, and number entered stores as P
              :Input "Enter payment, in dollars", P   will be more helpful for the user
- Storing—Example: :C+3→B   stores 3 more than the value of C to B
- Toolbars build the tabs you see at the top of the Home screen. These are useful for
  choices in your program. ToolBar and EndTBar come as a set in F2(Control),1, 6.
  Title is in F2, 1, 7. Example:
              :Toolbar
              : Title "New",a2   displays a tab F1 , labeled New, and executes
                                           the command at label a2
              : Title "Quit", a5   displays a tab F2 , labeled Quit, and executes
                                           the command at label a5
              :EndTBar
- If-Then statements are inF2, 2. Example:
              :If num>10 Then
              : Disp "go"
              :ElseIf num<10 Then
              : Disp "stop"
              EndIf

       If the number stored to num was exactly 10, nothing would display and the
       program would continue executing whatever followed the EndIf