# Novus 4515 Mathematician P.R.

## Operations Guide

# Made in America, with pride, by National Semiconductor

All the advanced electronics in this Novus calculator are manufactured by National Semiconductor Corp., a world leader in the design and production of solid-state electronic components. National is a multinational, NYSE-listed company that's demonstrated unparalleled growth over the last six years.

Your Novus calculator is built in the USA. That's because American technology — and specifically the know-how of National Semiconductor—is the key to this product's quality, reliability and computation "horsepower." No other manufacturer can equal National's ability to produce rugged, performance-packed components in the large volumes that result in quality products with small price tags.

The same National Semiconductor electronics have helped take Americans to the moon and back, and are the critical "guts" of high-performance products ranging from life-saving medical equipment to consumer products such as color tv's and digital watches.

You now own one of the world's most technically-advanced consumer products. We hope you'll be as proud to use it as we were to make it.

# DIRECTORY

## Getting Started

Turn your NOVUS Mathematician on with the switch located on the left side of the calculator. The calculator is automatically cleared and the display should now show 0. If it does not, check to see if your battery needs recharging by connecting the NOVUS AC Charger.

## AC Charger

Your NOVUS Mathematician is powered by rechargeable batteries which should give you about two months of operation with normal use. To charge your battery, connect the NOVUS AC Charger to the jack on the top right side of the machine. A typical full charge takes five hours. You can operate your calculator while it is charging with the charger connected. BE SURE YOUR MACHINE IS TURNED OFF BEFORE CONNECTING THE AC CHARGER.

## Keyboard Layout

Single function keys and the upper functions on double function keys have their functions defined in silver lettering above the key. They will be represented in this manual by ☐. Lower functions on double function keys have their functions defined in yellow lettering below the key. They will be represented in this manual by parentheses.

To access lower functions, press [F] then the desired key. If you accidentally touch [F] when you didn't want to, a touch of the [C↓] key will cancel the effect of the [F] key.

## Operation

### Display

The NOVUS Mathematician will accept and display any positive or negative number between 0.0000001 and 99999999. Any result larger than 99999999. will result in an overflow, indicated by all zeros and decimal points being displayed.

Negative numbers are represented by a minus sign just to the left of the number in the display.

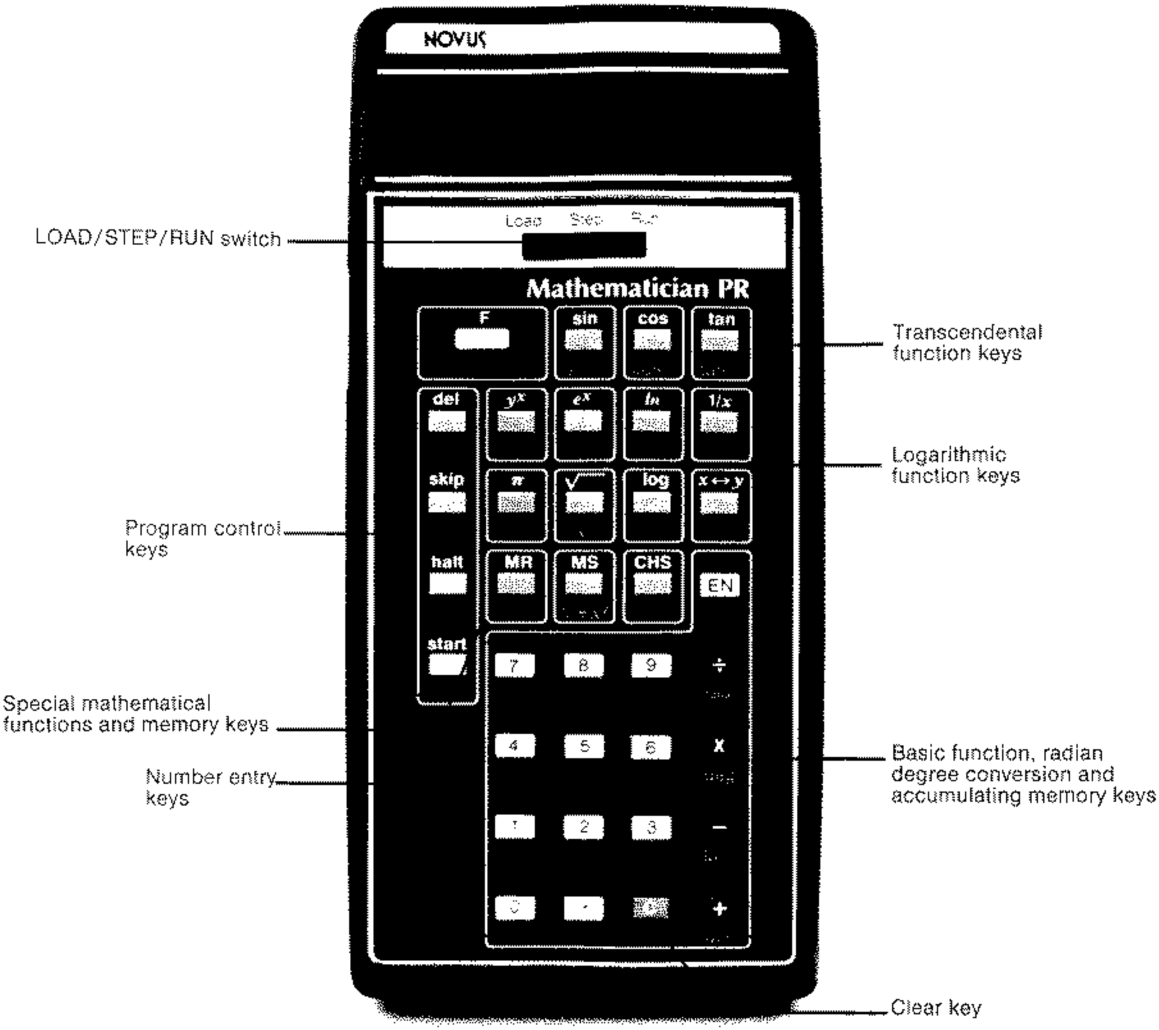
### Automatic Display Shutoff

To save battery life, the NOVUS Mathematician automatically shuts off the display and shows all decimal points if no key has been pressed for approximately 35 seconds. No data has been changed and further entries or operations will bring back the display. To restore the display without changing its contents, press the [CHS] key twice.

### Keying in and Entering Numbers

To enter the first number for a 2-function calculation, key in the number and press [ENT]. If your number includes a decimal point, key it in with the number. You do not have to key in the decimal in whole numbers.

# Keyboard Layout



### Correcting Mistakes

If you enter a wrong number, one touch of the [C↓] key will clear the error and bring back the previous number. Although it is not necessary to clear the Mathematician between problems, three touches of the [C↓] key will clear all except memory. If you make a mistake after touching a function key, the best way to correct your mistake is to enter the last number again and touch the opposite function. For example: If you find you have multiplied 12 by 6 when you wanted to divide 12 by 6, enter the 6 again, touch [÷] (division is the opposite of multiplication) and you are back where you started before making the mistake.

### X Y Exchange

The X Y exchange key, [X↔Y], allows you to exchange the contents of the display with what was last in the display.

### Change Sign Key

The [CHS] key enables you to change the sign of the number in the display. If the number is positive, touching [CHS] will make it negative and vice versa. To enter a negative number, key in the number and touch [CHS].

### Entering π

The constant Pi (3.1415926) can be entered directly by touching the [π] key.

## Performing Calculations

Since many people who use electronic slide rules deal with complex problems, Novus believes the calculator should not add to the complexity of the problem. Therefore, Novus selected the Reverse Polish Notation stack principle, which lets you do your problems the SAME WAY each time, no matter what the problem. In addition to the separate memory, there are three locations where numbers can be kept and operated on. These locations are called registers and in your Mathematician these have been combined into an automatic stack. (See Appendix A for a complete explanation of the stack).

### The Logic of Reverse Polish Notation (RPN)

If you remember the following three steps, you will quickly master your NOVUS Mathematician and have confidence in its answers.

1. Starting at the left and working right, key in the next number (or the first number if this is the beginning of a new problem).
2. Ask yourself: "Can an operation be performed?" If yes, perform all operations possible. If no, press [ENT].
3. Repeat steps 1 and 2 until your calculation is complete.

### One-factor calculations

One-factor functions work directly on what is in the display, there is no need to press [ENT] before performing the function.

[ln]* computes the natural logarithm of any positive number in the display.

[LOG]* computes the common logarithm of any positive number in the display.

[$e^x$]* computes the natural antilog of the number in the display by raising the constant 'e' (2.7182818) to the power in the display.

[1/x] computes the reciprocal of the number in the display.

Example: 1/2 = 0.5.

| KEY IN | DISPLAY SHOWS |
|---|---|
| 2 | 2 |
| [1/x] | .5 |

[√‾] computes the square root of any positive number in the display.

($X^2$) after touching the [F] key, computes the square of the number in the display.

Example: $5^2 = 25$.

| KEY IN | DISPLAY SHOWS |
|---|---|
| 5 | 5 |
| [F] ($X^2$) | 25. |

*See Appendix A for a diagram explanation of how these work on the stack.

### Trigonometric functions

[SIN] computes the sine of the angle in the display.*

[COS] computes the cosine of the angle in the display.*

[TAN] computes the tangent of the angle in the display.*

* DEGREES ONLY!

Touching the [F] key before touching ($\sin^{-1}$), ($\cos^{-1}$) or ($\tan^{-1}$) will compute the arc sine, arc cosine or arc tangent, respectively, of the number in the display.

Example: Arc sine .5 = 30°

| KEY IN | DISPLAY SHOWS |
|---|---|
| .5 | .5 |
| [F] | .5 |
| ($\sin^{-1}$) | 30. |

(rad) after touching the [F] key, converts number in the display from degrees to radians.

Example: 90° = 1.5707963 radians.

| KEY IN | DISPLAY SHOWS |
|---|---|
| 90 | 90 |
| [F] (rad) | 1.5707963 |

(deg) after touching the [F] key, converts number in the display from radians to degrees.

### Two-factor calculations

To perform two-factor calculations, key in the first number, touch [ENT], key in the second number and touch the desired function key.

[+] adds what is in the display to what was last in the display.

Example: 2 + 3 = 5.

| KEY IN | DISPLAY SHOWS |
|---|---|
| 2 | 2 |
| [ENT] | 2. |
| 3 | 3 |
| [+] | 5. |

[−] subtracts what is in the display from what was last in the display.

[×] multiplies what is in the display by what was last in the display.

[÷] divides what was last in the display by what is now in the display.

Example: $12 \div 6 = 2.$

| KEY IN | DISPLAY SHOWS |
|---|---|
| 12 | 12 |
| [ENT] | 12 |
| 6 | 6 |
| [÷] | 2. |

[Yˣ]* raises the number in the display to the power now in the display.

Example: $4^4 = 256.$

| KEY IN | DISPLAY SHOWS |
|---|---|
| 4 | 4 |
| [ENT] | 4. |
| 4 | 4 |
| [yˣ] | 256. |

Since taking the Xth root of Y is the same as raising Y to the 1/x power, to obtain roots, touch [1/x] before touching [yˣ].

Example: $\sqrt[4]{256} = 4.$

| KEY IN | DISPLAY SHOWS |
|---|---|
| 256 | 256 |
| [ENT] | 256. |
| 4 | 4 |
| [1/x] | .25 |
| [yˣ] | 3.999998** |

**Chain calculations with two-factor functions**

The number in the display is always ready to have calculations performed on it. Chain problems require no forethought with RPN! Just follow the three steps of RPN.

* See appendix A for a diagram explanation of how this function works on the stack.

**The reason for the small variation from the absolute answer lies in that the Mathematician uses a log, antilog method of raising to powers; i.e., $y^x = e^{x \ln y}$. While $\sqrt[4]{256} = 4$, most calculators will give you 3.999998 because there is simply no 8-digit number which gives 4 when e is raised to this power.

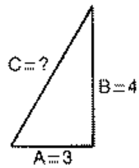


Example: $(2 \times 3) + (4 \times 5) = 26.$

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 2 | 2 | Starting at the left, key in the first number. |
| [ENT] | 2. | Can an operation be performed? No. Press [ENT] |
| 3 | 3 | Working left to right, key in the next number. |
| [×] | 6. | Can an operation be performed? Yes. Perform the operation. |
| 4 | 4 | Working left to right, key in the next number. |
| [ENT] | 4. | Can an operation be performed? No. (There aren't two factors to add together yet). Press [ENT] |
| 5 | 5 | Working left to right, key in the next number. |
| [×] | 20. | Can an operation be performed? Yes. Perform all operations possible. (In this case, two: multiplication then addition). |
| [+] | 26. | End of calculation. |

**Chain calculations combining one and two-factor functions**

Example: If you have a right triangle with side A = 3 and side B = 4, you can find the third side using the Pythagorean theorem $\sqrt{A^2 + B^2} = C$. Substituting: $\sqrt{3^2 + 4^2} = 5.$




| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 3 | 3 | Starting at the left, key in the first number. |
| [F] ($X^2$) | 9. | Can an operation be performed? Yes, squaring. Perform all operations possible. |
| 4 | 4 | Working left to right, key in the next number. |
| [F] ($X^2$) | 16. | Can an operation be performed? Yes. Perform all operations possible. (In this case, three: squaring, addition, square root). |
| [+] | 25. | |
| [√‾] | 5. | Calculation is complete. It's that simple! |

# Memory

The NOVUS Mathematician has a completely independent memory which can be used to store constants for later use, for storing intermediate results or to accumulate into memory.

[MS] stores the number in the display in memory. Any previously stored number is replaced by the new number. To clear memory, enter 0 then touch [MS].

[MR] recalls the number in memory to the display.

(M+) after touching [F], touching (M+) adds the number in the display to the number in memory and leaves the sum in memory. The display remains unchanged.

(M−) after touching [F], touching (M−) subtracts the number in the display from the number in memory and leaves the difference in memory. The display remains unchanged.

Example: Store 12 in memory, add 6 to it, subtract 3 from it and then recall memory to see what you have. In memory: $12 + 6 - 3 = 15$.

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 12 | 12 | |
| [MS] | 12. | Memory now has 12 stored in it, replacing what was previously in memory. Display remains unchanged. |
| 6 | 6 | |
| [F] (M+) | 6. | Memory now has 18 (12 + 6) stored in it. Display remains unchanged. |
| 3 | 3 | |
| [F] (M−) | 3. | Memory now has 15 (18 − 3) stored in it. Display remains unchanged. |
| [MR] | 15. | Recall what is in memory to the display. Memory remains unchanged. |

($M+X^2$) after touching the [F] key, squares the number in the display and adds it to the number in memory. Display remains unchanged.

Example: Sum of squares. $4^2 + 2^2 + 3^2 = 29$.

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 4 | 4 | |
| [F] ($X^2$) | 16. | |
| [MS] | 16. | Store the first number in the memory. |
| 2 | 2 | |
| [F] ($M+X^2$) | 2. | Memory now contains 20. ($16 + 2^2$). Display remains unchanged. |
| 3 | 3 | |
| [F] ($M+X^2$) | 3. | Memory now contains 29. ($20 + 3^2$). Display remains unchanged. |
| [MR] | 29. | Recall what is in memory to the display. Calculation complete. |

# Error Conditions

Any overflow or illegal operation will cause the NOVUS Mathematician to indicate an error condition by displaying all zeros and decimal points. (See Appendix C for a complete table of illegal operations). Touching [C↓] clears the error condition and lets you start the problem over again. Touching any key EXCEPT [1/x], [÷], [LOG] or [ln] clears the error condition and assumes continuance of the calculation in progress with the number in the display being equal to zero. Memory is not affected by the error condition. If performing a function would cause the contents of memory to overflow, the error condition will be displayed and the contents of memory will remain undisturbed.

# Programming

The addition of learn-mode programming to the already powerful NOVUS Mathematician creates a truly innovative combination of calculating power and convenience. The Mathematician's programming capability means you can virtually eliminate the possibility of errors in performing repetitious calculations. And it means you can save not just minutes, but hours of valuable time in performing sophisticated problems.

Learn-mode programming is essentially automatic key pressing. Once you have found an efficient sequence of steps that solves a particular problem, you can program those steps to work the problems with a full range of variables.

There are 100 steps of programming available. This means you can store up to 100 keyboard operations at one time. You can program the Mathematician with one large program or as many small programs as you can fit into the 100 steps. If you go past 100 steps, the calculator will indicate an error condition by displaying all decimal points.

**LOAD/STEP/RUN Switch**

LOAD — To program the calculator, key in a particular calculating sequence with the switch in the LOAD position. Once programmed, the Mathematician will perform that sequence of operations until you reprogram or turn the machine off.

STEP — With the switch in the STEP position, the calculator will execute one step of a stored program for each touch of the [start] key.

RUN — With the switch in the RUN position, touch [start] to execute a stored program.

[start] With the LOAD/STEP/RUN switch in the LOAD position, touching [start] clears the entire program storage area of all previous programs and initializes the calculator for accepting a new set of programs. Touching the [start] key is always necessary at the beginning of the first program.

With the LOAD/STEP/RUN switch in the RUN position, touching [start] begins execution of the first stored program, or, if the program is paused at a HALT command, touching [start] continues execution of the program with the first step following the HALT.

[halt] With the LOAD/STEP/RUN switch in the LOAD position, touching [halt] programs a data entry pause in the playback of a key sequence. This enables you to tell the program to stop for entry of a variable. Any positive or negative number entered after touching [halt] will not be stored as part of the program. Entering a number WITHOUT touching [halt] will enter that number in the program as a constant. The [halt] key is ignored if the LOAD/STEP/RUN switch is in the RUN position.

[skip] With the LOAD/STEP/RUN switch in the LOAD position, touching [skip] terminates the current program and marks the beginning of a new program.

With the LOAD/STEP/RUN switch in the RUN position, if the program is stopped at the beginning of the first program, touching [skip] will cause the first program to be skipped. Execution automatically begins again with the start of the second program and continues to the first programmed HALT or, if there is no programmed HALT, to the end of all programs. If the program is stopped at a HALT, touching [skip] will cause all subsequent steps of the current program to be skipped. Execution automatically begins again with the start of the next program and continues to the first programmed HALT, or if there is no programmed HALT, to the end of all programs.

[del] With the LOAD/STEP/RUN switch in the LOAD position, touching [del] (delete) provides an editing function by erasing the last step entered in the program. Multiple deletes can be used to remove several steps or even complete programs. If a programmed SKIP is deleted, or if an attempt is made to delete START, the calculator will indicate an error by displaying all decimal points. If a programmed SKIP has been deleted by mistake, re-entering [skip] will reinitiate that program.

Example: Program the Mathematician to calculate

$$\sinh x = \frac{e^x - e^{-x}}{2},$$

for $x = .6$; $x = 3$ and $x = 2.4$:

With the LOAD/STEP/RUN switch in the LOAD position:

| STEP | KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 1 | [start] | 0 | Clear program area and initiate new program. |
| 2 | [halt] | 0 | Pause to enter variable (the value of x). Since the Mathematician will perform calculations while you are programming it, we can use the first value of x to debug the program. |
| 3 | .6 | .6 | First value of x. |
| 4 | [$e^x$] | 1.822118 | |
| 5 | [ENT] | 1.822118 | |
| 6 | [1/x] | .54881187 | $e^{-x}$. |
| 7 | [−] | 1.2733062 | |
| 8 | 2 | 2 | Since no HALT preceded this numerical entry, it is programmed in as a constant. |
| 9 | [÷] | .6366531 | Program is complete. First value of sinh x is calculated providing "built-in" debugging. |

Move the LOAD/STEP/RUN switch to the RUN position:

| STEP | KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 1 | [start] | | Program starts at beginning and executes to first programmed HALT. |
| 2 | 3 | 3 | Program has paused for a variable. Enter next value of x. |
| 3 | [start] | 10.017866 | sinh 3. Program continues to end, calculates and displays sinh 3. |
| 1 | [start] | 10.017866 | Start program at beginning. |
| 2 | 2.4 | 2.4 | Enter next value of x. |
| 3 | [start] | 5.466226 | sinh 2.4. Program continues to end, calculates and displays sinh 2.4. |

## Multiple Programs

When programming with the LOAD/STEP/RUN switch in the LOAD position, keying in a [skip] terminates the current program and initiates a new one. Using this feature, you can key in as many separate programs or subprograms as will fit into 100 steps. Remember that touching [skip] with the LOAD/STEP/RUN switch in the RUN position while the current program is pausing at a HALT command terminates the current program and begins execution of the following program. The following program will then run until the first programmed HALT or to the end of all programs. If you want the Mathematician to pause at the beginning of each new program, be sure a [halt] is programmed immediately following [skip].

Example: Calculate the circumference and area of a circle or the area and volume of a sphere, whichever is needed. Since you do not know which you will need, you can write two programs, and use whichever one is necessary.

The first program will be for the circle and use the formulas:

circumference $= 2\pi r$, where r is the radius,
and area $= \pi r^2$.

The second program will be for the sphere using the formulas:

area $= 4\pi r^2$, where r is the radius,
and volume $= 4/3\pi r^3$.

Since you can debug the Mathematician using actual variables, use a radius of r = 1 while writing programs. With r = 1, circumference of circle = 6.2831852, area of circle = 4.1415296; area of sphere = 12.56637 and volume of sphere = 4.18879.

With the LOAD/STEP/RUN switch in the LOAD position:

| STEP | KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 1 | [start] | | Clear program area and initiate first program. |
| 2 | [halt] | | Pause to enter variable (the value of r). |
| 3 | 1 | 1 | Enter test value of r. |
| 4 | [MS] | 1. | Save for use in calculating area of circle. |
| 5 | [ENT] | 1. | |
| 6 | [$\pi$] | 3.1415926 | $\pi$ |
| 7 | [$\times$] | 3.1415926 | $\pi r$ |
| 8 | 2 | 2 | Since no HALT preceded this numerical entry, it is programmed in as a constant. |
| 9 | [$\times$] | 6.2831852 | $2\pi r$. Circumference of the circle. |
| 10 | [halt] | 6.2831852 | Pause to display circumference of the circle before calculating area of circle. When in RUN mode, touching [start] at this point will continue the program. |
| 11 | [MR] | 1. | Recall radius. |
| 12 | [F] ($x^2$) | 1. | $r^2$ |
| 13 | [$\pi$] | 3.1415926 | $\pi$ |
| 14 | [$\times$] | 3.1415926 | $\pi r^2$. Area of circle. First program finished. In RUN mode, first program will automatically stop here. |

| | | | |
|---|---|---|---|
| 15 | [skip] | 3.1415926 | Initiate second program (sphere program). |
| 16 | [halt] | 3.1415926 | Pause for a variable (the value of r). |
| 17 | 1 | 1 | Enter test value of r. |
| 18 | [MS] | 1. | Save for use in calculating volume. |
| 19 | [F] ($x^2$) | 1. | $r^2$ |
| 20 | [$\pi$] | 3.1415926 | $\pi$ |
| 21 | [×] | 3.1415926 | $\pi r^2$ |
| 22 | 4 | 4 | Since no HALT preceded this numerical entry, it is programmed in as a constant. |
| 23 | [×] | 12.56637 | $4\pi r^2$. Area of sphere. |
| 24 | [halt] | 12.56637 | Pause to display area of the sphere before calculating volume. When in RUN mode, touching [start] at this point will continue the program. |
| 25 | [MR] | 1. | Recall the radius. |
| 26 | [×] | 12.56637 | $4\pi r^3$ |
| 27 | 3 | 3 | |
| 28 | [÷] | 4.18879 | $4/3\pi r^3$. Volume of the sphere. In RUN mode, second program will automatically stop here. |

Move the LOAD/STEP/RUN switch to the RUN position.

Calculations involving circles and spheres.

Problem 1. Find the circumference and area of a circle with radius 5, a circle with radius 10 and a circle with radius 12.4:

| STEP | KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 1 | [start] | | Program starts at beginning of program 1 and continues to first programmed HALT. |
| 2 | 5 | 5 | Program has paused for variable, enter value of r. |
| 3 | [start] | 31.415296 | Circumference of circle. Program continues to next programmed HALT, calculates and displays circumference. |
| 4 | [start] | 78.539815 | Area of circle. Program continues to end of program 1, calculates and displays area. |
| 1 | [start] | 78.539815 | Program starts at beginning of program 1 and executes to first programmed HALT. |
| 2 | 10 | 10 | Enter next value of r. |
| 3 | [start] | 62.831852 | Circumference of circle with radius = 10. |
| 4 | [start] | 314.15296 | Area of circle with radius = 10. |
| 1 | [start] | 314.15296 | Start program 1 again. |
| 2 | 12.4 | 12.4 | Enter next value of r. |
| 3 | [start] | 77.911496 | Circumference of circle with radius = 12.4. |
| 4 | [start] | 483.05127 | Area of circle with radius = 12.4. |

Problem 2. Find the area and volume of a sphere with radius 3.25, and a sphere with radius 4.68:

| STEP | KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 1 | [skip] | | Skip over program 1. Program will start with program 2 and continues to first programmed HALT. |
| 2 | 3.25 | 3.25 | Enter first value of r. |
| 3 | [start] | 132.73228 | Area of sphere with radius = 3.25. Program continues to next programmed HALT, calculates and displays area. |
| 4 | [start] | 143.7933 | Volume of sphere with radius = 3.25. Program continues to end of program 2, calculates and displays volume. |
| 1 | [skip] | 143.7933 | Skip over program 1 to execute program 2 again. |
| 2 | 4.68 | 4.68 | Enter next value of r. |
| 3 | [start] | 429.3645 | Area of sphere with radius = 4.68. |
| 4 | [start] | 429.3645 | Volume of sphere with radius = 4.68. |

Problem 3. Find the circumference of a circle with radius 6.54, the area and volume of a sphere with radius 2.35:

| STEP | KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|---|
| 1 | [start] | | Start program 1. |
| 2 | 6.54 | 6.54 | Enter radius of circle. |
| 3 | [start] | 41.09203 | Circumference of circle with radius = 6.54. |
| 4 | [skip] | 41.09203 | Since the program was paused at a HALT in program 1 and the part of program 1 which calculates areas of circles is not needed, skip the remaining portions of program 1, start program 2 and continue to the first programmed HALT. |
| 5 | 2.35 | 2.35 | Enter radius of sphere. |
| 6 | [start] | 69.39778 | Area of sphere with radius = 2.35. |
| 7 | [start] | 54.361593 | Volume of sphere with radius = 2.35. |

## A Recap of Programming Tips

1. To clear display before starting program, touch [C].
2. To program, move LOAD/STEP/RUN switch to LOAD.
3. Begin the first program with [start]. Begin all subsequent programs with [skip].
4. To interrupt the program, whether to enter a variable or to display a result touch [halt]. If you want your calculator to pause at the beginning of each program, enter [halt] as the second step of the program.
5. To enter a constant, key in the desired number. It becomes part of the program.
6. To enter a variable, key in [halt], then the desired number. It does not become part of the program, but is used to debug program.
7. To run programs, move LOAD/STEP/RUN switch to RUN.
8. To start first program, touch [start]. To start second program, touch [skip]. To start the $n^{th}$ program, touch [skip] n–1 times.

# Appendices

## Appendix A — RPN and the Stack Principle

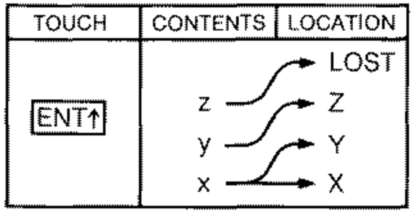
The NOVUS Mathematician uses RPN with three registers called X, Y and Z. A register is an electronic element used to store data while it is being displayed, processed or waiting to be processed. They are arranged in a stack with register X on the bottom. Register X is the displayed register.

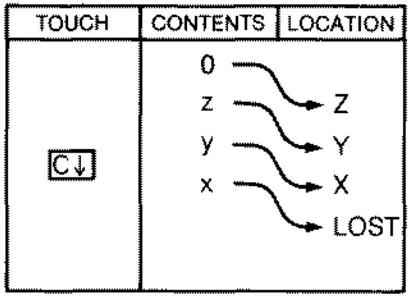
As numbers are keyed in, they go into the display (register X). When you touch [ENT], the number is duplicated into register Y. At the same time, the contents of register Y are transferred to register Z and the contents of register Z are transferred out of the stack.

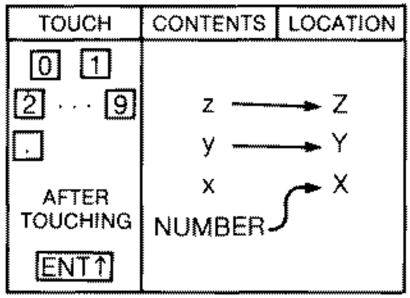
Performing an arithmetic operation (+ − × ÷) causes the contents of registers X and Y to be combined according to the operation performed and the results transferred to register X. At the same time, the contents of register Z are transferred to register Y and register Z is cleared automatically.

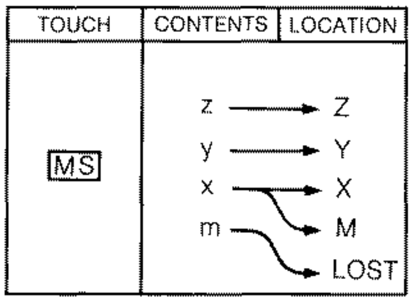
Since the memory (register M) is not affected by any operation other than specific memory functions, it is not part of the basic three-level stack.

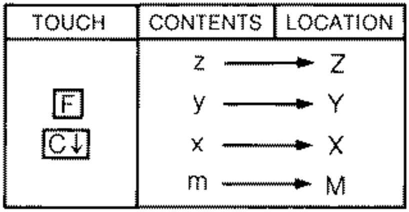
The following diagrams show what happens to the stack for each operation on the NOVUS Mathematician. To avoid confusion between the name of a register and its contents, the registers in these diagrams are represented by capital letters X, Y and Z and the contents of the registers by lower case letters x, y and z.

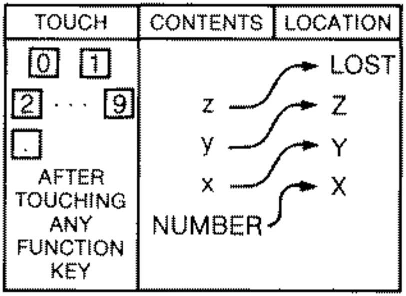


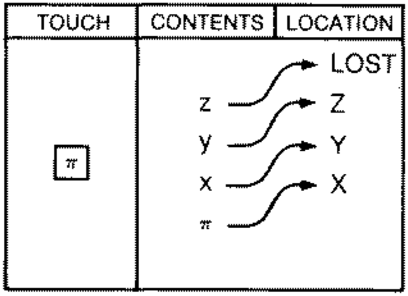



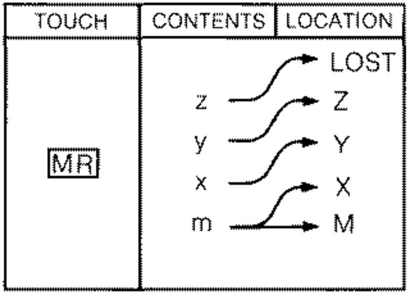



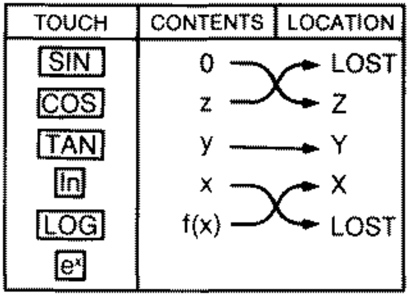



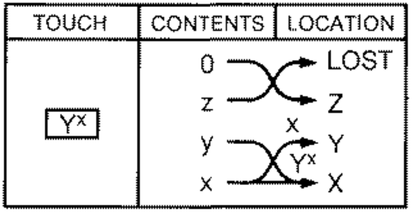


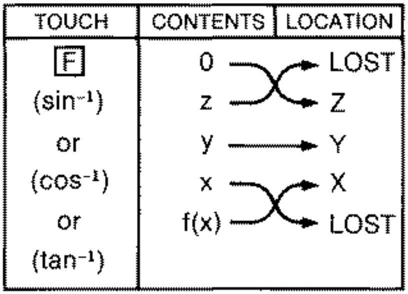




*Note: Performing any trig, log or antilog function clears register Z. f(x) is transferred to register X, and register Y remains unchanged. Performing the $Y^x$ function clears register Z. The contents of register X is transferred to register Y and $Y^x$ is transferred to register X.



| TOUCH | CONTENTS | LOCATION |
|---|---|---|
| 1/x<br>√ | z | Z |
| | y | Y |
| | x | X |
| | f(x) | LOST |

| TOUCH | CONTENTS | LOCATION |
|---|---|---|
| F<br>$(X^2)$ | z | Z |
| | y | Y |
| | x | X |
| | $x^2$ | LOST |

| TOUCH | CONTENTS | LOCATION |
|---|---|---|
| F<br>(rad)<br>or<br>(deg) | z | Z |
| | y | Y |
| | x | X |
| | f(x) | LOST |
| | (RADIANS TO DEGREES OR DEGREES TO RADIANS) | |

| TOUCH | CONTENTS | LOCATION |
|---|---|---|
| F<br>$(M+X^2)$ | z | Z |
| | y | Y |
| | x | X |
| | m | M |
| | $M+X^2$ | LOST |

| TOUCH | CONTENTS | LOCATION |
|---|---|---|
| X↔Y | z | Z |
| | y | Y |
| | x | X |

| TOUCH | CONTENTS | LOCATION |
|---|---|---|
| ERROR INDICATION | 0 | LOST |
| | z | Z |
| | y | Y |
| | x | X |
| | 0 | LOST |
| | m | M |

| TOUCH | CONTENTS | LOCATION |
|---|---|---|
| + | 0 | |
| − | z | Z |
| × | y | Y |
| ÷ | x → f(x) → | X |

f(x): y + x → X
y − x → X
y × x → X
y ÷ x → X

| TOUCH | CONTENTS | LOCATION |
|---|---|---|
| F<br>(M+)<br>(M−) | z | Z |
| | y | Y |
| | x | X |
| | m | f(x) → M |
| | | LOST |
| | f(x): m + x → M<br>m − x → M | |

## Appendix B — Some Examples

### Mathematics

Example: Sum of products
$(2 \times 3) + (4 \times 5) = 26$

| KEY IN | DISPLAY SHOWS |
|---|---|
| 2 | 2 |
| [ENT] | 2. |
| 3 | 3 |
| [×] | 6. |
| 4 | 4 |
| [ENT] | 4. |
| 5 | 5 |
| [×] | 20. |
| [+] | 26. |

Here is what happens in the stack for
$(2 \times 3) + (4 \times 5) = 26$

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| K | 2 | ENT↑ | 3 | × | 4 | ENT↑ | 5 | × | + |
| Z | | | | | | 6 | 6 | | |
| Y | | 2 | 2 | | 6 | 4 | 4 | 6 | |
| X | 2 | 2 | 3 | 6 | 4 | 4 | 5 | 20 | 26 |
| M | | | | | | | | | |

Example: Product of sums
$(2 + 3) \times (4 + 5) = 45$

| KEY IN | DISPLAY SHOWS |
|---|---|
| 2 | 2 |
| [ENT] | 2. |
| 3 | 3 |
| [+] | 5. |
| 4 | 4 |
| [ENT] | 4. |
| 5 | 5 |
| [+] | 9. |
| [×] | 45. |

Here is what happens in the stack for
$(2 + 3) \times (4 + 4) = 45$

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| K | 2 | ENT↑ | 3 | + | 4 | ENT↑ | 5 | + | × |
| Z | | | | | | 5 | 5 | | |
| Y | | 2 | 2 | | 5 | 4 | 4 | 5 | |
| X | 2 | 2 | 3 | 5 | 4 | 4 | 5 | 9 | 45 |
| M | | | | | | | | | |

Example: Convert the rectangular coordinates $X = 6$, $Y = 8$ to polar coordinates R and $\theta$.

Using the formulae: $R = \sqrt{X^2 + Y^2}$ and

$\theta = \tan^{-1}(Y/X)$

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 6 | 6 | X coordinate. |
| ENT | 6. | |
| ENT | 6. | Transfer contents of register Y to register Z to save for use in calculating $\theta$. |
| × | 36. | |
| 8 | 8 | Y coordinate. |
| MS | 8. | Save for use in calculating $\theta$. |
| F $(X^2)$ | 64. | |
| + | 100. | $X^2 + Y^2$ |
| √‾ | 10. | R calculated. |
| X↔Y | 6. | Exchange to bring X coordinate back to register X. |
| MR | 8. | Recall Y coordinate. |
| X↔Y | 6. | Exchange to divide Y by X. |
| ÷ | 1.3333333 | |
| F $(\tan^{-1})$ | 53.1301 | $\theta$ calculated. |

Note: To see R again, touch X↔Y

Here is what happens in the stack for $R = \sqrt{6^2 + 8^2}$ and $\theta = \text{TAN}\ (8/6)$

| K | 6 | ENT | ENT | × | 8 | MS | F | $X^2$ | + | √‾ | X↔Y | MR | X↔Y | ÷ | F | $TAN^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Z | | | 6 | | 6 | 6 | 6 | 6 | | | | 10 | 10 | | | |
| Y | | 6 | 6 | 6 | 36 | 36 | 36 | 36 | 6 | 6 | 10 | 6 | 8 | 10 | 10 | |
| X | 6 | 6 | 6 | 36 | 8 | 8 | 8 | 64 | 100 | 10 | 6 | 8 | 6 | 1.33 | 1.33 | 53.13 |
| M | | | | | | 8 | 8 | 8 | 8 | 8 | 8 | | | | | |

Although most problems can be solved in the straightforward left to right method discussed under "The Logic of RPN," thinking through the problem and planning in advance can lead to some shortcuts. Here is an example of a shortcut method of solving the problem.

Convert the rectangular coordinates X = 6, Y = 8 to polar coordinates R and Θ.

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 0 | 0 | |
| [MS] | 0. | Clear memory. |
| 8 | 8 | Y coordinate. |
| [F] ($M+x^2$) | 8. | Store $y^2$ in memory. |
| 6 | 6 | X coordinate. |
| [F] ($M+x^2$) | 6. | Add $x^2$ to $y^2$ in memory. |
| [÷] | 1.3333333 | Compute $\tan\Theta = y/x$. |
| [F] ($\tan^{-1}$) | 53.1301 | Θ calculated. |
| [MR] | 100. | Recall $x^2 + y^2$. |
| [√‾] | 10 | R calculated. |

Note: To see Θ again, touch [X↔Y]

Example: Find the cotangent, secant and cosecant of 30°. Using the formulae:

$$\cot = \frac{1}{\tan},\ \sec = \frac{1}{\cos},\ \csc = \frac{1}{\sin}$$

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 30 | 30 | |
| [MS] | 30. | Store for further use without having to re-enter. |
| [TAN] | .5773502 | |
| [1/x] | 1.732051 | COTANGENT 30° |
| [MR] | 30. | Re-enter 30° |
| [COS] | .8660255 | |
| [1/x] | 1.1547004 | SECANT 30° |
| [MR] | 30. | Re-enter 30° |
| [SIN] | .5 | |
| [1/x] | 2. | COSECANT 30° |

Example: Find the arc cotangent of 1.7320508.
arc cot 1.7320508 = 30°

| KEY IN | DISPLAY SHOWS |
|---|---|
| 1.7320508 | 1.7320508 |
| [1/x] | .57735027 |
| [F] | .57735027 |
| ($\tan^{-1}$) | 30. |

Example: Find the sine of 1.5707963 radians.

| KEY IN | DISPLAY SHOWS |
|---|---|
| 1.5707963 | 1.5707963 |
| [F] (deg) | 89.999999 |
| [SIN] | 1. |

## Engineering

Example: What is the equivalent resistance of a 10-ohm, 15-ohm and 20-ohm resistor connected in parallel?

Using the formula:

$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Substituting:

$$R_{eq} = \frac{1}{\frac{1}{10} + \frac{1}{15} + \frac{1}{20}} = 4.6153847$$

| KEY IN | DISPLAY SHOWS |
|---|---|
| 10 | 10 |
| [1/x] | .1 |
| 15 | 15 |
| [1/x] | .0666666 |
| [+] | .1666666 |
| 20 | 20 |
| [1/x] | .05 |
| [+] | .21666666 |
| [1/x] | 4.6153847 |

Example: Calculate the percentage by weight of 10 grams of a substance with normality of 0.15 in 45 milliliters of standard solution with mew of 0.03646.

Using the formula: $\%wt = \dfrac{(mew) \times N \times V \times 10^2}{W}$

where: %wt = percentage by weight
mew = millequivalent weight of the substance
N = normality of the substance
V = volume of standard solution in milliliters, and
W = weight of sample in grams.

Substituting:

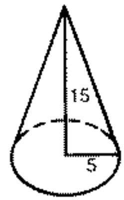
$$\%wt = \frac{0.03646 \times 0.15 \times 45 \times 10^2}{10} = 2.46105$$

| KEY IN | DISPLAY SHOWS |
|---|---|
| .03646 | .03646 |
| ENT | .03646 |
| .15 | .15 |
| × | .005469 |
| 45 | 45 |
| × | .246105 |
| 10 | 10 |
| F ($X^2$) | 100. |
| × | 24.6105 |
| 10 | 10. |
| ÷ | 2.46105 |

Example: Compute the area of a cone with radius 5 and height 15.

Using the formula: $A = \pi R \sqrt{R^2 + H^2} + \pi R^2$

Substituting: $A = \pi \times 5 \times \sqrt{5^2 + 15^2} + \pi \times 5^2$
$= 326.9045$




| KEY IN | DISPLAY SHOWS |
|---|---|
| π | 3.1415926 |
| ENT | 3.1415926 |
| 5 | 5 |
| × | 15.707963 |
| 5 | 5 |
| F ($X^2$) | 25. |
| 15 | 15 |
| F ($X^2$) | 225. |
| + | 250. |
| √ | 15.811388 |
| × | 248.36469 |
| π | 3.1415926 |
| ENT | 3.1415926 |
| 5 | 5 |
| F ($X^2$) | 25. |
| × | 78.539815 |
| + | 326.9045 |

Although most problems can be solved in the straightforward left to right method discussed under "The Logic of RPN," thinking through the problem and planning in advance can lead to some shortcuts. Here is an example of a shortcut method of solving the problem.

Compute the area of a cone with radius 5 and height 15.

| KEY IN | DISPLAY SHOWS |
|---|---|
| 0 | 0 |
| MS | 0. |
| π | 3.1415926 |
| 5 | 5 |
| F ($M+x^2$) | 5. |

| | |
|---|---|
| [×] | 15.707963 |
| [π] | 3.1415926 |
| [MR] | 25. |
| [×] | 78.539815 |
| [X↔Y] | 15.707963 |
| 15 | 15 |
| [F] (M+x²) | 15. |
| [C↓] | 15.707963 |
| [MR] | 250. |
| [√‾] | 15.811388 |
| [×] | 248.36469 |
| [+] | 326.9045 |

Example: If the internal pressure of a tank of gas at 295°K is 1500 psi, what is the pressure if the temperature is raised to 303°K?

Using the formula:

$$P_2 = \frac{P_1 T_2}{T_1} = \frac{1500 \times 303}{295} = 1540.6779 \text{ psi.}$$

| KEY IN | DISPLAY SHOWS |
|---|---|
| 1500 | 1500 |
| [ENT] | 1500. |
| 303 | 303 |
| [×] | 454500. |
| 295 | 295 |
| [÷] | 1540.6779 |

Example: What is the equivalent impedance of a 325-ohm resistor and a 15.2-millihenry inductor at a frequency of 1500 Hz?

Using the formula: $Z_{eq} = R/\Theta$ where

$$\Theta = \arc\tan \frac{2\pi fL}{R} = \arc\tan \frac{2 \times \pi \times 1500 \times .0152}{325} = 23.78739° \text{ and}$$

$$R = \frac{2\pi fL}{\sin\Theta} = 355.17239$$

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 2 | 2 | |
| [ENT] | 2. | |
| [π] | 3.1415926 | |
| [×] | 6.2831852 | |
| 1500 | 1500 | |
| [×] | 9424.7778 | |
| .0152 | .0152 | |
| [×] | 143.25662 | |
| [MS] | 143.25662 | Since you're going to use 2πfL again to calculate R, store it for further use. |
| 325 | 325 | |
| [÷] | .4407896 | |
| [F] (tan⁻¹) | 23.78739 | Θ calculated. |
| [SIN] | .4033439 | |
| [MR] | 143.25662 | Recall 2πfL |
| [X↔Y] | .4033439 | Exchange X and Y registers so you can divide what was last in display by what is now in display. |
| [÷] | 355.17239 | R calculated. |

Example: Find the volume of a sphere whose radius is 6.25.

Using the formula: $V = \frac{4}{3}\pi R^3$

Substituting: $V = \frac{4}{3} \times \pi \times (6.25)^3 = 1022.6532$

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 4 | 4 | |
| [ENT] | 4. | |
| 3 | 3 | |
| [÷] | 1.3333333 | |
| [π] | 3.1415926 | |
| [×] | 4.18879 | |
| [MS] | 4.18879 | Store the intermediate result for further use. Remember that $Y^X$ function clears register Z. |

| | | |
|---|---|---|
| 6.25 | 6.25 | |
| [ENT] | 6.25 | |
| 3 | 3 | |
| [$Y^X$] | 244.1405 | |
| [MR] | 4.18879 | Recall the intermediate result. |
| [×] | 1022.6532 | |

## Finance

Example: How much do you have to put in the bank for it to be worth $25,000 in 10 years if the interest rate is 8.5% per year?

Using the formula: $PV = \frac{FV}{(1+i)^n}$

where: PV = present value
FV = future value
i = interest rate (in decimal)
n = number of years.

Substituting: $PV = \frac{25000}{(1+.085)^{10}} = \$11057.15$

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 1 | 1 | |
| [ENT] | 1. | |
| .085 | .085 | |
| [+] | 1.085 | |
| 10 | 10 | |
| [$Y^X$] | 2.26098 | |
| 25000 | 25000 | |
| [X↔Y] | 2.26098 | |
| [÷] | 11057.152 | |

Example: If you invest $10,000 now at an interest rate of 8.5% per year, how much will your money be worth in 10 years?

Using the formula: $FV = (1+i)^n \times PV$

where: FV = future value
PV = present value
i = interest rate (in decimal)
n = number of years.

Substituting: $FV = (1+.085)^{10} \times 10{,}000 = \$22609.80$

| KEY IN | DISPLAY SHOWS | COMMENTS |
|---|---|---|
| 1 | 1 | |
| [ENT] | 1. | |
| .085 | .085 | |
| [+] | 1.085 | |
| 10 | 10 | |
| [$Y^X$] | 2.26098 | |
| 10000 | 10000 | |
| [×] | 22609.8 | |

# Other Products

**Other "professional" calculators from NOVUS...**

4510 • NOVUS Mathematician
The Electronic Slide Rule
- Trig and inverse trig functions
- Common and natural logs and anti-logs
- Fully addressable, accumulating memory

4520 • NOVUS Scientist
The Scientist's Electronic Slide Rule
- Scientific notation
- Trig and inverse trig functions
- Common and natural logs and anti-logs

4525 • NOVUS Scientist P.R.
The Scientist's Programmable Electronic Slide Rule
- Same features as 4520
- 100 step programming capability

6010 • NOVUS International Computer
The Electronic Measurement Converter
- More than 65 international measurement conversions
- Fully addressable, accumulating memory
- Total calculating capability with live percent

6020 • NOVUS Financier
The Electronic Financial Calculator
- Dedicated to solving financial calculations
- Pre-programmed financial equations
- Fully addressable, accumulating memory

6025 • NOVUS Financier P.R.
The Programmable Electronic Financial Calculator
- Same features as 6020
- 100 step programming capability

6030 • NOVUS Statistician
The Electronic Statistical Calculator
- Dedicated to solving statistical calculations
- Pre-programmed statistical equations
- Fully addressable, accumulating memory

6035 • NOVUS Statistician P.R.
The Programmable Statistical Calculator
- Same features as 6030
- 100 step programming capability

AC adaptors & chargers also available from NOVUS.

**For further information see your dealer or write:**

NOVUS CUSTOMER RELATIONS DEPT.
1177 Kern Ave.
Sunnyvale, CA 94086
(408) 732-5000

# Consumer Warranty

**NOVUS Model 4515**

NOVUS, the consumer products division of National Semiconductor Corporation, is proud to guarantee your electronic calculator to be free from defects in workmanship and materials for a period of one year from the date of your purchase. Defects caused by abuse, accidents, modifications, negligence, misuse or other causes beyond the control of NOVUS are, of course, not covered by this warranty, nor are batteries. Should the calculator prove defective within 30 days of purchase, NOVUS will repair or, at its discretion, replace it free of charge. If the defect occurs after 30 days from date of purchase, a charge of $3.50 will be made for handling and insurance. If your calculator becomes defective after the one-year period, NOVUS will make repairs for a nominal charge of $20.00. Simply mail it prepaid and insured with your check or money order to the nearest NOVUS service center. Repair prices are subject to change without notice. Please do not send or include cash. Make your check or money order payable to NOVUS. Upon receipt, your calculator will be promptly serviced and returned to you freight prepaid.

# Consumer Warranty Registration Certificate

Please put your warranty into effect by completing this form and mailing it within 10 days from date of purchase to the NOVUS service center in your area.

Model Number 4515

Serial Number______________________

Purchase Date______________________
(month/day/year)

Purchased from______________________

Address______________________

City, State, Zip______________________

Your Name______________________

Your Address______________________

City, State, Zip______________________

## Optional Information

Was this calculator purchased for:
- ☐ Gift ☐ Personal use

What is your occupation?
- ☐ Student or Teacher ☐ Professional
- ☐ Executive ☐ Financial or Commercial
- ☐ Engineering or Scientific ☐ Statistical fields
- ☐ Other occupation________________

What is your age group?
- ☐ Under 18 ☐ 18-34 ☐ 35-49 ☐ 50-over

Where will you most use your NOVUS calculator?
- ☐ At home ☐ At school ☐ At work
- ☐ During travel

Where did you learn about the NOVUS calculators?
- ☐ Magazine ☐ Newspaper ☐ Television
- ☐ Radio ☐ Mail ☐ Store salesman
- ☐ Friend
- ☐ Other________________

What most attracted you to your NOVUS calculator?
- ☐ Appearance ☐ Size ☐ Reputation
- ☐ Price ☐ Features and capabilities.



## Warranty Information For Your Records

**NOVUS Warranty Certificate**
Please retain for your records. See insert for trouble-shooting tips and product service locations.

Model Number________________

Serial Number________________

Purchased from________________

Date purchased________________

## Appendix C — Operating Limits

CONDITIONS FOR ERROR INDICATION

| FUNCTION | CONDITION (X = contents of register X) |
|---|---|
| +, −, ×, ÷ | $X > 99999999$ |
| ÷, 1/x | $\lvert X \rvert \leqslant 0.00000001$ |
| $\sqrt{X}$ | $X < 0$ |
| $Y^X$ | $Y \leqslant 0$; $18.42060 < X \ln Y < -28$ |
| LOG X, Ln x | $X \leqslant 0$ |
| $e^x$ | $18.42068 < X < -28$ |
| SIN, COS | $X \geqslant 7$ radians, $X \geqslant 401°$ |
| TAN | $\lvert X \rvert \geqslant 90°$, $X \geqslant 7$ radians |
| $SIN^{-1}$, $COS^{-1}$ | $X > 1$ |
| $TAN^{-1}$ | $X > 99999999$ |

NOVUS

Consumer Products From National Semiconductor