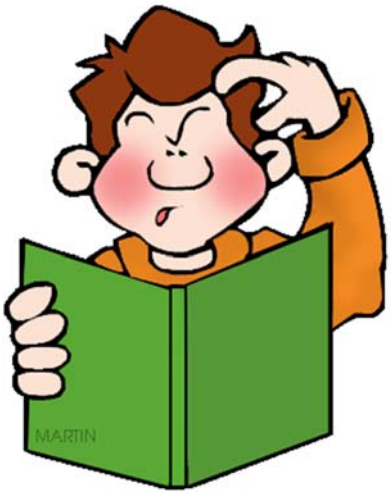
Using the

TI nSpire CX CAS Handheld

(www.mathguy.us)



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Using the TI nSpire CX CAS Handheld

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To move to a chapter, **[ctrl] click** on the Chapter Description above. Note: this works only in the Microsoft Word version of this document.

External Links

nSpire CX CAS manual is available at: https://education.ti.com/en/us/guidebook/details/en/502A552F7D6E4756A75BD8482FEB0E26/gettingstartedwiththeti-nspirecxhandheld. This document is TI's guide to using the nSpire CX CAS.

nSpire CX CAS Reference Guide is available at: https://education.ti.com/en/us/guidebook/details/en/3F30BA6FDA6F49608C44BB4B5F3746FA/ti-nspirecasreferenceguide-2. This document provides a list of keyboard functions available for use with the nSpire. It can be very useful.

TI Computer Link Software is available at: https://education.ti.com/en/us/software/details/en/82035809F7E6474099944056CCB01C20/ti-nspire_computerlink. This free software will allow you to connect your nSpire handheld to your computer. It allows you to perform a limited number of tasks on the nSpire from a PC or Mac. It is not needed if you have the Teacher or Student Software.

TI Teacher Software and **TI Student Software** are available at: https://education.ti.com/en/us/products/computer_software/ti-nspire-software/ti-nspire-and-ti-nspire-cas-teacher-software/tabs/overview. This software is useful for teachers and for making presentations about the nSpire CX CAS. However, it is not free and is not necessary for students. You may want to try the 30-day trial to see if you find it useful before purchasing it.

TI nSpire tutorials are available at:

- https://www.atomiclearning.com/ti_nspire
- https://education.ti.com/en/timathnspired/us/resource/video-tutorials

TI nSpire lessons (.tns files – require Teacher or Student software) are available at:

- http://www.ticalc.org/pub/nspire/basic/math/
- https://sites.google.com/site/tinspiregroup/assignments
- https://education.ti.com/en/timathnspired/us/home

[ctrl] click on any of the hyperlinks above to go directly to the associated website. Note: this works only in the Microsoft Word version of this document.

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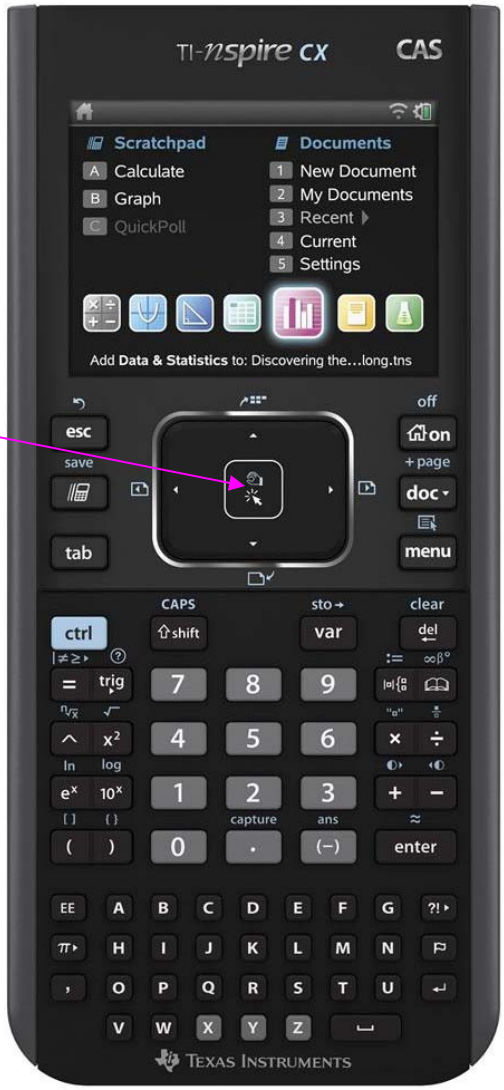
Chapter 1: Introduction



Note: click and double-click with this key.

Context Menus:

- **[ctrl]** → **[menu]** – opens a context menu that acts like a right click on a PC**.**

Moving through dialog boxes:

- **[tab]** – moves to the next box.
- **[shift]** → **[tab]** – moves (backward) to the previous box.

Shift Lock: **[ctrl]** → **[shift].**

You must be in a document in order to use certain nSpire capabilities (e.g., hide graph, construct tangent line). To save Scratchpad work to a document:

- **[doc]** → **File (1)** → **Save (4)** → **[enter].**

Document Settings: **[home]** → **Settings (5). ***

Graph Settings: Enter the graph portion of the Scratchpad . Then, **[menu]** → **Settings (8). ***

* Click **Make Default** after changing settings.

Grab something on the screen (so you can move it):

- **[ctrl]** → **click** to grab. **[enter]** when done moving the item.

When working on problems, consider working inside a document so that various applications can be linked, functions defined, etc. Work in a document can also be saved for later.

Special keys:

- Space bar: . Underscore: **[ctrl]** → .
- Backslash (\): **[shift]** → .

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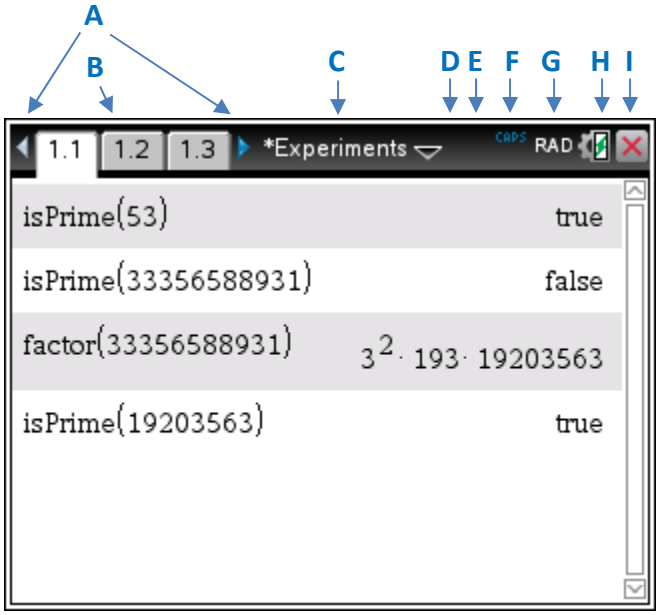
Adjusting Screen Brightness

- Press and hold the **[ctrl]** key.
- Press the + key to increase brightness, or the − key to decrease brightness.

Screen Icons (top of screen)



A. Page scrolling arrows

B. Problem.Page tabs

C. Document name

D. Press-to-Test indicator (not shown) – see note below.

E. Wireless network login indicator (not shown)

F. [shift], [ctrl], or [CAPS] status

G. Radians or Degrees indicator

H. Battery indicator

I. Close document button

Note: Press-to-Test mode disables access to pre-existing documents and scratchpad entries. It can be used, for example, in standardized testing to prevent students from loading the nSpire with information to use on the test.

TI discusses the use of Press-to-Test mode on its website at: https://education.ti.com/en-GB/uk/products/ti-nspire/ti-nspire-cx-handheld/exam-acceptance/press-to-test. Press-to-Test mode is easy to get into, but a pain in the neck to get out of.

On-Screen Help

- Press **[ctrl]** → trig to get help on-screen. This is occasionally, but not always, useful.

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Chapter 2: Documents

Create a new document

- **[home]** → **New Document (1)**
- **[ctrl]** → **I** – Insert a page within a problem in a document.

Work with existing files and folders

- **[home]** → **My Documents (2)**

File/folder manipulation (inside **My Documents: [home]** → **2**)

To **delete** a file or folder:
[ctrl] → **[menu]** → **Delete (6)**

- **[menu]** → **New Folder (1)** – create a new folder.
- **[menu]** → **Rename (2)** – rename a file or folder.
- **[menu]** → **Save As (3)** – save a file with a different name.
- **[menu]** → **Open (4)** – open a file. Shortcut: **[ctrl]** → **O**
- **[menu]** → **Close (5)** – close a file. Shortcut: **[ctrl]** → **W**
- **[menu]** → **Send (6)** – transfer a file or folder to another nSpire or a PC.

Finished working with existing files and folders

- **[home]**

Documents menu: from inside a document: **[doc]**

- **File (1)** – New, Open, Close, Save, Save As, Send
- **Edit (2)** – Undo, Redo, Cut, Copy, Paste, Delete, Color
- **View (3)** – Move forward or backward a page, or enter the "Page Sorter" overview
- **Insert (4)** – Problem, Page (shortcut: **[ctrl]** → **I**), Applications, Program Editor
- **Page Layout (5) – Split Screen**
  - **Custom Split (1)**
  - **Select Layout (2)** – select one of eight layouts (see "Page Layouts" below)
  - **Select App (3)** – select an app to use in a new pane; same as **[menu]**
  - **Swap Applications (4)** – swap the panes in which applications reside
  - **Delete Application (5)** – deletes the pane containing the selected application
  - **Delete Page (6)**
  - **Group (7)** – groups together existing pages onto a single page
  - **Ungroup (8)** – splits apps on a single page to separate pages

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Keyboard Shortcut Summary for Documents

- **[ctrl]** → **N** – New document
- **[ctrl]** → **O** – Open document
- **[ctrl]** → **W** – Close document
- **[ctrl]** → **S** – Save document
- **[ctrl]** → **I** – Insert a page
- **[ctrl]** → **Y** – Redo
- **[ctrl]** → **X** – Cut
- **[ctrl]** → **C** – Copy
- **[ctrl]** → **V** – Paste
- **[ctrl]** → **Z** – Undo
- **[ctrl]** → **[esc]** – Undo

Saving a File

- **[ctrl]** → **S.** To change location, **[shift]** → **[tab]**
- **[doc]** → **File(1)** → **Save (4)** or **Save As (5)**

Seven Core Apps

- **Calculator** (also on Scratchpad)
- **Graph** (also on Scratchpad)
- **Geometry** – coordinate and non-coordinate
- **Lists and Spreadsheet** – like Microsoft Excel; good for statistical applications
- **Data and Statistics**
- **Notes** – useful for adding comments to documents
- **Vernier DataQuest** – used with probes (e.g., CBR2 motion detector) to collect real world data.

Inside a Document

- A document can have up to 30 problems; a problem can have up to 50 pages.
- Add a problem to an existing document:
  - **[doc]** → **Insert (4)** → **Problem (1)**
  - Select the type of page you want to insert into the new problem
- **[ctrl]** → **I** – Insert a page within a problem in a document.
- Page numbering inside a document (see tabs at the top) **[a.b]:**
  - **a** is the problem number.
  - **b** is the page number within that problem.
- **[ctrl]** ⇦ or **[ctrl]** ⇨ – Move left and right (or use mouse) from page to page**.**
- **[ctrl]** ⇧ – gives overview of whole document (Page Sorter View).
- Variables are defined at the problem level, and exist throughout all pages of a problem.
- Documents do not interact with the Scratchpad.

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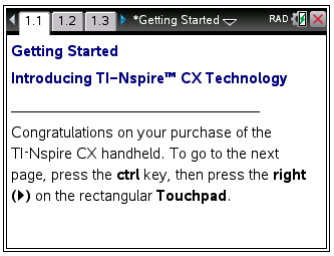
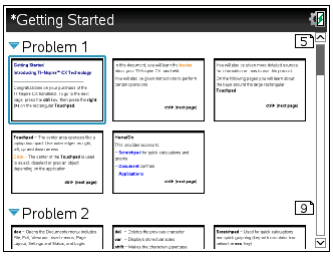
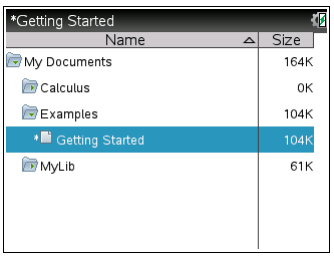
Page Views



- Full Page View
  - Shows a single page.
  - Can have up to four apps on one page.
  - **[ctrl]** → **[tab]** moves clockwise from app to app on a page (or use mouse)



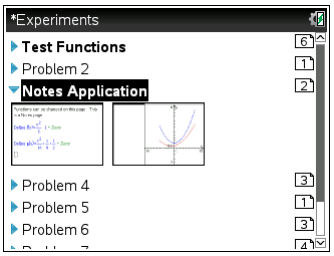
- Page Sorter View: **[ctrl]** ⇧
  - Can see all problems and pages within a document.
  - To go to a page, highlight the page and press **[enter]**.
  - To move a page from one location to another.
    - Highlight the page you want to move.
    - **[ctrl]** → **click** – to grab the page.
    - Move to the location where you want the page to be using the arrow keys on the touchpad.
    - Press **[enter]** to drop the page in place.



- My Documents View – goes to file tree: **[ctrl]** ⇧ → **[ctrl]** ⇧

Working with Problems and Pages in Page Sorter View **([ctrl] ⇧)**

- Collapse or expand all problems (see only problem numbers and names):
  - **[menu]** → **Expand All (1)** or **Collapse All (2)**
- Collapse or expand a single problem:
  - **[ctrl]** → **[menu]** → **Expand All (1)** or **Collapse All (2)**
- Name or rename a problem. Problems are named with numbers by default. To name it something meaningful, select the problem, then press:
  - **[menu]** → **Rename (5)** → type name → **[enter]**
- Add a problem to an existing document: **[menu]** → **Insert Problem (6)**
- Add a page to an existing problem: **[menu]** → **Insert Page (7)**
- Move a problem: Select the problem, then press:
  - **[ctrl]** → **[menu]** → **Cut (2)** or **Copy (3)** → **[Enter]**
  - Move to the new location, then press: **[ctrl]** → **[menu]** → **Paste (4)**
- Delete a problem: Select the problem, then:
  - **[ctrl]** → **[menu]** → **Delete (5)**



Page Sorter View with Problems 1 and 3 named. Problem 3 is selected and expanded.

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Page Layout Options

- **[doc] → Page Layout (5) → Select Layout (2)** – select one of the following:


Layout 1


Layout 2


Layout 3


Layout 4


Layout 5


Layout 6


Layout 7


Layout 8

- **[doc] → Page Layout (5) → Custom (1)** – to change where the page splits occur.
- **[ctrl] → [tab]** – to move from pane to pane (in a clockwise direction)
- **[menu]** – to select the application to add to a pane
- To combine consecutive pages: from the first of two pages to be combined, **[doc] → Page Layout (5) → Group (7)**
- To split an application on a page to a separate page: **[doc] → Page Layout (5) → Ungroup (8)**

Chapter 3: Calculator Application

Fraction Template: **[ctrl]** →  brings up the template.

Change number of digits showing on the screen:

- From Home Screen, **Settings (5)** → **Document Settings (2).**
- Recommended: click on **[Make Default]** after changes.
- Note: values are not rounded in memory, just on the screen.

Logarithm Template: **[ctrl]** → 

brings up the template.

Clear scratchpad history

- **[ctrl]** → **[menu]** → **Clear History (1).**
- **[menu]** → **Actions (1)** → **Clear History (5).**
- To undo the clearing (i.e., bring it all back): **[ctrl]** → **[esc].**

Clear current line

- **[ctrl]** → 

Variable "**ans**"

- The variable **ans** contains the last answer obtained by pressing **[enter].**
- It can be used in any expression by typing **ans**.
- It can also be accessed with **[ctrl]** → **[(−)].** Notice **ans** on the keypad above **[(−)].**
- Successive presses of **[enter]** perform the same operation on each new **ans** variable.

Copy, Paste, Edit

- Highlight the desired item, then:
- Copy: **[ctrl]** → **C**
- Paste: **[ctrl]** → **V**
- To copy only a portion of the highlighted item:
  - Position the cursor at one end of what you want to copy.
  - Hold **[shift]** and use the arrow keys to move to the other end of what you want to copy.
  - **[ctrl]** → **C** to copy the selection.

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Convert exact answer to decimal

- **[ctrl]** → **[enter]** instead of **[enter].**
- **[menu]** → **Number (2)** → **Convert to Decimal (1).**
- Command: **approx(___).**

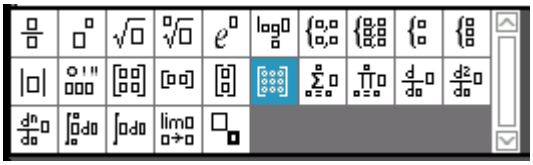
Catalog (key) – on the right side of the nSpire, under the **[del]** key

- Category 1 contains the entire catalog.
- Jumping around in the list:
  - Press a letter to jump to commands starting with that letter.
  - **[ctrl]** → **1** to obtain the last item in the catalog (like a PC's "end" key).
  - **[ctrl]** → **3** to page down.
  - **[ctrl]** → **7** to obtain the first item in the catalog (like a PC's "home" key).
  - **[ctrl]** → **9** to page up.
- Syntax of a command is shown at the bottom of the screen.
  - To expand the syntax, press **[tab]** → **[enter].**
- Wizards
  - Press **[tab]** multiple times to highlight **Wizards.**
  - Press **[enter]** to turn the wizard on.
  - Press **[tab]** again to move on.

A **wizard** is a user interface with dialog boxes that help you complete a complex task more easily.

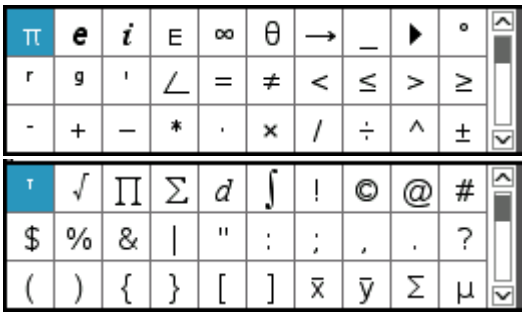
Expression Template:

- Contains templates for integrals, derivatives, limits, matrices, roots, logarithms, etc.
-



Symbol Palette: **[ctrl]** →

- Contains symbols that can be used: $\pi, e, i, \infty, <, \leq, >, \geq, =$, arrows, Greek letters, statistical symbols, currency signs, set notation, mathematical shorthand, etc.
-



… and a lot more symbols – 544 in total.

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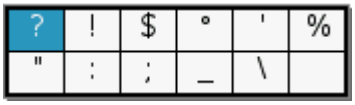
π Template (bottom left of nSpire)

- 
- 

?!⇨ Template (bottom right of nSpire)

- 
- 

Menu Items in the Calculator (and sub-menus)

Actions: **[menu] → 1**

- **Define (1)** – define a variable (use equal sign "=", not ":=" in the definition)
- **Recall Definition (2)**
- **Delete Variable (3)**
- **Clear a-z (4)**
- **Clear History (5)**
- **Insert Comment (6)**
- **Library (7)**
- **Lock (8)** – locks and unlocks variables.

Calculator [Menu]

1 Actions
2 Number
3 Algebra
4 Calculus
5 Probability
6 Statistics
7 Matrix & Vector
8 Finance

Number: **[menu] → 2**

- **Convert to Decimal (1)**
- **Approximate to Fraction (2)**
- **Factor (3)**
- **Least Common Multiple (4)**
- **Greatest Common Divisor (5)**
- **Remainder (6)**
- **Fraction Tools (7)**
- **Number Tools (8)**
- **Complex Number Tools (9)**

Algebra: **[menu] → 3**

- **Solve (1)** – solve(equation, variable).
- **Factor (2)** – factor(expression). Also converts trig expressions.
- **Expand (3)** – expand(expression). Provides the partial fraction expansion of a rational expression.
- **Zeros (4)** – zeros(expression, variable).
- **Complete the Square (5)**
- **Numerical Solve (6)** – nSolve(equation, variable).
- **Solve System of Equations (7)**
- **Polynomial Tools (8)**
- **Fraction Tools (9)**
- **Convert Expression (A)**
- **Trigonometry (B)**
- **Complex (C)**
- **Extract (D)**

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Calculus: **[menu] → 4**

- **Derivative (1)**
- **Derivative at a Point (2)**
- **Integral (3)**
- **Limit (4)**
- **Sum (5)**
- **Product (6)**
- **Function Minimum (7)** – fmin(*expression, x[, lowBound, upBound]*)
- **Function Maximum (8)** – fmax(*expression, x[, lowBound, upBound]*)
- **Tangent Line (9)** – tangentLine(*expression, x, value*)
- **Normal Line (A)** – normalLine(*expression, x, value*)
- **Arc Length (B)** – arcLen(*expression, x, start, end*)
- **Series (C)** – options are: **Taylor Polynomial (1), Generalized Series, (2), Dominant Term (3)**
- **Differential Equation Solver (D)** – deSolve(*ODE, Var, depVar*) – 1st or 2nd order only.
  - Example: deSolve($y'' + 2y' + y = x^2, x, y$) Note: access ' via the **"π⇨" key**.
- **Implicit Differentiation (E)** – impDif(expression, x, y)
- **Numerical Calculations (F)** – Numerical integration, etc.

Items 1 to 6 in the Calculus menu provide templates to fill in to obtain a solution.

Within a function definition, items in **[brackets]** are optional.

Probability: **[menu] → 5**

- **Factorial (1)** – can also calculate factorials with **"!"** in the symbol palette  (4th row)
- **Permutations (2)**
- **Combinations (3)**
- **Random (4)** – everything to do with random numbers
- **Distributions (5)** – Normal, Student's t, χ^2, F, Binomial, Geometric, Poisson

Statistics: **[menu] → 6**

- Ties into the "Lists & Spreadsheet" app
- **Stat Calculations (1)** – 1-variable, 2-variable, various regressions
- **Stat Results (2)**
- **List Math (3)** – mean, median, max, min, population and sample SD and Variance
- **List Operations (4)** – sort, fill, sequence, conversion to/from List or Matrix
- **Distributions (5)** – Normal, Student's t, χ^2, F, Binomial, Geometric, Poisson
- **Confidence Intervals (6)**
- **Stat Tests (7)** – Hypothesis testing, regression, ANOVA

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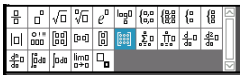
Matrix & Vector: **[menu] → 7**

- Create variable size matrix –   (middle element on 2nd row)
- **Create (1)** – Matrix, Zero Matrix, Identity, Diagonal, Random Matrix, Fill, Submatrix, Augment, Column Augment, Construct Matrix
- **Transpose (2)**
- **Determinant (3)**
- **Row-Echelon Form (4)**
- **Reduced Row-Echelon Form (5)**
- **Simultaneous (6)**
- **Norms (7)**
- **Dimensions (8)**
- **Row Operations (9)**
- **Element Operations (A)**
- **Advanced (B)** – Trace, decomposition, Eigenvalues, Eigenvectors, Characteristic Polynomial.
- **Vector (C)** – Unit vector, dot product, cross product, convert to other coordinate systems.

Finance: **[menu] → 8**

- **Finance Solver (1)** – n, i, PV, Pmt, FV, PpY
- **TVM Functions (2)** – (time value of money) n, i, PV, Pmt, FV
- **Amortization (3)**
- **Cash Flows (4)**
- **Interest Conversion (5)**
- **Days between Dates (6)**

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Chapter 4: Variables and Functions

General

Note: the **underline character** is:

[ctrl] → 

- Variable and function names can be 1-16 characters long (letters, digits, underlines).
- Variables can be defined using other variables.
- Functions can be defined using other functions and variables.
- Stored functions can be graphed in the Graph App. The independent variable, when graphing, must be x.
- **[var]** brings up the list of existing variables and functions.

Defining a variable or function

- Method 1: Type the expression to be saved. Then, **[ctrl]** → **[store]** → ***name***
  - Example: **1/x** → **[ctrl]** → **[store]** → **recip(x)** **[enter]** creates a function recip(x) that returns the value 1/x.
- Method 2: ***name*** → **[: =]** → ***expression***. Multiple variables/functions can be defined if separated by a colon.
  - Example***: num1:=10:num2:=20*** (no spaces).
- Method 3: Especially good for defining functions.
  - **[menu]** → **Actions (1)** → **Define (1)** or type **"define"**
  - ***function name*** **(variable list)** = ***expression*** → **[enter]** (no spaces)
  - Example: **define x_squared(x)=x^2** **[enter]** creates a function x_squared(x) that returns the value x^2.

Deleting a variable or function

- **DelVar *name1, name2, etc.*** or
- **[menu]** → **Actions (1)** → **Delete Variable (3)** → ***name***

Choosing from a list of variables/functions

- **[var]** brings up a list of existing variables and functions to choose from. Useful in many circumstances, especially if you have long variable/function names that you do not want to retype or if you forget what you named a variable/function.

Lock or unlock a variable or function

- **Lock *name*** – locks the variable or function so that it cannot be changed.
- **Unlock *name*** – unlocks the variable or function so that it can be changed.

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Chapter 5: Graphs Application

Add a function to a graph (also toggles the equation entry line)

- **[ctrl] → G**

Note: you can save your scratchpad work in a document as follows: **[doc] → File (1) → Save (4) → [enter].**

Alternative method (especially for Conics, Parametric or Polar)

- **[menu] → Graph Entry/Edit (3) →**
  - **Function (1)**
  - **Relation (2)** – for equations of the form: $\mathbf{x = f(y)}$
  - **Equation Templates (3)** – for conics
  - **Parametric (4)** – for parametric equations
  - **Polar (5)** – for polar equations
  - **Diff Eq (8)** – for slope fields of differential equations

Edit the function

- Mouse over the curve or the label showing the equation. **Double-click** on it.

Hide a function on the current graph (must be in a document, not Scratchpad).

- Mouse over the function and press **[enter]** to select the function.
- **[ctrl] → [menu] → Hide (4)**

Show a hidden function on the current graph (must be in a document, not Scratchpad).

- **[menu] → Actions (1) → Hide/Show (3).** Then, mouse over the curve and **click** on it.

Delete a function and remove it from the current graph

- Mouse over the function and press **[enter]** key to select the function.
- Press the **[del] key** or **[ctrl] → [menu] → Delete (4** or **5)** – the number to use depends on whether or not you are in a document.

Delete all functions on a graph

- **[menu] → Actions (1) → Delete all (5 or 6)** – the number to use depends on whether or not you are in a document.

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Linking a function and a graph on separate pages within a problem

- The pages must be in the same problem within a document
- On a Calculator Page or Notes Page, define the function.
- **[ctrl]** → **I** → **Graphs (2)** – to open a Graphs page.
- **[ctrl]** → **G** – to open the equation entry line.
- **[var]** – to select a function to graph. Enter x as the independent variable**.**
- **[enter]** – to graph the function.

Modify the view

- Zoom: Hover the mouse over one of the axes. **[ctrl]** → **click** to grab the axis. Use the arrow keys or move the cursor to expand or compress the axes. Then, press **[enter].**
- Reposition Graph: Hover the mouse over a blank portion of the graph (i.e., in the background). **[ctrl]** → **click** to grab the graph. Use the arrow keys or move the cursor to reposition the graph. Then, press **[enter].**
- Resize page split when showing multiple displays on a page: **[doc]** → **Page Layout (5)** → **Custom (1)**. Then, use the arrow keys to change the page split. Then, press **[enter].**

Create and use a slider

- **[ctrl]** → **G.** Enter an equation containing parameters, then press **[enter].** Enter any slider settings for variables that you wish to allow to vary in the graph. Note: this may not work in parametric equation mode; use the alternative below.
- Adjust slider settings: Click on the slider box, then: **[ctrl]** → **[menu]** → **Settings (1).** This allows changing all settings including **Minimize.** Click on **Minimize**.
  - Note: **Minimize** is very useful because it makes for a cleaner looking graph.
- Alternative:
  - On a blank **Graphs page**, **[menu]** → **Actions (1)** → **Insert Slider (B)**
  - Enter the ***variable name*** (i.e., ***parameter name***), the range, step size and whether the slider is horizontal or vertical. Click **Minimized** to get a cleaner slider. Then, click **OK**.
  - Repeat for any other parameters desired.
  - Define a function containing the parameters: **[ctrl]** → **G.**
  - Move the slider to see the effect of changing the value of a parameter.
- To animate a slider: Click on the slider box, then: **[ctrl]** → **[menu]** → **Animate (4).**
- To stop the slider animation, **[ctrl]** → **[esc]** or **[ctrl]** → **[menu]** → **Stop Animate (4)** (this is a toggle for animation).
- To delete a slider: Click on the slider, then press **[del].**
- Note: when using a slider, any parameters you create become variables; you may need to delete these after you are done with the exercise.

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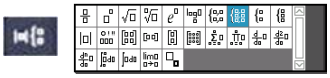
Graph a 3D Function (inside a document only)

- On a **Graphs page**, **[menu] → View (2) → 3D Graphing (3).**
- Enter an equation
  - 3D equation in the form $z = f(x, y)$: just type the equation using x and y.
  - 3D Parametric Function: **[menu] → 3D Graph Entry/Edit (3) → Parametric (2).**
- Rotate the 3D graph
  - Manual: use the touchpad keys (⇦, ⇨, ⇧, ⇩).
  - Auto: mouse not on the graph; then **a** or **[ctrl] → [menu] → Auto Rotation (4).**
  - Stop automatic rotation: **[esc]** or **r.**
- Change view
  - **[menu] → Range/Zoom (4).** Change range, aspect ratio, zoom, orientation.
  - **x** (multiplication) to zoom in – for 3D graphs only.
  - ÷ (division) to zoom out – for 3D graphs only.
- Hide (or Show) 3D box: **[menu] → View (2) → Hide (**or **Show) Box (4).** This is a toggle, so you can hide or show the hidden 3D box with the same commands.
- Orientation
  - **x**, **y** or **z** – to orient along the corresponding axis.
  - **o** – to switch to the default orientation.
- Add the plane "$z = 0$" to the plot: **[menu] → Trace (5) → z Trace (1).**
- Context menu: Mouse on surface of plot until it grays out, then: **[ctrl] → [menu] → …**
  - Change attributes: **Attributes (3)**
  - Delete graph of function: **Delete (5)**
  - Edit the equation: **Edit Relation (6)**
  - Change color: **Color (8)**
- Go back to 2D graphing: **[menu] → View (2) → Graphing (1)**

Graph a Piecewise Function

- Allows you to define a function over one or more intervals. Very useful if you want to graph a function over only one interval.
- On Graphs page –  (8th element on top row) → **[enter].**
- Example: piecewise function for a single interval:
  - In the template, indicate that you want only **1** piece **[enter].**
  - On the function entry line, $\mathbf{f1(x)} = \{\mathbf{f(x)}, \mathbf{-2 \le x < 3}$
  - In this example, $\mathbf{f(x)}$ must have been previously defined, e.g., on another page.
  - Notice there is no right brace, "}". This is how the nSpire shows the piecewise function. If you try to enter "}", you get "{ }", so don't.

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Graph a Conic

- On a Graphs page, **[menu] → Graph Entry/Edit (3) → Equation Templates (3)** – select the conic you want to graph.
  - **Parabola (2), Circle (3), Ellipse (4), Hyperbola (5)**
  - **Conic (6)** – General conic equation $(ax^2 + bxy + cy^2 + dx + ey + f = 0)$
- Enter values in the template, careful to note the syntax required. **[enter]** to graph.
  - Note: depending on the parameters of the conic, you may need to alter the window size: **[menu] → Window/Zoom (4) → Zoom – Out (4)**
- Move the equation to a better location.
  - Hover the cursor over the equation.
  - **[ctrl] → [click]** to grab the equation.
  - Move the equation with the cursor or with the arrow keys.
  - **[enter]** to leave it where you have taken it.
- To analyze the conic
  - **[menu] → Analyze Graph (6) → Analyze Conics (9)**
  - Select the item you want to show on the graph.
  - Hover the mouse over, and **click** on, the graph you want to show this item for.
  - You may need to move any labels that appear. Follow the grab-and-move instructions above (hover over, [ctrl], click, move with arrows or mouse).

Graph a function of the form $x = f(y)$

- **[ctrl] → G → [del] → Relation (6).** Enter the equation and press **[enter].**
- Example: **[ctrl] → G → [del] → Relation (6) →** $\mathbf{x = c}$ **→ [enter]** – to graph a vertical line at $\mathbf{x = c}$, where c is defined elsewhere as a constant or as a variable.

Graph Inequalities

- **[ctrl] → G → [del].** Select the desired inequality sign and press **[enter].**
- Repeat to graph multiple inequalities.

Graph a Parametric Function

- **[menu] → Graph Entry/Edit (3) → Parametric (4)**
- Independent variable is $\boldsymbol{t}$.

Graph a Polar Equation

- **[menu] → Graph Entry/Edit (3) → Polar (5)**
- Independent variable is θ.

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Menu Items on a Graphs page (and sub-menus) **–** will differ on the Scratchpad

Actions: **[menu] → 1**

Graphing [Menu]

1 Actions
2 View
3 Graph Entry/Edit
4 Window/Zoom
5 Trace
6 Analyze Graph
7 Table
8 Settings

- **Pointer (1)**
- **Select (2)** – Region, Image, Grid.
- **Hide/Show (3)**
- **Attributes (4)** – line thickness, style (dotted, dashed, solid), label style, continuous vs. discrete.
- **Set Conditions (5)**
- **Delete All (6)**
- **Text (7)** – to insert a text box on the graph
- **Coordinates and Equations (8)**
- **Calculate (9)**
- **Redefine (A)**
- **Insert Slider (B)**
- To change color, highlight a curve on the graph, then **[ctrl] → [menu] → Color (B)**

View: **[menu] → 2**

- **Graphing (1)**
- **Plane Geometry (2)**
- **3D Graphing (3)**
- **Hide Analytic Window (4)**
- **Hide Axes (5)**
- **Grid (6)** – No grid, Dot Grid, Lined Grid.
- **Show Entry Line (7)** – Also **[ctrl] → G.**
- **Hide Axes End Values (8)**
- **Hide Object Selection Guides (9)**

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Graph Entry/Edit: **[menu] → 3**

- **Function (1)**
- **Relation (2)**
- **Equation Templates (3)** – Line, Parabola, Circle, Ellipse, Hyperbola, Conic (general equation).
- **Parametric (4)** – define: $x(t)$, $y(t)$ and a range for the parameter t.
- **Polar (5)** – define: $r = f(\theta)$
- **Scatter Plot (6)**
- **Sequence (7)** – Sequence, Custom.
- **Diff Eq (8)**

Window/Zoom: **[menu] → 4**

- **Window Settings (1)** – set x and y mins, maxes, and scale
- **Zoom – Box (2)** – use the mouse to define the view box
- **Zoom – In (3)** – define the center of the graph with the mouse and zoom in
- **Zoom – Out (4)** – define the center of the graph with the mouse and zoom out
- **Zoom – Standard (5)** – default setting
- **Zoom – Quadrant 1 (6)** – set the axes to emphasize Q1
- **Zoom – User (7)** – saves the current window settings (allows you to go back to these after trying other zoom options – alternative is to undo till you get what you want)
- **Zoom – Trig (8)** – automatically sets **xMin** and **xMax** to multiples of π.
- **Zoom – Data (9)** – sets the axes so all of your data points are visible
- **Zoom – Fit (A)** – sets the y-axis so that all minima and maxima are visible within the current range of x-values. May need to modify **xMin** and **xMax** before using this.
- **Zoom – Square (B)** – sets the axes so that tick marks on the x- and y-axes are equal size
- **Zoom – Decimal (C)** – sets the axes scales to 0.1 and assures that maxima and minima are shown within the current range of x-values.

Trace: **[menu] → 5**

- **Graph Trace (1)** – will identify maxima, minima and zeros as you move along the curve. Enter a number to move the trace to that x-value.
- **Trace All (2)** – traces multiple functions simultaneously. Enter a number to move the trace to that x-value.
- **Trace Step (3)**
- **Geometry Trace (4)**
- **Erase Geometry Trace (5)**

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Analyze Graph: **[menu] → 6**

- **Zero (1)**
- **Minimum (2)**
- **Maximum (3)**
- **Intersection (4)**
- **Inflection (5)**
- **dy/dx (6)**
- **Integral (7)**
- **Bounded Area (8)**
- **Analyze Conics (9)** – Center, Vertices, Foci, Axes of Symmetry, Directrix, Asymptotes, Radius, Eccentricity, Latus Rectum

Table: **[menu] → 7**

- **Split-screen Table (1)** – Also **[ctrl] → T.** Splits the screen and adds table of values.
- **Remove Table (2)** – Also **[ctrl] → T.**

Geometry: **[menu] → 8** (available only in a document)

- **Points and Lines (1)** – Point, Point On, Intersecting Points, Line, Segment, Ray, Tangent, Vector, Circle Arc
- **Shapes (2)**
- **Measurement (3)**
- **Construction (4)**
- **Transformation (5)**

"Float" shows significant digits

"Fix" shows digits after the decimal

Settings: **[menu] → 8** or **9**

A setting for the AP Exam would be "Fix 3"

- **Display Digits** – Auto, Float (0-12), Fix (0-12).
- **Graphing Angle** – typically radians
- **Geometry Angle** – typically degrees
- **Automatically hide plot labels**
- **Show axes end values**
- **Show tool tips for function manipulation**
- **Automatically find points of interest**
- **Force geometric triangle angles to integers**
- **Automatically label points**
- **Restore, Make Default, Cancel** at bottom of screen.

Note: After defining your settings for graphs, it is a good idea to click on **Make Default**, so that your settings are applied to all of your graphs.

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Chapter 6: Calculus

Define a function and its derivative

- On a calculator page: **f(x):=***expression*
- **g(x):=** → **[shift]** → **–** will bring up the derivative template.
- [^] places you in the "exponent" of the derivative, allowing you to select the n-th derivative of a function.
- Alternatively, press [ctrl] and highlight the appropriate derivative template.
    - **Example:** Type: **f(x):=sin(x) [enter]**.
    - Type: **g(x):=** → **[shift]** → **–** → [^] → **2** to indicate you want a second derivative.
    - Type $\boldsymbol{x}$ after d in the denominator, and type **f(x)** in the parentheses after $\frac{d^2}{dx^2}$.
    - Press **[enter]**. This will make **g(x)** the second derivative of **f(x).**
    - Note: If you subsequently change the definition of **f(x)**, then **g(x)** will change to be the second derivative of the new **f(x).**

Graph a derivative

- On a Graphs page, graph a function, e.g., $\mathbf{f1}(\boldsymbol{x}) = \mathbf{3}\,\mathbf{sin}(\boldsymbol{x})^{\mathbf{2}}$, which is the way to type the function $y = 3\sin^2 x$ into the nSpire.
- **[ctrl]** → **G** → [ctrl] **.** Highlight the derivative template: [$\frac{d}{dx}$]. Fill in the template. **[Enter].**
- Enter $\boldsymbol{x}$ in the denominator of the template and $\mathbf{f1}(\boldsymbol{x})$ to the right of the equal sign.
    - Note: if your function is not $\mathbf{f1}$, enter whatever the name of your function is.
    - You can also bring up a list of functions with **[var].**
- Change the attributes of the curve, if desired.
    - Hover the mouse over the curve to be modified.
    - **[ctrl]** → **[menu]** → **Attributes (3).**

Graph an anti-derivative

- On a Graphs page, graph a function, e.g., $\mathrm{f1}(x) = 3\sin(x)^2$, which is $y = 3\sin^2 x$.
- **[ctrl]** → **G** → [ctrl] **.** Highlight the definite integral template: [$\int_{\square}^{\square}$].
- Fill in the template as follows:
    - Make the lower limit $\mathbf{0}$.
    - Make the upper limit $\boldsymbol{x}$.
    - Make the integrand $\mathbf{f1}(\boldsymbol{x})$.
    - Make the d_ variable $d\boldsymbol{x}$.
    - Press **[Enter].**
- It may take a little time for the nSpire to graph the antiderivative, so be patient.

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Construct a Tangent Line on a Graph (must be in a document, not Scratchpad)

- On a Graphs page, graph a function.
- **[menu] → Geometry (8) → Points & Lines (1) → Tangent (7)**
- Mouse over the curve at the location where you want the tangent line. Then, either click twice or press **[enter]**. You can move the tangent line like a Trace.
- The equation of the tangent line will be shown on the graph.
- You can grab the arrows of the tangent line to extend them.

Equation of a Tangent Line (on a calculator page)

- **tangentLine(***expression, var=value***)** – returns the equation of the line tangent to *expression* at *var = value*.
  - **tangentLine**$\left(\frac{x^3}{3}, x, 2\right)$ ⇒ $4 \cdot x - \frac{16}{3}$

Construct a Normal Line on a Graph (must be in a document, not Scratchpad)

- On a Graphs page, graph a function.
- **[menu] → Geometry (8) → Points & Lines (1) → Tangent (7)**
- Mouse over the curve at the location where you want the normal line, and construct a tangent line.
- **[menu] → Geometry (8) → Construction (4) → Perpendicular (1)**
- Mouse to the point of tangency on the tangent line. Then, either click twice or press **[enter]**. You can move the tangent line like a Trace; as you do, the normal line will move as well.

Equation of a Normal Line (on a calculator page)

- **normalLine(***expression, var=value***)** – returns the equation of the line normal to *expression* at *var = value*.
  - **normalLine**$\left(\frac{x^3}{3}, x, 2\right)$ ⇒ $\frac{19}{6} - \frac{x}{4}$

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Find all points of intersection of two curves

- Graph two curves on a Graphs page.
- **[menu]** → **Geometry (8)** → **Points and Lines (1)** → **Intersection Points (3)**
- **Click** on each of the two curves. The intersection points will then be labeled on the graph.

Find a single point of intersection of two curves

- Graph two curves on a Graphs page.
- **[menu]** → **Analyze Graph (6)** → **Intersection (4)**
- **Click** on the lower bound. Move right and **click** on the upper bound.
- The intersection point will then be labeled on the graph.

Area between two curves (find points of intersection first)

- **[menu]** → **Analyze Graph (6)** → **Bounded Area (8).**
- Move the mouse to the desired intersection points and **click** on each one. This will find the area bounded by the two curves. Repeat if desired.
- The area will be printed on the screen in text. Finding the text is sometimes a challenge.
- *Note:* After you find the bounded area, you can **[menu]** → **Analyze Graph (6)** → **Bounded Area (8)** again. Click on the leftmost point of your bounded region, then move the mouse to the right. On the screen you will see the accumulated area from the leftmost point of your bounded region to the location of the mouse as you move to the right.

Special Project Examples – Calculus

- Solid of Revolution about the x-axis (3D) – Appendix C
- Connect a Geometry Item to a Curve in a Graph (2D) – Appendix C
- Volume by Cross Section (3D) – Appendix C

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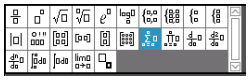
Graph a Differential Equation (i.e., slope field)

- **[menu] → Graph Entry/Edit (3) → Diff Eq (8)**
  - Enter a differential equation in the form $y' = f(x, y)$.
  - Note that the function is really of the type: $\boldsymbol{y1' = f(x, y1),\ y2' = f(x, y2),}$ etc. That is, in the definition of the differential equation, you do not type $\boldsymbol{y}$ as a variable; you must type the ***y*-variable name** (e.g., $\boldsymbol{y1}$ or $\boldsymbol{y2}$) used on the left side of the equal sign.
  - Examples: $\boldsymbol{y1' = \sin(x) \cdot \cos(y1)}$ or $\boldsymbol{y2' = x \cdot (y2)^2}$
  - The **prime** $(')$ sign is in the symbol palate – 3rd item in the 2nd row.
- Make sure the box next to the y' definition is checked in the function entry line. This is the box that tells the nSpire whether or not to show the graph you define.
- **[tab] → [click]** to the […] box – to define the nature of the plot.
- **[tab]** to the initial condition field – enter x-value **[tab]** y-value, if desired.
- **[tab] → [click]** to the "additional conditions" box – to enter any additional conditions, if desired. Then, **[OK].**
- **[enter]** to graph the differential equation (i.e., the slope field and particular solution based on the initial conditions).
- **[esc]** to remove the entry line from the screen so you can see the slope field better.

Summation

- Access the Summation Template:  – 7th item in the second row.
- On the bottom, enter the summation index variable and the starting value.
- On the top, enter the maximum value of the index variable. Note that this may be ∞. The ∞ sign is in the symbol palate – 5th item in the top row.
- On the right, enter the expression to be summed (in terms of the index variable).
- **[enter].**
- Example: $\boldsymbol{\sum_{n=1}^{\infty}\left(\frac{1}{n^4}\right)}$ yields: $\boldsymbol{\frac{\pi^4}{90}}$. This is the value of $\boldsymbol{\zeta(4)}$.
- Some infinite summations do not have nice solutions and the nSpire will not provide a desirable solution. Example: replace $\boldsymbol{4}$ with $\boldsymbol{3}$ in the above example to get a value for $\boldsymbol{\zeta(3)}$, and no solution is provided. In these cases, try a large value as the upper limit of the index to get an approximate value.
- Example: $\boldsymbol{\sum_{n=1}^{1000}\left(\frac{1}{n^3}\right)}$ yields: $\boldsymbol{1.20206}$. $\boldsymbol{\sum_{n=1}^{5000}\left(\frac{1}{n^3}\right)}$ yields: $\boldsymbol{1.20206}$.
- Summations work very well when finite limits.

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Sequences

- **Seq(***expression*, *var*, *low*, *high*[, *step*]**)** – generates a sequence based on *expression*. *var* increments from *low* to *high* in steps of 1 unless *step* is provided.
- Examples:
  - **Seq($\mathbf{n^3}$, n, 1, 5, 2)** yields: **{1, 27, 125}** (which is: 1^3, 3^3, 5^3)
  - **Seq($\mathbf{1/n^3}$, n, 1, 5, 2)** yields: **{1, $\frac{1}{27}$, $\frac{1}{125}$}** (which is: $\frac{1}{1^3}, \frac{1}{3^3}, \frac{1}{5^3}$)

Combining Summations and Sequences

- **Sum(Seq(***expression*, *var*, *low*, *high*[, *step*]**))** – generates the sum of the items in the sequence provided.
- Examples:
  - **Sum(Seq($\mathbf{n^3}$, n, 1, 5, 2))** yields: **153** (which $= 1^3 + 3^3 + 5^3$)
  - **Sum(Seq($\mathbf{1/n^3}$, n, 1, 5, 2))** yields: $\frac{3527}{3375}$ (which is: $\frac{1}{1^3}, \frac{1}{3^3}, \frac{1}{5^3}$)
    - **[ctrl]** → **[enter]** – to get the decimal solution**: 1.4504**

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Chapter 7: Notes Application

Open a Notes Page in a Document

- **[ctrl]** → **[doc]** → **Add Notes (6)**, or
- **[ctrl]** → **I** → **Add Notes (6)**
- Then, type your notes

Note: the space key, ␣, is located at the bottom right of the nSpire.

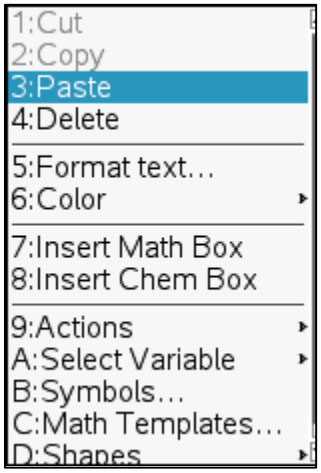
The shift key, ⇧shift, is located above the **7** key.

Select Text (that has already been typed)

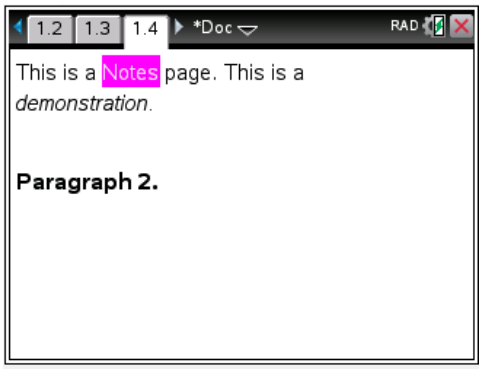
- **Selection:** (this may take some practice)
  - Move the cursor to the beginning or end of a selection.
  - Hold down the **[click]** key, then press the **[shift]** key.
  - With the **[shift]** key still depressed, you can release the **[click]** key. Then, move the cursor or use the arrow keys to highlight the selection.
- **Single Word:** Place the cursor on a single word and double-click to select the word.
- **Sentence:** Place the cursor anywhere within a sentence and triple-click to select the entire sentence.

Change Text Attributes (select text, then …)

- Font
  - **[menu]** → **Format (4)** → **Format Text (1)**
  - Select the font, font size, bold, italic, underline, etc. for the text.
  - Press **[esc]** to apply your selections.
- Foreground Color
  - **[menu]** → **Format (4)** → **Text color (4)**
  - Select a color, then **click** or **[enter].**
- Background Color
  - **[menu]** → **Format (4)** → **Fill color (3)**
  - Select a color, then **click** or **[enter].**
- **[ctrl]** → **[menu]** (Right Click) Menus for selected text →



- Sample page with text modified:



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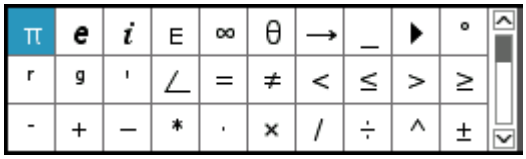
Use Shapes and Special Characters

- To input a special character, access the symbol template: ∞β°. This gives access to:

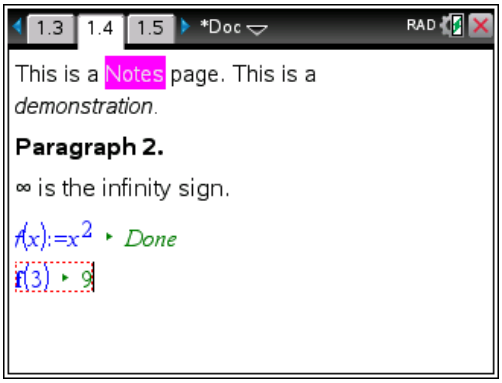


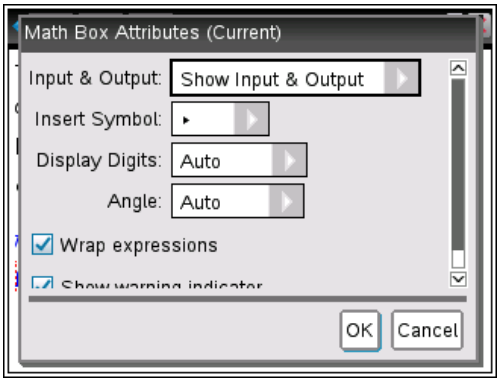
and many more symbols.

- To insert a shape, such as an angle, triangle or circle, **[menu] → Insert (3) → Shape (3)**

Math Boxes

- A Math Box in a Notes Application is similar the Calculator App. You can define functions, perform calculations, etc.
- **[ctrl] → M** or **[menu] → Insert (3) → Math Box (1)** to insert a Math Box, or press a mathematical function key, e.g., x^2, to automatically open a Math Box.
- Attributes of the Math Box can be changed: position yourself inside the math box you want to change and press: **[ctrl] → [menu] → Math Box Attributes (8)**. A notes page, with and without the Math Box attributes menu open, are shown below.





- Items defined in a Math Box are available throughout a problem in a document. For example, if a function, $f(x)$, is defined in a Math Box on a Notes page, it can be accessed as $f(x)$ on Calculator and Graphs pages in the same problem.

Chem Boxes

- A Chem Box is useful for formatting chemical equations.
- **[ctrl] → E** or **[menu] → Insert (3) → Chem Box (2)** to insert a Chem Box.
- Type the equation. Recall that the " → " **key** is located in the symbol palette: ∞β°. Subscripts will automatically be placed in the proper position.
- Example. Type: $2CO + MoO2 \rightarrow 2CO2 + Mo$ **[enter]**
  Output on screen: $2CO + MoO_2 \rightarrow 2CO_2 + Mo$

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Chapter 8: Lists & Spreadsheet Application

Open a Lists & Spreadsheet Page in a Document

- **[ctrl]** → **[doc]** → **Add Lists & Spreadsheet (4)**, or
- **[ctrl]** → **I** → **Add Lists & Spreadsheet (4)**

Size of page: 26 columns; 2,500 rows

Moving around

- Use arrow keys to move from cell to cell within a spreadsheet.
- Move to a specific cell: **[ctrl]** → **G** or **[menu]** → **Actions (1)** → **Go To (4)**, then type the cell reference (e.g., **B3**) and press **[enter]**.
- **[enter]** – moves down one row in the current column.
- **[tab]** – moves to the column title in the current column (or back into the body of the spreadsheet). **[tab]** acts as a toggle in this regard.
- Move to Row 1 in the current column: **[ctrl]** → **7**.
- Move to the last filled cell in the current column: **[ctrl]** → **1**.
- Page up in the current column: **[ctrl]** → **9**.
- Page down in the current column: **[ctrl]** → **3**.

Naming columns

- Move to the top row in a column using the arrow keys or **[tab]**.
- Type the name of the column. Only lower case letters are used in column names.

Cut, Copy, Paste – Highlighted rows and columns may be cut, copied and pasted:

- **[ctrl]** → **X** – Cut
- **[ctrl]** → **C** – Copy
- **[ctrl]** → **V** – Paste
- **[ctrl]** → **Z** or **[ctrl]** → **[esc]** – Undo (if you make a mistake)
- **[ctrl]** → **Y** – Redo (if you want to "undo" an undo)

Select an Entire Row – While positioned in the row you want to select, either:

- Move to the far left of the row and press  , or
- **[menu]** → **Actions (1)** → **Select (3)** → **Select Row (1).**

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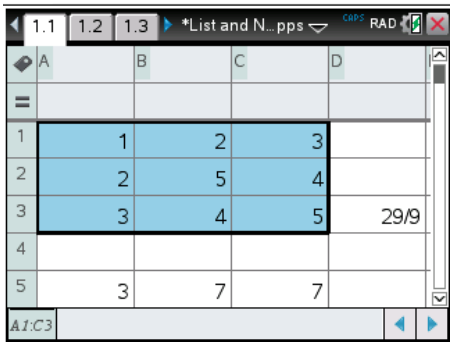
Select an Entire Column – While positioned in the column you want to select, either:

- Move to the far top of the column and press ^, or
- **[menu] → Actions (1) → Select (3) → Select Column (2)**

Select a Block of Cells

- Move to one corner of the block you wish to select.
- Hold down the shift key and use the arrow keys to move to the other corner of the block.



Delete a Row, Column or Block of Cells

- Select the entire row, column or block of cells you want to delete (see above).
- Press **[del]**.

Insert a Cell, Row or Column – From any location in the spreadsheet, the inserted row or column will be placed where you currently reside, like in Microsoft Excel.

- **[menu] → Insert (2) → Insert Cell (1)** – to insert a single cell. This moves all other cells in the column down one space.
- **[menu] → Insert (2) → Insert Row (2)** – to insert a row
- **[menu] → Insert (2) → Insert Column (3)** – to insert a column

Move a Column – Move to a cell in the column you want to move. Then:

- **[menu] → Actions (1) → Move Column (1)** – use the arrow keys to move to where you want the column to appear.
- If moving the column to the right, it will be placed just to the left of the bold vertical guide line.
- If moving the column to the left, it will be placed just to the right of the bold vertical guide line.

Resize a Column – Move to a cell in the column you want to resize. Then:

- **[menu] → Actions (1) → Resize (2) → Resize Column Width (1)** – then use the arrow keys to change the size of the column.
- **[menu] → Actions (1) → Resize (2) → Maximize Column Width (2)** – creates a column that takes up most of the screen width.
- **[menu] → Actions (1) → Resize (2) → Minimize Column Width (3)** – changes the size of the column to the minimum that fits the data in the column.

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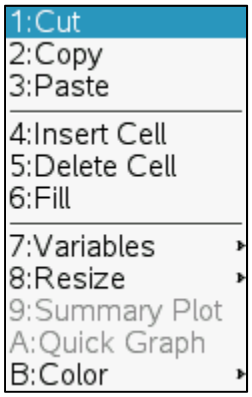
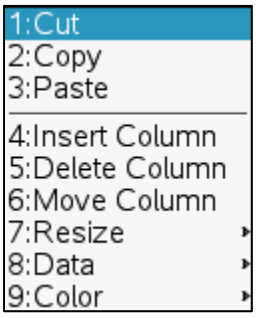
[ctrl] → [menu] (Right Click) Menus in a Spreadsheet

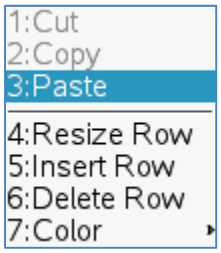
With a: Cell Selected



Column Selected



Row Selected

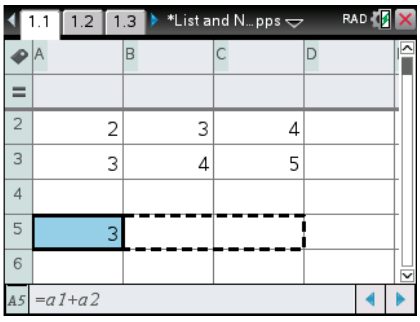


Using Formulas in a Spreadsheet

- Works very similar to Microsoft Excel.
- Move to the cell in which you would like to enter a formula.
- Type the " = " sign, followed by whatever formula you want to use. Then, **[enter]**.
  - Use cell references, example: **=a1^(a2÷2)**
- Keyboard functions that can be used in the Calculator application are available for use in cell formulas.
- A line on the bottom of the screen shows the formula in the current cell.
- If a data item in the spreadsheet changes, all of the other cells will update automatically. If you face a situation where you need to manually recalculate all cells, this can be done by pressing **[ctrl] → R** or **[menu] → Actions (1) → Recalculate (5)**

Copy Formulas to Other Cells

- Move to the cell you would like to copy. Then, press **[ctrl] → Click** to select the formula in that cell.
- Move up, down, left or right using the arrow keys to indicate which cells are to receive the formula. The cells into which the formula will be copied are identified by bold dashed lines (see the figure at right). Then, press **[enter]** to copy the formula to the indicated cells.



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Absolute and Relative Cell References

- The default cell reference is relative, meaning that when a cell is copied to other cells, each input maintains the relative position it had in the original cell.
    - Example: If **A4=A1+A2**, note that **A1** is 3 cells above **A4** and **A2** is two cells above **A4**.
    - Copying cell **A4** into cell **C8** will make **C8=C5+C6**. **C5** is 3 cells above **C8** and **C6** is two cells above **C8**.
- When entering a formula, placing a **$** before either the column (letter) or row (number) of a cell reference will maintain that column or row when the formula is copied. This is called an absolute cell reference.
    - Example: If **A4=$A1+A$2**, then, when **A4** is copied, the column for the first input remains constant, and the row for the second input remains constant.
    - Copying cell **A4** into cell **C8** will make **C8=$A5+C$2**.
    - This is especially useful if a single cell is use multiple times, for example a single interest rate to be used for multiple calculations. The rate could be placed in cell **A1** and referred to as **A1** in all formulas.
- Summary: Column references (letters) and row references (numbers) should be considered separately when creating formulas.
    - Any reference (column or row) with a **$** in front of it is absolute (i.e., will not change when copied).
    - Any reference (column or row) without a **$** in front of it is relative (i.e., will change when copied).

Reference a Block of Cells

- A rectangular block of cells can be referenced in the form "top left cell":"bottom right cell". For example, you would reference the cells in rows **4** to **7** which are in columns **C** to **E**, i.e., the block of cells from **C4** to **E7**, as **C4:E7**.
- The colon character "**:**" can most easily be typed via the  Template, located near the bottom right of the nSpire.
- Example: If you were to type **=sum(C4:E7)** into cell **F7**, this would place the sum of the 12 cells in the block **C4:E7** into cell **F7**.
    - "**sum**" is a function available in the nSpire's Library. nSpire functions may be typed into a Calculator page, a Math Box, or a cell in a Spreadsheet.

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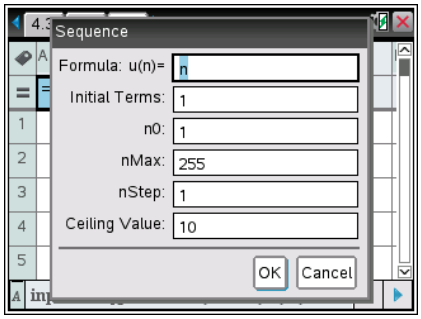
Insert Data in Multiple Rows of a Column

To insert data in multiple rows using a formula that contains a number of trials:

- Enter the formula in the Formula Row (the row between the Name of the column and Row 1): Example: **=randint(3, 6, 15)** inserts random numbers from 3 to 6 in the first 15 rows of the column.

To insert data in multiple rows using a sequence:

- Move to the Formula Row in the column where you wish to enter data: **[menu] → Data (3) → Generate Sequence (1)**
- A table similar to the one at right will appear to help you to define the sequence.



  - **Formula u(n) = :** enter the formula for the data entries. The formula can be a simple as **n** if you wish to show the row number or it can be more complex. The element in Row 1 will be **u(n0)** unless initial terms are specified.
  - **Initial Terms:** enter any terms you want to use to start your sequence. You may enter multiple terms, separated by commas if you wish. The **Formula u(n)** will be used in rows below the last entered initial term.
  - **n0:** the label on this should be **n1**, in my opinion. It is the first value of **n** to be used to define an element in the column (if there are no initial terms specified). If initial terms are specified, they override the values calculated using the formula.
  - **nMax:** the maximum value of **n** used in the formula. Note: fewer values of **n** could be used if the Ceiling Value is specified. Ceiling Value overrides nMax.
  - **nStep:** the increment in **n** if one is desired. The items entered in the column will be: **u(n), u(n+nStep), u(n+2·nStep), u(n+3·nStep), …**
  - **Ceiling Value:** the maximum value to be entered in the column. The sequence will end with the last value equal to or below **Ceiling Value**.
  - Click on **OK** when you are finished defining your sequence. If you do not like the resulting sequence, you can redefine it using the same steps.
- The formula may be recursive, i.e., it may refer to other elements in the column. Example: **u(n) = u(n-1) + u(n-2)**, with initial terms of **"1,1"** could be used to generate the Fibonacci sequence.
- To move quickly among rows you may use the following shortcuts:
  - **[ctrl] → 1** to move to the bottom element in the row.
  - **[ctrl] → 7** to move to the top element in the row (i.e., Row 1).
  - **[ctrl] → 3** to move down one screen.
  - **[ctrl] → 9** to move up one screen.

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Chapter 9: Probability

[menu] → **Probability (5)** – to open the Probability Menu and generate random numbers or probabilities based on a specified distribution.

Menu Items – Probability

Probability [Menu]

1 Factorial (!)
2 Permutations
3 Combinations
4 Random
5 Distributions

Factorial: **1** – inserts the factorial sign (**!**) after the item.

Permutations: **2** – inserts the function **nPr()**. The user must insert "**n, r**" in the parentheses. Returns the number of permutations of **n** items taken **r** at a time. For permutations, selection order matters.

Combinations: **3** – inserts the function **nCr()**. The user must insert "**n, r**" in the parentheses. Returns the number of combinations of **n** items taken **r** at a time. For combinations, selection order does not matter.

Random: **4** – generates random numbers as follows:

- **Number (1)** – inserts the function **rand(***num***)**, which generates *num* random real numbers between 0 and 1.
- **Integer (2)** – inserts the function **randInt(***lowbound, upbound [, num]***)**, which generates a random integer between *lowbound* and *upbound*. *num*, when specified, returns *num* random integers in the desired range.
- **Binomial (3)** – inserts the function **randBin(***n, p [, num]***)**, which generates a random (integer) number of successes in *n* trials with probability *p* of success. *num*, when specified, returns the results of *num* trials.
- **Normal (4)** – inserts the function **randNorm(**μ, σ, *[, num]***)**, which generates a random real number from a Normal Distribution with mean μ and standard deviation σ**.** *num*, when specified, returns the results of *num* trials.
- **Sample (5)** – inserts the function **randSamp(***List_name, nun [,* **noRepl***]***)**, which generates *num* random values from the pre-defined list *List_name***.** **noRepl**, when specified, returns results without replacement.
- **Seed (6)** – inserts the function **randSeed** *n_Seed***.** *n_Seed* becomes the seed value for further random number generation. Use this command to set a random seed when you would like to be able to replicate your random numbers.

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Distributions: **5** – provides probability density function (PDF) values or cumulative areas under the PDF for various distributions:

- **Normal Pdf (1)** – inserts the function **normPdf(***x, μ, σ***)**, which provides the y-value associated with the given x-value for a Normal PDF with mean μ and standard deviation σ.
- **Normal Cdf (2)** – inserts the function **normCdf(***low, high, μ, σ***)**, which provides the area under the curve between $x = low$ and $x = high$ for a Normal PDF with mean μ and standard deviation σ.
- **Inverse Normal (3)** – inserts the function **invNorm (***area, μ, σ***)**, which provides the x-value associated with the given *area* under the curve from $-\infty$ to x for a Normal CDF with mean μ and standard deviation σ.

- **t Pdf (4)** – inserts the function **tPdf(***t, ν***)**, which provides the y-value associated with the given t-value for a Student's t PDF with ν degrees of freedom.
- **t Cdf (5)** – inserts the function **tCdf(***low, high, ν***)**, which provides the area under the curve between $t = low$ and $t = high$ for a Student's t PDF with ν degrees of freedom. Note that you must calculate the required t-values using a formula such as $t = \frac{\bar{x}-\mu}{s/\sqrt{n}}$ to use **tPdf(***t, ν***)** or **tCdf(***low, high, ν***)** properly.
- **Inverse t (6)** – inserts the function **invT (***area, ν***)**, which provides the t-value associated with the given *area* under the curve from $-\infty$ to t for a Student's t PDF with ν degrees of freedom.

- **χ^2 Pdf (7)** – inserts the function **χ^2Pdf(***x, ν***)**, which provides the y-value associated with the given x-value for a χ^2 PDF with ν degrees of freedom.
- **χ^2 Cdf (8)** – inserts the function **χ^2Cdf(***low, high, ν***)**, which provides the area under the curve between $x = low$ and $x = high$ for a χ^2 PDF with ν degrees of freedom.
- **Inverse χ^2 (9)** – inserts the function **invχ^2 (***area, ν***)**, which provides the x-value associated with the given *area* under the curve from 0 to x for a χ^2 CDF with ν degrees of freedom.

- **F Pdf (A)** – inserts the function **FPdf(***x, ν_{num}, ν_{denom}***)**, which provides the y-value associated with the given x-value for an F PDF with ν_{num} degrees of freedom in the numerator and ν_{denom} degrees of freedom in the denominator.

  Note: The F distribution is used predominantly in Analysis of Variance (ANOVA) to test whether two independent samples have been drawn from populations with the same variance.

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- **F Cdf (B)** – inserts the function **FCdf(***low, high,* v_{num}, v_{denom}**)**, which provides the area under the curve between $x = low$ and $x = high$ for an F PDF with v_{num} degrees of freedom in the numerator and v_{denom} degrees of freedom in the denominator.
- **Inverse F (C)** – inserts the function **invF (***area,* v_{num}, v_{denom}**)**, which provides the x-value associated with the given *area* under the curve from 0 to x for an F CDF with v_{num} degrees of freedom in the numerator and v_{denom} degrees of freedom in the denominator.

- **Binomial Pdf (D)** – inserts the function **binomPdf(***n, p, x***)**, which provides the probability of x successes in *n* trials with probability *p* of success.
- **Binomial Cdf (E)** – inserts the function **binomCdf(***n, p,* x_1, x_2**)**, which provides the probability of x_1 to x_2 successes in *n* trials with probability *p* of success.

- **Geometric Pdf (F)** – inserts the function **geomPdf(***p, x***)**, which provides the probability of the first success occurring on the x-th trial, with probability *p* of success.
- **Geometric Cdf (G)** – inserts the function **geomCdf(***p,* x_1, x_2**)**, which provides the probability of the first success occurring on the x_1-th to x_2-th trials, with probability *p* of success.

- **Poisson Pdf (H)** – inserts the function **poissPdf(**λ, *x***)**, which provides the probability of x of successes if the average number of successes in the given time period is λ.

  Note: In a Poisson distribution, $\mu = \lambda$ and $\sigma = \lambda$. The probability of λ successes is given by: $P(\lambda, x) = \dfrac{\lambda^x \, e^{-\lambda}}{x!}$.
- **Poisson Cdf (I)** – inserts the function **poissCdf(**λ, x_1, x_2**)**, which provides the probability of x_1 to x_2 successes if the average number of successes in the given time period is λ.

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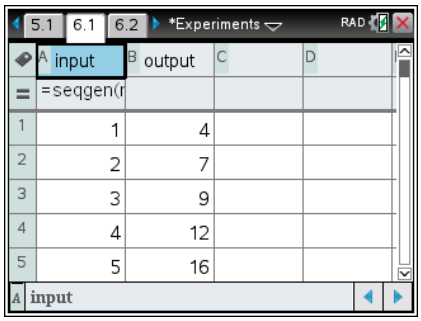
Chapter 10: Statistics

[menu] → **Statistics (6)** – to open the Statistics Menu.

To work with data, input the data in a Lists & Spreadsheet application first.

- Name each column that you wish to use by typing its name in the top row of the column. These names will be used to reference the data in the columns for statistical applications.
- Enter data beginning in Row 1. Note: Some data can be entered in multiple rows by entering formulas in the Formula Row (the row between the Name of the column and Row 1).



  - Example: **=randint(3, 6, 15)** inserts random numbers from 3 to 6 in the first 15 rows of the column. Note: if you use random values, you can recalculate a new set with **[ctrl]** → **R.**
  - Example: **[menu]** → **Data (3)** → **Generate Sequence (1)** – to insert the elements of a sequence in the cells in a column (e.g., 1, 2, 3, … or 3, 5, 7, …). See page 35.

Quick Graph

After data in one or more columns have been named and entered:

- Select a column by clicking on the letter (not the name) at the top of the column or by pressing the up arrow from the row containing the column name.
- Select a second column if working with two-variable data:
  - The independent variable should be in the leftmost of the two columns to be selected, and the dependent variable should be to its immediate right. With the column containing the independent variable selected, hold down the shift key and press the right arrow once to include the second column in the selection.
- **[menu]** → **Data (3)** → **Quick Graph (9)** to show a dot plot of the data.

Graph on a Separate Page

- **[ctrl]** → **I** → **Add Data & Statistics (5)** to begin a graph of the data. The data shown will be the set in column A of the List & Spreadsheet application.
- Click on the x-axis label and select the independent variable from the list provided for the graph. If this is the only variable entered, you will see a dot plot of x-values.
- To add a dependent variable to the graph, click on the y-axis label of the graph (or press **[tab]**), and select the dependent variable from the list provided.

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Working with the Graph

- On the Data & Statistics page, you can change the plot type, plot properties, remove a variable (or both variables), add a slider, add text, plot a regression equation of any available type, or modify the graph window.
- You can also add data to existing lists. Just edit any formulas in the Formula Row, copy formulas to new cells, or enter data directly. One caution: if data in a column is determined based on a formula in the Formula Row, direct data entry may cancel the formula.

One Variable Data

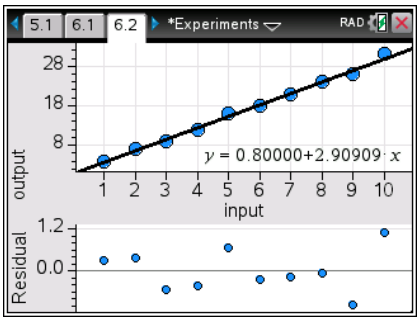
With a single variable defined in the plot:

- Quantitative data: **[menu] → Plot Type (1)** allows you to select a Dot Plot (1), Box Plot (2), Histogram (3) or Normal Probability Plot (4).
- Categorical data: **[menu] → Plot Type (1)** allows you to select a Dot Chart (7), Bar Chart (8) or Pie Chart (9).
- To change variables, click on the x-axis label and select the variable from the list provided.
- You can force quantitative data to be displayed as categorical data by pressing: **[menu] → Plot Properties (2) → Force Categorical X (B)**. Note: in this mode, data are considered alphabetically, so, for example, 10 will reside between 1 and 2. Move a category by **[ctrl] → Click**-ing it and dragging the label where you would like it to be.
- You can force categorical data which are based on quantitative values to be displayed as quantitative data by pressing: **[menu] → Plot Properties (2) → Force Numerical X (B)**.

Two Variable Data and Regression

With both x- and y-variables defined in the plot:

- **[menu] → Plot Type (1)** allows you to select either a Scatter Plot (5) or an XY-Line Plot (6). These are identical except the XY-Line Plot connects the dots with lines.
- To add a regression line, **[menu] → Analyze (4) → Regression (6)** and select the type of regression desired. Both the regression curve and its equation will be shown on the graph.
- To show the plot of residuals below the regression plot, **[menu] → Analyze (4) → Residuals (7) → Show Residual Plot (2)**



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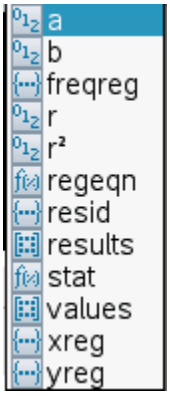
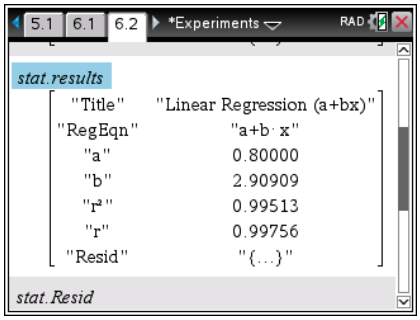
- Note about selecting a regression method: Be careful to consider the nature of the data you are plotting when selecting a regression method. More powerful methods, e.g., cubic rather than linear, will typically be better fits, but not necessarily because the model is better. Randomness in the data can be disguised by using too powerful a method. In general, it is best to use the simplest model that generates random residuals that do not fan out significantly at either end of the graph.
- To plot a vertical line for a particular x -value, e.g., the mean or median of the x-values, **[menu]** → **Analyze (4)** → **Plot Value (8)** and enter the value or an expression for the value to be plotted, e.g., mean(*input_list*). The line will be plotted only on the original data plot, not the residual plot.
- To see the impact of a single point (e.g., an influential point or an outlier), **[ctrl]** → **click** on the point and move it with the cursor or arrow keys. The point becomes hollow and highlighted. The regression curve and residuals, if shown, will move with it.
    - To leave the point in its new location, press **[enter]**.
    - To put the point back where it was, **[ctrl]** → **[esc]** or **[ctrl]** → **Z**.
    - To change the point's form back to what it was before you moved it, **click** on it.

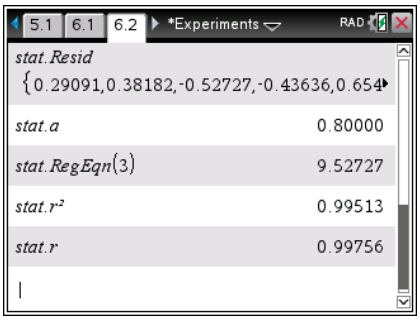
After preforming a Regression:

- **[menu]** → **Statistics (6)** → **Stat Results (2)** – provides key items from the analysis. For individual items, including items not listed in these results, see the next bullet point.
- **stat.** (make sure you type the dot) will provide an opportunity to view and/or use the results of the analysis. For example, after a Linear Regression, **stat.** brings up the menu at right, from which the user may select any of the items shown. Of particular interest:
    - **resid** provides a list of the residuals of the regression.
- Examples:





Stat Results for a Linear Regression.



stat. selection of individual items from the menu.

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Confidence Intervals

- **[menu]** → **Statistics (6)** → **Confidence Intervals (6)** and select the type of confidence interval you would like to create. Press **[enter]**.
- In the Data Input Method menu that pops up:
  - Select Data if you want to base your interval on a set of data in a List. You will then be asked for the items (e.g., List name, the frequency list and the confidence level) that will be used to create the Confidence Interval. Select **OK**.
  - Select Stats if you would like to base your interval on a set of statistics. You will then be asked for the values of the statistics (e.g., mean, standard deviation, n, confidence level) that will be used to create the Confidence Interval. Select **OK**.

Hypothesis Tests

- **[menu]** → **Statistics (6)** → **Stat Tests (7)** and select the type of test you would like to perform. Press **[enter]**.
- In the Data Input Method menu that pops up:
  - Select Data if you want to base your test on a set of data in a List. You will then be asked for the items (e.g., test value, List name, the frequency list and the type of alternative hypothesis) you wish to use to perform the test. Select **OK**.
  - Select Stats if you would like to base your test on a set of statistics. You will then be asked for the values of the statistics (e.g., test value, mean, standard deviation, n, and the type of alternative hypothesis you wish to use) that will be used to perform the test. Select **OK**.

Menu Items – Statistics

Statistics [Menu]

1 Stat Calculations
2 Stat Results
3 List Math
4 List Operations
5 Distributions
6 Confidence Intervals
7 Stat Tests

Stat Calculations: **1** – use to perform a statistical analysis on 1-variable data or 2-variable data, including regression analysis.

- **One-Variable Statistics (1)** – provides a set of statistics for the list identified.
- **Two-Variable Statistics (2)** – provides a set of statistics for each of two lists identified, typically x and y.
- **Linear Regression $(mx + b)$ (3)** – provides the results of a linear regression in the form $y = mx + b$.
- **Linear Regression $(a + bx)$ (4)** – provides the results of a linear regression in the form $y = a + bx$.
- **Median-Median Line (5)** – provides a regression line based on the medians of the three thirds of data, when data are aligned according to values of the independent variable.
- **Quadratic Regression (6)** – Regression using a 2nd degree polynomial.
- **Cubic Regression (7)** – Regression using a 3rd degree polynomial.
- **Quartic regression (8)** – Regression using a 4th degree polynomial.
- **Power Regression (9)** – Regression using a power function.
- **Exponential Regression (A)** – Regression using a exponential function.
- **Logarithmic Regression (B)** – Regression using a logarithmic function.
- **Sinusoidal Regression (C)** – Regression using a sine function.
- **Logistic Regression $(d = 0)$ (D)** – Regression using a logistic function.
- **Logistic Regression $(d \neq 0)$ (E)** – Regression using a logistic function.
- **Multiple Linear Regression (F)** – Regression on multiple variables using linear functions.
- **Correlation Matrix (G)** – provides a matrix of the correlations of the variables in a Multiple Linear Regression.

Stat Results: **2** – provides the results of any statistical analysis performed.

List Math: **3** – provides the following elements related to a set of one-variable data (any list):

- **Minimum (1)**
- **Maximum (2)**
- **Mean (3)**
- **Median (4)**
- **Sum of Elements (5)**
- **Product of Elements (6)**
- **Sample Standard Deviation (7)** – using $(n - 1)$ in the denominator
- **Sample Variance (8)** – using $(n - 1)$ in the denominator
- **Population Standard Deviation (9)** – using n in the denominator
- **Population Variance (A)** – using n in the denominator

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List Operations: **4** – perform operations on a list of data:

- **Sort Ascending (1)**
- **Sort Descending (2)**
- **Cumulative Sum List (3)**
- **Fill (4)**
- **Sequence (5)**
- **Difference List (6)**
- **Augment (7)**
- **Convert List to Matrix (8)**
- **Convert Matrix to List (9)**
- **Left (A)**
- **Mid (B)**
- **Right(C)**

Distributions: **5** – See Probability (p.37) for descriptions.

- **Normal Pdf (1)**
- **Normal Cdf (2)**
- **Inverse Normal (3)**
- **t Pdf (4)**
- **t Cdf (5)**
- **Inverse t (6)**
- **χ^2 Pdf (7)**
- **χ^2 Cdf (8)**
- **Inverse χ^2 (9)**
- **F Pdf (A)**
- **F Cdf (B)**
- **Inverse F (C)**
- **Binomial Pdf (D)**
- **Binomial Cdf (E)**
- **Geometric Pdf (F)**
- **Geometric Cdf (G)**
- **Poisson Pdf (H)**
- **Poisson Cdf (I)**

Intervals: **6**

- **z Interval (1)**
- **t interval (2)**
- **2-Sample z Interval (3)**
- **2-Sample t interval (4)**
- **1-Prop z Interval (5)**
- **2-Prop z Interval (6)**
- **Linear Reg t Intervals (7)**
- **Multiple Reg Intervals (8)**

Stat Tests: **7**

- **z Test (1)**
- **t Test (2)**
- **2-Sample z Test (3)**
- **2-Sample t Test (4)**
- **1-Prop z Test (5)**
- **2-Prop z Test (6)**
- **χ^2 GOF Test (7)**
- **χ^2 2-way Test (8)**
- **2-Sample F Test (9)**
- **Linear Reg t Test (A)**
- **Multiple Reg Tests (B)**
- **ANOVA (C)**
- **ANOVA 2-Way (D)**

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Chapter 11: Connectivity

Connecting Two nSpires

- The cable used to connect two nSpires has a mini-USB connection on each end.
- You can connect two nSpires as long as they have the same keypad.
- Insert one end of the mini-USB cable into each nSpire. The USB connection for an nSpire CX CAS is located on the top of the handheld – see the illustration at right.

Copying Files or Folders between nSpires

- Connect the two nSpires.
- On the nSpire that contains the file or folder to be Transferred, press: **[home]** → **My Documents (2)** to open the document file browser.
- Use the arrow keys to highlight the file or folder you want to copy.
- **[doc]** → **File (1)** → **Send (6)** to send the file to the other nSpire.
- A progress bar will be displayed during the transfer and a notification will be displayed when the transfer is complete.

Connecting an nSpire to a PC (note: this will also charge the nSpire battery)

- The cable used to connect an nSpire to a PC has a mini-USB connection on one end and a standard USB connection on the other end.
- Insert the mini-USB cable into the nSpire and the standard USB cable into your PC.
- You may copy files to or from the PC using TI software.
- If you have not purchased either the Teacher or Student software, you may use the free TI nSpire computer link software for this purpose. It is available at: https://education.ti.com/en/us/software/details/en/82035809F7E6474099944056CCB01C20/ti-nspire_computerlink.

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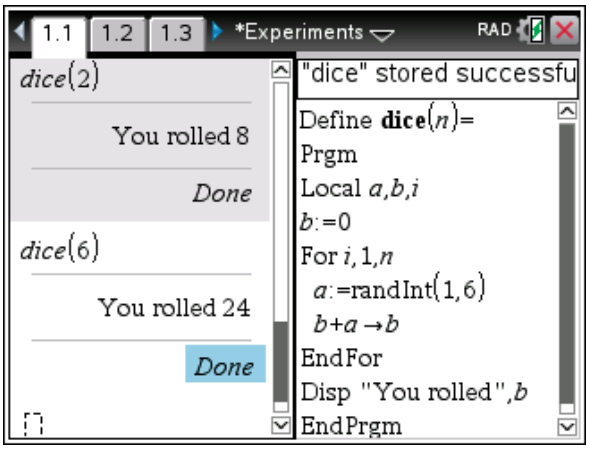
Charging the nSpire battery

- The cable used to charge an nSpire is the same one used to connect it to a PC.
- Insert the mini-USB cable into the nSpire.
- Insert the standard USB cable into either a PC or a wall charger. If you use a wall charger, you must plug the wall charger into a standard AC outlet (sorry – had to say that).

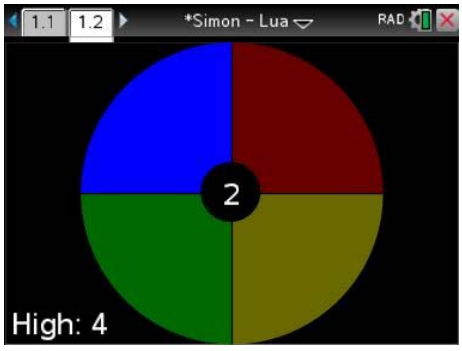
Chapter 12: Programming

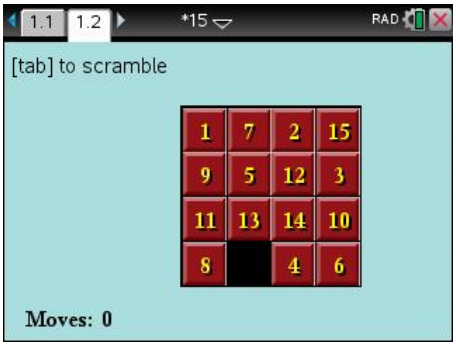
Programming Languages



- TI Basic is the simpler of the two programming languages you can use on the TI nSpire. More about TI Basic is presented below.
  - The Basic programming language is easy to learn, as its name implies. Books on Basic programming can be found at most booksellers.
  - A sample program in TI Basic, for rolling n dice, is shown above.
  - TI Basic is similar to, but not exactly the same as, the Basic programming language. A good online primer on TI Basic is available at: **Error! Hyperlink reference not valid.**. Anyone wanting to program the TI nSpire should begin here.
  - A guide to programming in TI-Basic can be found on pages 315-342 of the TI nSpire Software Manual (pages 327-354 of the PDF file), which is available at: http://www.manualslib.com/download/325947/Ti-Ti-Nspire.html.

- Lua is a more complex language, and includes substantial graphical capabilities. Lua programming is not covered in this document.
  - Information on Lua programming can be obtained at: https://www.lua.org/.
  - Some examples of Lua programming can be found on John Hanna's nSpire page at: http://www.johnhanna.us/TI-nspire.htm. The screens for two of John's latest programs are shown below.





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Functions vs. Programs

User-defined functions and programs are together referred to as scripts. They differ in complexity, functionality and design.

- Functions are usually short and return a single result to the user. In fact, a function's purpose is to return a value.
- Functions may be used within mathematical expressions; programs cannot.
- Functions can be graphed; programs cannot
- Programs are typically longer than functions and involve more logical decision making. Programs are run outside of mathematical expressions, and may produce numerous results for the user.
- Some processes can be developed through either a program or a function. Which approach you choose to use will ultimately depend on the complexity of the process you are modeling and how you wish to use the result(s).

Although we do not cover TI Basic programming in detail in this document, it may be helpful to take a look at a sample function and a sample program. We do this below. But first, …

Writing a Script in TI Basic

To write a script (i.e., a function or program), you must be on a Calculator page in Problem 1 in a document. You can be on any page in Problem 1. You cannot write a script in the Scratchpad.

It is a good idea to create a document to contain functions and programs only. If you write a lot of scripts, you may want to create several such documents in order to organize them.

- To begin writing a script, on a calculator page, press: **[menu]** → **Functions & Programs (9)** → **Program Editor (1)** → **New (1).**
- Assign a name to the script. Note: you do not need to tell the nSpire the arguments (i.e., the variables in the parentheses of the script definition) that you wish to use with the script until after you enter the scripting panel on the page.
- Identify the script as a function or program (see above for the difference).
- Identify the type of library access you desire. None leaves the script in the library for the current problem only. LibPriv places it in a private library. LibPub will make it possible for you to place your script the nSpire Catalog, so you will be able to access it in other documents or the Scratchpad.
- Click on **OK** or press **[enter]** when you are done.
- The page will split to show a panel containing the script, with some lines pre-set.
- **[ctrl]** → **[tab]** will move you back and forth between the panels on the screen.

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Writing a Function in TI Basic

Follow the instructions under "Writing a Script" above, identifying the script as a function. If you wish the function to be available in the nSpire Catalog, be sure to select LibPub as the type of library access you desire.

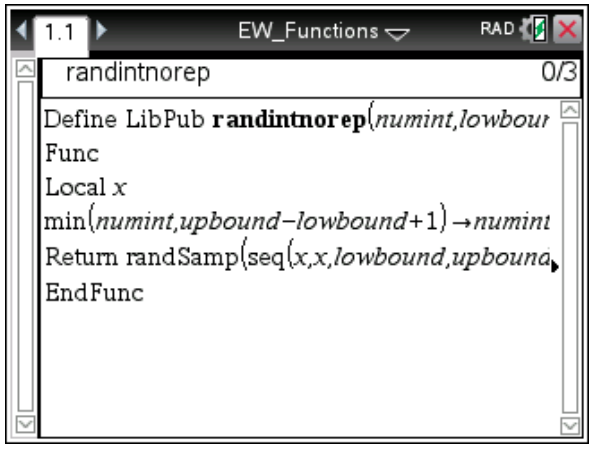
Let's look at a sample function. The one shown below is handy in Probability Theory – the randIntNoRep function, which returns a set of n non-repeating integers over a specific range (*lowBound* to *upBound*). The function exists in the TI-84 Catalog, but for some reason is not included in the default nSpire Catalog. The solution: write a function so you can use it on the nSpire. By writing this function, we reduce the required calculator entry from:

randSamp(seq(*x, x, lowBound, upBound,* **1)***, n,* **1)** to **randIntNoRep(***n, lowBound, upBound***)**,

which is simpler and much easier to remember. Further, **randIntNoRep** can be placed in the nSpire Catalog so it can be used in any document or on the scratchpad of your nSpire.

Let's take a look at the function **randIntNoRep** line by line:

- Line 1: Define LibPub randintnorep(*numint, lowbound, upbound*)= This line is generated by the program editor. It contains the name of the program, the library access for the function and parentheses. Every function has a name followed by parentheses; if you wish to pass arguments to the function, you must type them in the parentheses in the top line. I typed the arguments *numint*, *lowBound* and *upBound* inside the parentheses to let the function know that I want it to return *numint* integers between *lowBound and lowBound*, inclusive.



- Line 2: Func This line is placed in the program by the program editor. It identifies this script as a function (i.e., not a program).
- Line 3: Local x This line provides the names of any variables that I want to define inside the script only – that is, I do not want these variables to exist in the problem after the script runs. Every variable used in a function should be either an argument passed to the function by the user (e.g., *numint*) or listed in a Local statement. Otherwise, you may inadvertantly create variables in your document.
- Line 4: min(numint, upbound-lowbound+1)→numint Just to eliminate errors, I wanted to make sure it was not possible to ask for more integers than exist in the specified range. So, I limit *numint* to the number of integers in the range between *lowBound and lowBound*, inclusive.

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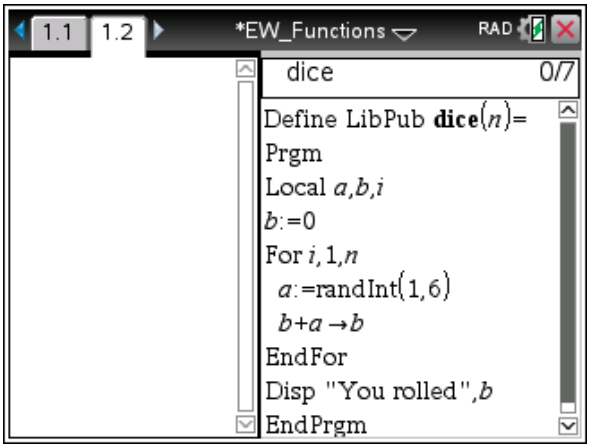
- Line 5: Return randSamp(seq(*x, x, lowbound, upbound,* 1)*, numint,* 1) This is the guts of the function. I use the more complicated nSPire functions to generate the list of random integers I want. The keyword Return tells the function that the result of this statement is what should be returned to the user. All functions have one or more Return statements; without them, nothing is returned to the user and the function is useless.
- Line 6: EndFunc This line is placed in the function by the program editor. It signifies the end of the function.

See After Writing Your Script below for the processes that must occur after you write your function to make sure it works properly and becomes available via the nSpire Catalog.

Writing a Program in TI Basic

Follow the instructions under "Writing a Script" above, identifying the script as a program. If you wish the program to be available in the nSpire Catalog, be sure to select LibPub as the type of library access you desire.

Let's look at a sample program. The one shown here, **Dice**, simulates the rolling of n dice and returns the message "You rolled" followed by the total number rolled.



- Line 1: Define LibPub dice(n)= This line is generated by the program editor. It contains the name of the program, the library access for the program and parentheses. I placed the argument n inside the parentheses to let the program know how many dice will be rolled.
- Line 2: Prgm This line is placed in the program by the program editor. It identifies this script as a program (i.e., not a function).
- Line 3: Local a,b,i This line provides the names of any variables that I want to define inside the program only – that is, I do not want these variables to exist in the problem after the script runs. Every variable used in a program should be either an argument passed to the function by the user (e.g., *n*) or listed in a Local statement. Otherwise, you may inadvertantly create variables in your document.
- Line 4: b:=0 The variable b is what I will use to accumulate the total of the dice thrown. So, I need to initialize it at a value of 0.

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- Line 5: For i,1,n to line 8: EndFor This four-line block of code is a standard For-Loop in the Basic programming language. I told the program to execute lines 6 and 7 multiple times, as the variable *i* is iterated from 1 to *n*. Each iteration assigns a random number from 1 to 6 to the variable a, then adds a to the accumulated total in b.
- Line 9: Disp "You rolled", b I want the user to understand the output of the program, so I created a message to be printed on the screen along with the result.
- Line 10: EndPrgm This line is placed in the program by the program editor. It signifies the end of the program.

After Writing Your Script

After you have written your script (either a function or a program), you should check to see if the nSpire can understand what you wrote and save your script.

- If you are not already in the panel containing the script, **[ctrl]** → **[tab]** to it.
- To check your syntax (i.e., whether you wrote the script so the nSpire can understand it), and save the script to the nSpire's memory,
    - Press: **[menu]** → **Check Syntax & Store (2)** → **Check Syntax & Store (1)** or, use the shortcut **[ctrl]** → **B**. If your syntax is incorrect, you will receive an error message describing the error. Note: if your syntax is correct, your script may still contain logical errors – the nSpire only does what you tell it to, so be precise in your scripting efforts.
    - If you want to check your syntax before saving your work, press: **[menu]** → **Check Syntax & Store (2)** → **Check Syntax (2)**
- Finally, move back to the Calculator panel and test your script. For example, In the case of the sample program **dice(*n*)**, the user must type **dice(3)** to roll 3 dice, **dice (5)** to roll 5 dice, etc. Check to see if the results make sense.
- If the script does not behave the way you wanted it to, you will need to move back to the scripting panel and correct your script.

Saving Your Script to the Catalog

The following steps must be taken to save your script so that it is available from the nSpire catalog for use in other documents and the Scratchpad.

- First, make sure each script that you want to access via the catalog has the keyword LibPub in the definition line.

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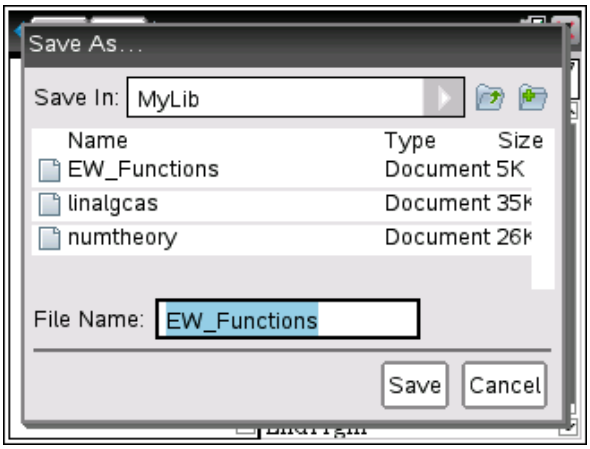
- Save the file containing the scripts in the MyLib directory with a name you can easily remember.
- Refresh the Public Library, and therefore the Catalog, by pressing: **[home] → My Documents (2) → [menu] → Refresh Libraries (B)**

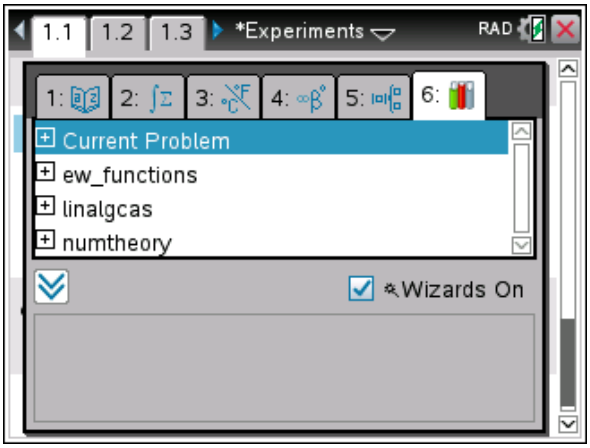


At this point you will be able to access your functions and programs in any situation where you need them.

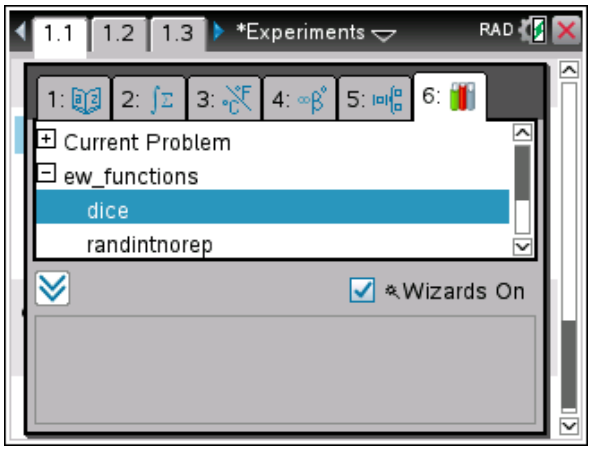
Accessing User-Defined Scripts from the Catalog

To access any your scripts from the Catalog, you must remember the name of the file in which you saved them in the MyLib directory. The steps to access your scripts are:

- From a Calculator page, press the catalog key: 



- Press: **6** to bring up the set of user-defined scripts. You will see something like the display in the figure at left.



- Click on the name of the file that includes your scripts. You will see something like the display in the figure at left.

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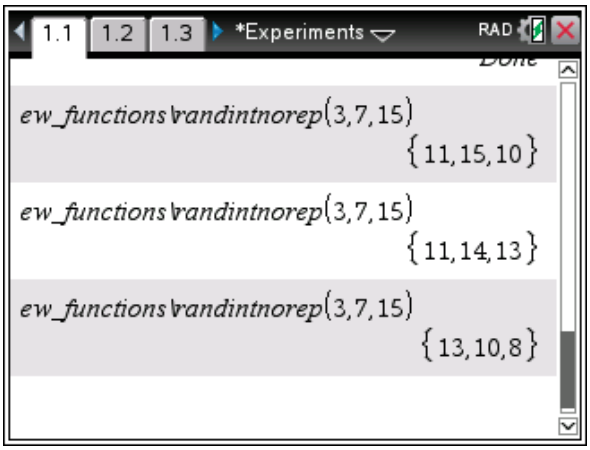
- Click on the name of the script you wish to use. On the screen, you will see the name of the file containing your script, a backslash (\) and the name of the script. Enter any arguments required inside the script's parentheses and press **[enter]** to see the results. See the figure at right, which contains several executions of the function randintnorep to generate three non-repeating random integers between 7 and 15, inclusive.



Note that functions may be used inside programs and other functions, so you can create some rather intriguing cascades of functions. *Just be sure you do not outsmart yourself.* Automated processes are best developed in small steps, where the results of each step can be evaluated for reasonableness.

Some Keywords and Structures to Know When Programming Scripts

You will need to study how to program if you want to write anything beyond the simple types of scripts shown in this chapter. Below is a list of some of the keywords you should be aware of if you choose to write scripts:

- **Disp** *expression or string* [, *expression or string*] … – prints the message or variable value in *expression or string* on the screen. An *expression* may contain one or more variables, operations, functions, etc.
- **Request** *prompt string*, *variable* – requests input from the user. The *prompt string* must be in quotes (""); it is displayed on the screen in a dialog box. When the user enters the value of *variable* in the box and presses **[enter]**, the program continues.
- **Return** e*xpression* – used in a function to return *expression* as the result of the function. In a subroutine, **Return** (with no argument) is used to exit the subroutine.
- **Lbl** *label name* – identifies a location within the program with the *label* provided.
- **Goto** *label name* – causes the program to branch to the location *label name*.
- **Stop** – stops the current process.
- **For** *variable, start value, end value* [, *step*]
  Block of code
  EndFor
  Executes a *block of code* starting with the *variable* equal to *start value*, then incrementing *variable* repeatedly by *step*, stopping when the incremented value exceeds *end value*. If *step* is not present, the increment is 1.
- **While** *expression*
  Block of code
  EndWhile
  Executes a *block of code* as long as *expression* is true.
- **Loop**
  Block of code
  EndLoop
  Executes a *block of code* repeatedly until you actively exit the loop. There must be a condition in the *block of code* that executes an **Exit** command or the loop will be infinite.
- **If** *expression* **Then**
  Block of code
  Else
  Block of code
  EndIf
  Executes the first *block of code* if *expression* is true and the second *block of code* if *expression* is not true.

Many functions and programs can be written with just these keywords (and, of course, variable manipulation). Learn more at:
https://education.ti.com/en/us/solutions/ti-codes.

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Appendix A

Keyboard Shortcuts for the TI-nSpire CX CAS

Document

- **[ctrl]** → **N** – New document.
- **[ctrl]** → **O** – Open document.
- **[ctrl]** → **W** – Close document.
- **[ctrl]** → **S** – Save document.
- **[ctrl]** → **I** – Insert a page within a problem in a document.

Copy, Paste, etc.

- **[ctrl]** → **Z** – Undo. Also **[ctrl]** → **[esc]**
- **[ctrl]** → **Y** – Redo.
- **[ctrl]** → **X** – Cut.
- **[ctrl]** → **C** – Copy.
- **[ctrl]** → **V** – Paste.

Graph Application

- **[ctrl]** → **G** – add a function to a graph.
- **[ctrl]** → **T** – toggle between full screen and a split screen showing a table of values.

Notes Application

- **[ctrl]** → **M** – insert a Math Box.
- **[ctrl]** → **E** – insert a Chem Box.

Lists and Spreadsheet Application

- **[ctrl]** → **G** – move to a specific cell.
- **[ctrl]** → **R** – recalculate all formulas.

Program Editor

- **[ctrl]** → **B** – check syntax and store program.
- **[ctrl]** → **F** – find a string in a program.
- **[ctrl]** → **H** – find and replace a string in a program.

Keyboard Alternatives

pi	π
theta	θ
infinity	∞
sqrt(…)	$\sqrt{\ }$
abs(…)	$\lvert\ \rvert$
@d	degrees
@r	radians
<=	$\leq$
>=	$\geq$
@i	i
@e	e

Note: the "@" sign is in the 4th line of the symbol palette  .

Calculus

- **[shift]** → + to open the integral template.
- **[shift]** → – to open the derivative template.

Line Editing

- **[ctrl]** → **7** move to beginning of line.
- **[ctrl]** → **1** move to end of line.
- **[ctrl]** → **9** move up one page.
- **[ctrl]** → **3** move down one page.

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Appendix B

Some Keyboard Commands for the TI-nSpire CX CAS

Many commands can be input from the keyboard. Here are some of the more interesting ones.

Note: the "@" key is in the 4th line of the symbol palette . The ">" key is the first symbol in the inequality palette . The "∠" key is in the 2nd line of the symbol palette .

General

- **lock** *var1*[, *var2*, …] – locks the specified variable(s) so it cannot be changed.
- **unlock** *var1*[, *var2*, …] – unlocks the specified variable(s) so it can be changed.

Algebra

- **abs(***expression***)** – returns the absolute value of *expression* or list, or the magnitude of a complex expression.
  - **abs**$(\{-3, -5, 2-3i\}) \Rightarrow \{3, 5, \sqrt{13}\}$
- **domain(***expression*, *var***)** – returns the domain of *expression* over the variable.
  - **domain**$\left(\frac{1}{x^2-3x+2}, x\right) \Rightarrow x \neq 1 \text{ and } x \neq 2$
- **factor(***expression***)** – factors *expression*. If *expression* is a number, returns the prime factorization of the number.
  - **factor**$(x^2 - y^2) \Rightarrow (x+y)\cdot(x-y)$
  - **factor(230052)** $\Rightarrow 2^2 \cdot 3 \cdot 19 \cdot 1009$
- **cfactor(***expression***)** – factors *expression* into complex factors if necessary. If the expression is a number, returns the prime factorization of the number.
  - **cfactor**$(x^2 + y^2) \Rightarrow (x + -i\cdot y)\cdot(x + i\cdot y)$
  - **cfactor(230052)** $\Rightarrow 2^2 \cdot 3 \cdot 19 \cdot 1009$
- **completesquare(***expression, var***)** – completes the square of *expression* in the given variable.
  - **completesquare** $(x^2 - 4\cdot x) \Rightarrow (x-2)^2 - 4$
- **mod(***expression, number***)** – returns ***expression* modulo *number***
  - **mod(13, 3)** $\Rightarrow$ **1** (because $13 \pmod 3 = 1$)
- **polyroots(***polynomial, var***)** – returns the real roots of *polynomial* in the variable given.
  - **polyroots**$(x^2 + 3x - 10, x) \Rightarrow$ **{-5, 2}**

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- **polyroots({***list of coefficients***})** – returns the real roots of *polynomial* with coefficients defined by the list.
  - **polyroots**$(\{1, 3, -10\})$ ⇒ **{-5, 2}**
- **cpolyroots(***polynomial, var***)** – returns the complex roots of *polynomial* in the variable given.
  - **polyroots**$(x^2 + 1, x)$ ⇒ $\{-i, i\}$
- **cpolyroots({***list of coefficients***})** – returns the real roots of *polynomial* with coefficients defined by the list.
  - **polyroots**$(\{1, 0, 1\})$ ⇒ $\{-i, i\}$
- **zeros(***expression, var***)** – returns the real zeros of *expression* in the variable given. Same as **polyroots** for a polynomial, but can handle other functions.
  - **zeros**$(\sin\theta, \theta)$ ⇒ $\{n1 \cdot \pi\}$ (where, n1 is any integer)
- **czeros(***expression, var***)** – returns the complex zeros of *expression* in the variable given. Same as **cpolyroots** for a polynomial, but can handle other functions.

Trigonometry

- *expression* **@>sin** – converts *expression* to one based only on the sine function.
  - **1-cos(x)²@>sin** ⇒ **sin(x)²**
- *expression* **@>cos** – converts *expression* to one based only on the cosine function.
  - **1-sin(x)²@>cos** ⇒ **cos(x)²**
- **tCollect(***expression***)** – converts products and integer powers of sines and cosines in *expression* to a linear combination of sines and cosines of multiple angles, angle sums and angle differences. It is the inverse of **tExpand**.
  - **tCollect(sin(x)·cos(y))** ⇒ $\frac{\sin(x-y)+\sin(x+y)}{2}$
- **tExpand(***expression***)** – expands *expression* using the sine and cosine functions.
  - **tExpand(sin(x+y))** ⇒ **cos(x)·sin(y)+sin(x)·cos(y)**
- *expression* **@>polar** – converts Rectangular coordinates to Polar coordinates.
  - **[1, 3.] @>polar** ⇒ **[3.16228 ∠1.24905]** (angle result is in radians)
  - See below for conversion of Polar coordinates to Rectangular coordinates.
- *expression* **@>cylind** – converts 3D Rectangular coordinates to Cylindrical.
  - **[1, 2., 3] @>cylind** ⇒ **[2.23607 ∠1.10715 3]** (angle result is in radians)

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- *expression* **@>sphere** – converts 3D Rectangular or Cylindrical coordinates to Polar.
  - **[1, 2., 3.] @>sphere** ⇒ **[3.74166 ∠1.10715 ∠0.64052]** (angle results are in radians)
  - **[1, ∠$\frac{\pi}{4}$, 3.] @>sphere** ⇒ **[3.16228 ∠$\frac{\pi}{4}$ ∠0.32175]** (angle results are in radians)
- *Vector in polar form* **[enter]** – converts Polar coordinates to Rectangular.
  - **[menu]** → **Matrix & Vector (7)** → **Create (1)** → **Matrix (1)** – to create a 1x2 matrix (a vector). The first element is the magnitude, the second element is the angle (use the ∠ key and enter the angle in radians).
  - $\left[3\ \angle\frac{\pi}{4}\right]$ **[enter]** ⇒ $\left[\frac{3\sqrt{2}}{2}, \frac{3\sqrt{2}}{2}\right]$ (exact answer)
  - $\left[3\ \angle\frac{\pi}{4}\right]$ **[ctrl]** → **[enter]** ⇒ **[2.12132, 2.12132]** (approximate answer)

Matrices

- **augment(***matrix1, matrix2***)** – returns a new matrix with *matrix2* appended to *matrix1* as new columns.
- **charpoly(***square matrix, var***)** – returns the characteristic polynomial of *square matrix* in the variable specified.
- **det(***square matrix***)** – returns the determinant of *square matrix*.
- **diag(**list**)** – returns a diagonal matrix with the elements of list along the diagonal.
- **eigVc(***square matrix***)** – returns the eigenvectors of *square matrix*.
- **eigVl(***square matrix***)** – returns the eigenvalues of *square matrix*.
- **ref(***matrix***)** – returns the row-echelon form of *matrix*.
  - $\mathbf{ref}\begin{bmatrix}-2 & -2 & 0 & -6\\ 1 & -1 & 9 & -9\\ -5 & 2 & 4 & -4\end{bmatrix} \Rightarrow \begin{bmatrix}1 & -\frac{2}{5} & -\frac{4}{5} & \frac{4}{5}\\ 0 & 1 & \frac{4}{7} & \frac{11}{7}\\ 0 & 0 & 1 & -\frac{62}{71}\end{bmatrix}$
- **rref(***matrix***)** – returns the reduced row-echelon form of *matrix*.
  - $\mathbf{ref}\begin{bmatrix}-2 & -2 & 0 & -6\\ 1 & -1 & 9 & -9\\ -5 & 2 & 4 & -4\end{bmatrix} \Rightarrow \begin{bmatrix}1 & 0 & 0 & \frac{66}{71}\\ 0 & 1 & 0 & \frac{147}{71}\\ 0 & 0 & 1 & -\frac{62}{71}\end{bmatrix}$

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Calculus

- **fmax(***expression, var***[**, *lowbound***[**, *upbound***]])** – returns the function maximum of the expression. If *lowbound* and/or *upbound* are included, they restrict the domain over which the maximum is determined.
  - **fmax**$\left(\frac{-10x+5}{x^2+6x+5}, x\right)$ ⇒ $x = -5$ **or** $x = -1$ (which are the asymptotes)
  - **fmax**$\left(\frac{-10x+5}{x^2+6x+5}, x, -4.99, -1.01\right)$ ⇒ $x = \frac{-(\sqrt{33}-1)}{2}$ (which is the relative maximum of the function on the interval [-4.99, -1.01])
- **fmin(***expression, var***[**, *lowbound***[**, *upbound***]])** – returns the function minimum of the expression. If *lowbound* and/or *upbound* are included, they restrict the domain over which the maximum is determined. Works the same way as **fmax**.
- **normalLine(***expression, var=value***)** – returns the equation of the line normal to *expression* at $var = value$.
  - **nomalLine**$\left(\frac{x^3}{3}, x, 2\right)$ ⇒ $\frac{19}{6} - \frac{x}{4}$
- **tangentLine(***expression, var=value***)** – returns the equation of the line tangent to *expression* at $var = value$.
  - **tangentLine**$\left(\frac{x^3}{3}, x, 2\right)$ ⇒ $4 \cdot x - \frac{16}{3}$

Probability and Statistics

- **nCr(***n, r***)** – returns $\frac{n!}{(n-r)!r!}$
  - **nCr**$(x, 3)$ ⇒ $\frac{x \cdot (x-1) \cdot (x-2)}{6}$
  - **ans|**$x = 5$ ⇒ **10**

Note: The "**|**" key is the last symbol in second row of the inequality palette  .

- **nPr(***n, r***)** – returns $\frac{n!}{(n-r)!}$
  - **nPr**$(x, 3)$ ⇒ $x \cdot (x-1) \cdot (x-2)$
  - **ans|**$x = 5$ ⇒ **60**
- **randSeed** *number* – sets the random seed value for generating random numbers. If $number = 0$, the seed sets to the factory result. One way to get a decent random seed is to enter the time in minutes and seconds. Succeeding random numbers, then are more likely to be truly random.
  - **randseed 1542** (for 15 minutes and 42 seconds past the hour)
- **rand()** – returns a random decimal between 0 and 1.

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- **rand(*n*)** – returns ***n*** random decimals between 0 and 1.
- **randInt(**lowBound, upBound[, n]**)** – returns a random integer between **lowBound** and **upBound**, inclusive.
- **randInt(**lowBound, upBound[, n]**)** – returns ***n*** random integers between **lowBound** and **upBound**, inclusive.
- **randSamp(seq(***x, x, lowBound, upBound,* **1)**, *n,* **1)** – returns ***n*** non-repeating random integers between **lowBound** and **upBound**, inclusive.
    - **randSamp(seq(x, x, 3, 8, 1), 6, 1)** ⇒ **{3, 6, 8, 4, 7, 5}**
    - note: this is complicated to remember, so you may want to write a function "**randIntNoRep(***n, lowBound, upBound***)**" like exists on the TI-84 and store it in the public library. The code for this is provided in Chapter 10.
- **mean(***list[, freqList]***)** – returns the mean of the items in *list* with frequencies in *freqList*.
- **median(***list[, freqList]***)** – returns the median of the items in *list* with frequencies in *freqList*.
- **stDevPop(***list[, freqList]***)** – returns the standard deviation of the population in *list* with frequencies in *freqList*. It uses "**n**" in the denominator of the calculation.
- **stDevSamp(***list[, freqList]***)** – returns the standard deviation of the sample in *list* with frequencies in *freqList*. It uses "**n-1**" in the denominator of the calculation.
- There are no Library functions for the skewness or kurtosis statistics of a population or sample.
- **sum(***list[, Start[, End]]***)** – returns the sum of the items in *list*.

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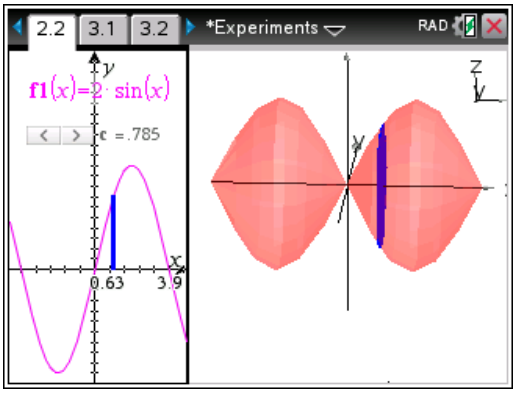
Appendix C: Special Projects

Solid of Revolution about the x-axis



- Add a Graphs page. **[ctrl] → I → Add Graphs (2).**
- Break the display into two panels. **[doc] → Page Layout (5) → Layout 2 (2).**
- Adjust the panel sizes.
  - **[doc] → Page Layout (5) → Custom (1).**
  - Use the arrow keys to change the page split so that roughly 1/3 is on the left.
- In the left panel, plot the function to be revolved: **[ctrl] → G** → enter function definition.
- Create a vertical segment under the curve that can be moved left and right.
  - Graph vertical line: **[menu] → Graph Entry/Edit (3) → Relation (2) → $\mathbf{x = c}$**
  - Add a slider for the constant **c**: **[menu] → Actions (1) → Insert Slider (B).** Set an initial value of **c** so that you can see it well on the graph.
  - Mark the points of intersection of the line $\mathbf{x = c}$ with your curve and the x-axis: **[menu] → Geometry (8) → Points & Lines (1) → Intersection Points (3).**
  - Draw a segment between the two points of intersection: **[menu] → Geometry (8) → Points & Lines (1) → Segment (5).** Click on the points of intersection.
  - Hide the points of intersection and the vertical line $\mathbf{x = c}$. Hover the mouse over each, then **[ctrl] → [menu] → Hide (4).** Also, do this to labels if you like.
  - Change attributes of the curve or segment. Hover over the object, then
    - **[ctrl] → [menu] → Attributes (3)** to change thickness or make dotted.
    - **[ctrl] → [menu] → Color (8)** to change color.
  - Zoom as desired: **[menu] → Window/Zoom (4).**
- Graph the disk and the solid of revolution in the right panel. Begin by clicking in the right panel (or **[ctrl] → [tab]**). The functions will be defined parametrically.
  - **[menu] → View (2) → 3D Graphing (3).**
  - **[menu] → 3D Graph Entry/Edit (3) → Parametric (2).**
  - Graph the disk in 3D: $\mathbf{xp1(t,u) = c}$; $\mathbf{yp1(t,u) = f1(c)\cdot\cos(t)\cdot\cos(u)}$; $\mathbf{zp1(t,u) = f1(c)\cdot\sin(t)}$
  - Graph the solid in 3D: $\mathbf{xp2(t,u) = t}$; $\mathbf{yp2(t,u) = f1(c)\cdot\cos(u)}$; $\mathbf{zp2(t,u) = f1(c)\cdot\sin(u)}$
  - Change attributes, hide the 3D box, etc. for a prettier display.
  - Zoom as desired.

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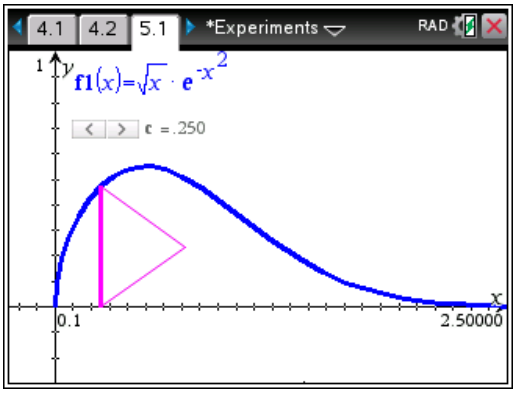
Connect a Geometry Item to a Curve in a Graph

Example: Equilateral Triangle



- Add a Graphs page and plot a function: **[ctrl] → G**
- Create a vertical segment under the curve that can be moved left and right.
  - Graph vertical line: **[menu] → Graph Entry/Edit (3) → Relation (2) → $x = c$**
  - Add a slider for the constant c: **[menu] → Actions (1) → Insert Slider (B)**. Set a value of c that you can see well on the graph.
  - Mark the points of intersection of the line $x = c$ with your curve and the x-axis: **[menu] → Geometry (8) → Points & Lines (1) → Intersection Points (3)**.
  - Draw a segment between the two points of intersection: **[menu] → Geometry (8) → Points & Lines (1) → Segment (5)**. Click on the points of intersection.
  - Hide the points of intersection and the vertical line $x = c$. Hover the mouse over each, then **[ctrl] → [menu] → Hide (3 or 4)**. Also, do this to labels if you like.
  - Change attributes of the curve or segment. Hover over the object, then
    - **[ctrl] → [menu] → Attributes (3)** to change thickness or make dotted.
    - **[ctrl] → [menu] → Color (8)** to change color.
  - Zoom as desired: **[menu] → Window/Zoom (4).**
- Create an equilateral triangle with one side being the vertical segment.
  - Draw a pair of rotated segments:
    - **[menu] → Geometry (8) → Transformation (5) → Rotation (4)**.
    - Click on the segment.
    - Click on the bottom point of the segment.
    - Type $-\pi \div 3$ **[enter]**. Rotation is counter clockwise.
    - Click on the segment.
    - Click on the top point of the segment.
    - Type $\pi \div 3$ **[enter]**. Rotation is counter clockwise.
    - This will complete the triangle.
  - Change attributes and colors of the curve, segment and triangle.
  - Hide anything you do not want to show.

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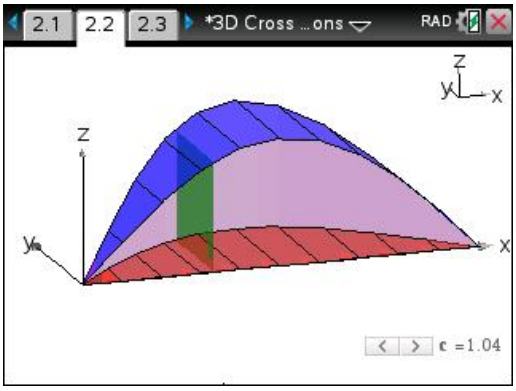
Volume by Cross Section
Using 3D Parametric Equations
Example: Square Cross Sections



Add a Graphs page and plot functions:

- **[ctrl]** → **I** → **Graphs (2)** – to add a Graphs page.
- **[menu]** → **View (2)** → **3D Graphing (3)** → **[esc]** – to create a 3D graph.
- **[menu]** → **View (2)** → **Hide Box (4)** – to hide the 3D box.
- Add a slider for the constant **c**, which will vary with the variable x: **[menu]** → **Actions (1)** → **Insert Slider (B)**. Enter minimum and maximum values of x, set a value of **c** between the minimum and maximum values of x, and click on **Minimize**. Then click **[enter]**.
- **[menu]** → **3D Graph Entry/Edit (3)** → **Parametric (2)** – to make the graph parametric.
- Set the ranges of the x, y and z variables that will be shown on the graph: **[menu]** → **Range/Zoom (4)** → **Range Settings (1)**. Note that the ranges for some variables may need to be expanded in order to show the boundary lines for those variables on the graph.
- Plot each of the functions in the table below. Note that the functions will vary for cross sections other than a square. Some math is required to generate the correct functions.
  - **[ctrl]** → **G** (if needed, to open the entry line; it may already be open).
  - Enter the values of the x-, y- and z-equations of the curve. Make sure you **[tab]** to the ellipsis button ... to enter the proper ranges of the parameters **t** and **u**.
  - Adjust the attributes and color of the curve, hide labels, etc.
- Rotate the graph (w/ arrow keys or "**a**" key) and move the slider to check out your creation.

Graph settings range: x-range: $[0, \pi]$ y-range: $[0, 1.1]$ z-range: $[0, 1]$

Curve	**1**	**2**	**3**	**4**	**5**
Description	top curve (height)	base curve	front boundary	back boundary	vertical slice
***t*-range**	$[0, 2\pi]$	$[0, 2\pi]$	$[0, \pi]$	$[0, \pi]$	$[0, 1]$
***u*-range**	$[0, \pi]$	$[0, \pi]$	$[0, 1]$	$[0, 1]$	$[0, 1]$
***xp_*(t, u)**	t	t	t	t	**c**
***yp_*(t, u)**	$\frac{1}{3} \cdot \mathbf{f1}(\mathbf{t}) \cdot u$	$\frac{1}{3} \cdot \mathbf{f1}(\mathbf{t}) \cdot u$	0	$\mathbf{f1}(\mathbf{t})$	$u \cdot \mathbf{f1}(\mathbf{c})$
***zp_*(t, u)**	$\mathbf{f1}(\mathbf{t})$	0	$u \cdot \mathbf{f1}(\mathbf{t})$	$u \cdot \mathbf{f1}(\mathbf{t})$	$t \cdot \mathbf{f1}(\mathbf{c})$

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Appendix D

Index of Hyperlinks to Key Items

In the Microsoft Word version of this document, you can go to a topic by pressing **[ctrl] click** on its description above. Both Microsoft Word and Adobe PDF (good for phones) versions of this document are available online at: http://www.mathguy.us/BySubject/nSpire.php.