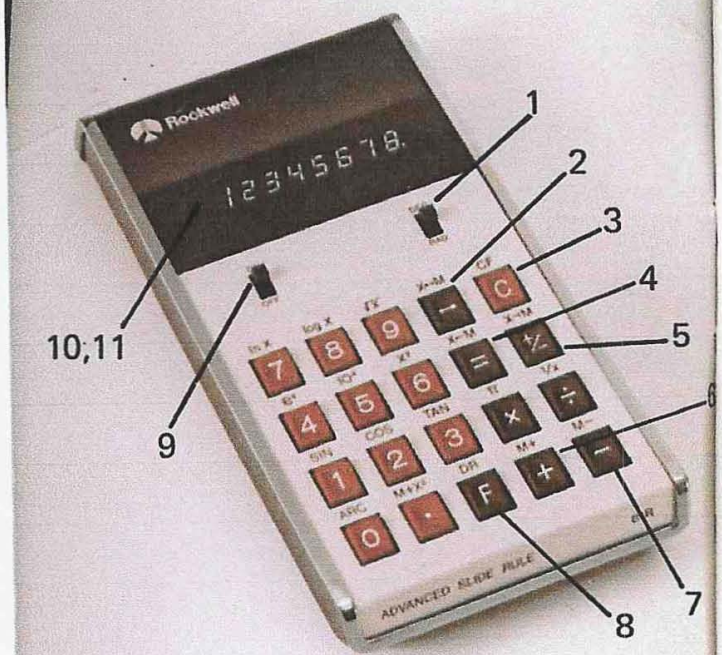
The Answer Book

Owner's Manual for
Rockwell Model 61R
Advanced Slide Rule
Electronic Calculator

Rockwell International

...where science gets down to business

2520-D-62-R2-407 Litho in U.S.A.



1. Degrees/Radians selection switch
2. Display/Register and Display/ Memory exchange key
3. Clear/Entry Correction and Clear Function key
4. Equal/Memory Display key
5. Change Sign/Store Display key
6. Add/Add to Memory key
7. Subtract/Subtract from Memory key
8. Function/Data Recovery key
9. On/Off switch
10. Overflow indicator
11. Negative number indicator

Welcome to the world of Rockwell reliability!

If your problems involve trigonometric and logarithmic functions, now you have The Answer—the Rockwell 61R Advanced Slide Rule.

Your Rockwell 61R has been designed not only to perform the four basic functions of arithmetic but also to compute natural and common logs and anti-logs, trigonometric and inverse trigonometric functions, square roots, roots and powers for any real numbers, and reciprocals. The constant pi may be recalled for use at any time, and there is an addressable memory for storing data or accumulating results.

Your Rockwell 61R uses one of the most sophisticated electronic devices on the market: a single microelectronic silicon chip. This device is no bigger than a fleck of confetti, yet it is programmed to provide the capabilities for solving many types of complex problems. Rockwell International has had more experience with these remarkable devices than anyone else in the industry.

This instruction manual will assist you in understanding the various key functions and the operation of your calculator.

CONTENTS

GENERAL INFORMATION

BEFORE OPERATING YOUR CALCULATOR

Your Rockwell 61R Advanced Slide Rule calculator is supplied with rechargeable internal batteries and a battery charger, Part No. 328R07-001. DO NOT OPERATE YOUR CALCULATOR WITHOUT THE CHARGER UNTIL YOU HAVE CHARGED THE BATTERIES FOR FIVE HOURS. Failure to do so can damage the batteries.

OPERATING POWER

Your calculator operates from nickel cadmium rechargeable batteries. You may use the calculator while the nickel cadmium batteries are being charged; however, your battery charger is not an AC adapter and should not be left plugged in indefinitely.

BATTERY CHARGER

To charge the nickel cadmium batteries, simply plug the charger into the jack provided in your calculator and a standard 120-volt wall outlet. With the calculator turned off, allow

approximately five (5) hours for the batteries to be fully charged. Your calculator CAN be used while the batteries are being charged, but the time required for the batteries to become fully charged will increase. The nickel cadmium batteries will provide a minimum of three (3) hours operating time when fully charged. The nickel cadmium battery life will be prolonged by recharging the batteries after approximately three (3) hours operating time. The need for recharging is indicated by the display becoming dimmer. Do not continue to use your calculator on battery power once the display becomes dim. The nickel cadmium batteries may be permanently damaged by overuse without charging.

SPECIAL CARE AND PRECAUTIONS

Observance of the following will prevent damage to and assure trouble-free service from your calculator and the charger and nickel cadmium batteries supplied with it.

1. Use only the charger furnished with your calculator.

2. Do not charge the batteries continuously as battery degradation could occur after approximately 72 hours.
3. Avoid exposing your calculator to extreme cold or heat. Keep it out of direct, intense sunlight and away from heating devices.
4. Keep your calculator away from moisture and liquids.
5. Do not drop or subject your calculator to heavy shock or vibration.
6. When not in use, turn the calculator off and place it in its carrying case for maximum protection.
7. Never use a dry or wet cleaner of any kind on the case. Simply wipe the case with a clean dust cloth.
8. Do not attempt to repair the calculator yourself. The parts are replaceable, but not repairable.

GETTING STARTED

Your machine has a feature that automatically clears all registers when power is turned on. Place the power switch in the ON position, and a zero appears in the right hand digit position. The calculator is now

ready to accept key entries and perform calculations.

DISPLAY

Numbers with an absolute value of 0.0000001 to 99999999 can be displayed. Negative entries and results are indicated by a minus symbol at the far left of the display. Results in excess of eight digits are indicated by the overflow indicator, a large dot in the far left of the display. The eight most significant digits are displayed with the decimal adjusted eight places to the left of the correct position (see Wrap-Around Decimal). For fractional numbers less than one, a zero is displayed to the left of the decimal point. No leading zeros are displayed for numbers greater than one. The results of the calculations are displayed instantaneously for most calculations.

NOTE: Computations using very large or very small numbers may be performed on your slide rule calculator by utilizing appropriate scaling (see page 30).

EXPLANATION OF SWITCHES AND INDICATORS

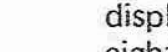
ON/OFF SWITCH

The ON position applies power to your calculator and clears it of all previously entered data.

DEG/RAD SWITCH

Refer to page 41.

OVERFLOW INDICATOR



● lights if the answer exceeds 8 digits to the left of the decimal point. The ● indicator also lights if memory accumulation exceeds eight whole digits (no fraction). (See Overflow conditions, page 27 and Wrap-Around Decimal, page 28 for detailed information on calculator overflow.)

NEGATIVE NUMBER INDICATOR

– lights when negative numbers are displayed.

OPERATION

The Rockwell 61R Advanced Slide Rule has 20 keys, including a unique "second function" key that allows each key to have two separate uses. The first (primary) use is identified on the face of the key; the second (secondary) use is identified above the key. In this manual, the first use is represented (except for digits) by enclosing the identification in a box, [ ]; the second use, by enclosing the identification in parentheses, ( ). The following explanation will help you understand the operation and uses of each key.

DIGIT ENTRY KEYS

[0] THROUGH [9]: Depressing any digit key enters that digit and causes it to appear in the display. To enter the number 24, depress [2] first, then [4].

DECIMAL POINT ENTRY KEY

[•]: Depressing the [•] key places the decimal point in your entries.

ARITHMETIC FUNCTION KEYS

[+] ADD, [−] SUBTRACT, [×] MULTIPLY, [÷] DIVIDE: Depressing any of these four keys selects the next operation to be performed by the calculator and causes the previously selected operation to be executed. During calculations, intermediate results are automatically displayed after these keys are depressed.

ANSWER KEY

[=]: Depressing the [=] key causes your answer to appear in the display, then terminates the calculation. The answer can be retained as the first number for your next calculation (see page 16).

CLEAR KEY

[C]: Depressing the [C] key clears the display of erroneous entries, cancels overflow conditions, or clears the calculator of stored numbers and functions. (See Clear Operations, page 23, for detailed instructions on use of the [C] key.)

CHANGE SIGN KEY

[+/−]: Depressing the [+/−] key changes the sign of a displayed number.

REGISTER EXCHANGE KEY

[↔]: Depressing the [↔] key interchanges the contents of the display and the working register.

FUNCTION KEY

[F]: Depressing the [F] key conditions the calculator to interpret the next key depressed in accordance with the function identified above the key.

NOTES: The secondary functions of the keys are described under Key Secondary Functions, page 33.

Techniques for recovery of data following unintentional depression of the wrong arithmetic function key or the [F] key are given under Recovery Techniques, page 60. Recovery of data with the (DR) key is also described under Recovery Techniques.

BASIC OPERATIONS

Your Rockwell 61R uses algebraic logic. This means that your calculator works the same way you think and entries are made the same way you would write an algebraic equation.

Problem:
Addition 3 + 4 = 7

Keyboard Entry	Display
3	3.
[+] 4	4.
[=]	7.

Problem:
Subtraction 7 − 5 = 2

Keyboard Entry	Display
7	7.
[−] 5	5.
[=]	2.

Problem:
Multiplication 3 x 5 = 15

Keyboard Entry	Display
3	3.
[x] 5	5.
[=]	15.

Problem:
Division 36 ÷ 4 = 9

Keyboard Entry	Display
36	36.
[÷] 4	4.
[=]	9.

Mixed Calculations

The following example shows how the calculator is used to solve complex mathematical problems with a minimum of key depressions. The examples also illustrate how the arithmetic function keys execute preceding operations and cause intermediate results to be displayed.

Problem: $\frac{(4 + 6)\ 8 - 7}{8} = 9.125$

Keyboard Entry	Display	Comments
4	4.	
[+] 6	6.	
[x]	10.	(4 + 6) executed
8	8.	
[−]	80.	(4 + 6)8 executed
7	7.	
[÷]	73.	(4 + 6)8 − 7 executed
8	8.	
[=]	9.125	Final result

If you want to use an answer in further calculations, there is no need to re-enter the number. Just depress the desired arithmetic function key for the next operation and enter another number.

Problem:
Answer Re-entry: 17.4 + 3.7 = 21.1
21.1 + 32.4 = 53.5

Keyboard Entry	Display	Comments
17.4	17.4	
[+] 3.7	3.7	
[=]	21.1	
[+]	21.1	Not necessary to re-enter 21.1
32.4	32.4	
[=]	53.5	

REPEAT OPERATIONS

The repeat operation capability of your Rockwell 61R is a time-saving feature that enables you to add, subtract, multiply or divide a series of identical numbers without re-entering the numbers each time.

Problem: ((((6 x 6) – 6) ÷ 6) + 6) = 11

Keyboard Entry	Display	Comments
6	6.	
[x]	6.	Not necessary to re-enter 6
[–]	36.	
[÷]	30.	
[+]	5.	
[=]	11.	

CONSTANT OPERATIONS

The automatic constant is another time-saving feature of your Rockwell 61R. This feature enables you to add, subtract, multiply, or divide by the same number repeatedly without re-entering the number for each new calculation. The number entered after the last arithmetic function key depressed is always saved as the constant (addend, subtrahend, multiplier or divisor). The constant function is the last function key depressed before depressing the [=] key. To perform multiple operations with this constant, simply enter a new augend, minuend, multiplicand or dividend, and depress the [=] key for an answer.

Problem:
Constant Addend: 6 + 3 = 9 8 + 3 = 11

	Keyboard Entry	Display
6 + 3 = 9	6	6.
	[+] 3	3.
	[=]	9.
8 + 3 = 11	8	8.
	[=]	11.

Problem:
Constant Subtrahend: $9 - 5 = 4$ $11 - 5 = 6$

	Keyboard Entry	Display
$9 - 5 = 4$	9	9.
	[−] 5	5.
	[=]	4.
$11 - 5 = 6$	11	11.
	[=]	6.

Problem:
Constant Multiplier: $12 \times 4 = 48$ $3 \times 4 = 12$

	Keyboard Entry	Display
$12 \times 4 = 48$	12	12.
	[×] 4	4.
	[=]	48.
$3 \times 4 = 12$	3	3.
	[=]	12.

Problem:
Constant Divisor: $10 \div 5 = 2$ $12 \div 5 = 2.4$

	Keyboard Entry	Display
$10 \div 5 = 2$	10	10.
	[÷] 5	5.
	[=]	2.
$12 \div 5 = 2.4$	12	12.
	[=]	2.4

Mixed Operations with Constants

Problem: $\frac{(5 + 3)\ 3 - 2}{2} = 11$

Keyboard Entry	Display	Comments
5	5.	Undetermined
[+] 3	3.	Constant = 3
[×]	8.	Constant = 3
[−]	24.	Constant = 3
2	2.	Constant = 2
[÷]	22.	Constant = 2
[=]	11.	Constant = 2

CLEAR OPERATIONS

1. One depression of the [C] key when there is no overflow condition clears the displayed number but does not affect the stored constants or the operation.

Problem:
Entry Correction: 12 + 5.5 = 17.5

Keyboard Entry	Display	Comments
12	12.	
[+] 5.6	5.6	Error; wrong number
[C]	0.	Cleared
5.5	5.5	
[=]	17.5	

2. A double depression of the [C] key clears any operation in progress and clears the calculator except the memory.

Problem:
Clear Calculator (Except Memory)

Keyboard Entry	Display	Comments
2	2.	
[+]	2.	
[C]	0.	Entry cleared
[C]	0.	Calculator cleared

3. Depressing the [C] key during an overflow (see Overflow Conditions) cancels the overflow condition. The number in the display is correct if multiplied by 10^8 and may be used in further calculations. Chain and constant operations are not affected by overflowing.

Problem:
Clear Error (Overflow): 12345678 x 9 = 111111102

Keyboard Entry	Display	Comments
12345678	12345678.	
[x] 9	9.	
[=]	● 1.1111110	Overflow Indicator lights; calculator accepts only clear entry key
[C]	1.1111110	Answer must be multiplied by 10^8 (see page 28)

4. Depressing the (CF) key after pressing the [F] key clears the secondary function operation and restores the previous conditions (see page 60).
5. Depressing the [C], [F] and (X → M) keys clears the memory (see page 33).

OVERFLOW CONDITIONS

The following operations result in an overflow condition which causes the Overflow Indicator, ●, to light and all keys except [C] to become inoperative:

1. Any answer or subtotal exceeding 8 digits to the left of the decimal point, regardless of its arithmetic sign (absolute value greater than 99,999,999.). The 8 most significant digits are displayed as follows: [●XXXXX.XXX]. Calculations can be continued, if desired (see Wrap-Around Decimal).
2. Memory accumulation exceeding 8 whole digits to the left of the decimal point, regardless of the arithmetic sign. The number used in the last memory operation remains in the display: [● XXX.]. Calculations can be continued, if desired (see Wrap-Around Decimal).
3. Division by zero. A 0 is displayed: [● 0.]
4. Exceeding capacity or range of scientific functions (see pages 92 through 96).

WRAP-AROUND DECIMAL

The wrap-around decimal feature of your calculator lets you proceed when the answer obtained in the display or memory exceeds the capacity of the calculator (10^8 or greater), except when the overflow condition is the result of computing a scientific function. The calculator automatically retains the 8 most significant digits, places the decimal point 8 positions to the left of its true position, and lights the Overflow Indicator. You may proceed with the problem solution after depressing the [C] key once to clear the overflow condition, but you must multiply the final problem answer by 10^8 (100,000,000) or move the decimal point 8 places to the right. Any numbers subsequently added or subtracted must be divided by 10^8 before entering. If two overflows occur in the same problem, the final answer must be multiplied by $10^8 \times 10^8 = 10^{16}$ and so on. This same feature applies to the numbers in memory.

Problem: $\frac{98{,}000{,}000 \times 2{,}000}{0.04} - 20{,}000{,}000 = 4{,}899{,}980{,}000{,}000$

Keyboard Entry	Display	Comments
98000000	98000000.	
[x] 2000	2000.	
[÷]	● 1960.0000	Overflow Indicator lights
[C]	1960.0000	Displayed number times 10^8 equals true number
.04	0.04	
[−]	49000.	
.2	0.2	Number entered $(20000000 \div 10^8) = .2$
[=]	48999.8	This answer times 10^8 equals true answer

COMPUTATIONS WITH VERY LARGE OR VERY SMALL NUMBERS

Computations which may exceed the 8-digit capacity of the calculator can be scaled, entered as if they were expressed in scientific notation, and the appropriate power of 10 determined as a second step.

Problem: $2 \times 10^{-6} \times 5 \times 10^{-5} = 10 \times 10^{-11}$

Keyboard Entry	Display	Comments
2	2.	Times 10^{-6}
[x] 5	5.	Times 10^{-5}
[=]	10.	Times 10^{-11}

CHANGE SIGN OPERATION

Depressing the [+/-] key changes the sign of the number in the display. The Rockwell 61R Advanced Slide Rule allows sign change at any point in a calculation.

Problem: $\frac{4^2\ (-3)}{6} = -8$

Keyboard Entry		Display	Comments
4		4.	
[x]		4.	
[x]		16.	
3		3.	
[+/-]	–	3.	Negative Number Indicator lights
[÷]	–	48.	
6		6.	
[=]	–	8.	

REGISTER EXCHANGE OPERATION

Another useful feature of your Rockwell 61R Advanced Slide Rule calculator is the register exchange capability. Depressing the [↔] key exchanges the data (number) in the display with the number in the working register (the previously displayed number or the constant).

Problem: $\frac{15}{3+6} = 1.6666666$

Keyboard Entry	Display	Working Register Constant
3	3.	Undetermined
[+]	3.	3
6	6.	3
[÷]	9.	6
15	15.	9
[↔]	9.	15
[=]	1.6666666	9

KEY SECONDARY FUNCTIONS

Depressing the [F] key conditions the 61R Advanced Slide Rule to perform the second function of the next key depressed. The secondary function is cancelled after execution of all second function operations except (ARC) (see page 46) or (DR) (see page 61). Operation and uses of the keys in performing their second function are described in subsequent paragraphs.

NOTES: The display is blank during many operations using the scientific function keys. No keyboard entries should be attempted before the display turns on again.

Range of accuracy of the Rockwell 61R calculator is given on pages 92 through 94.

MEMORY OPERATION

Your Rockwell 61R Advanced Slide Rule calculator has a completely independent memory which is unaffected by arithmetic or scientific operations. Through

the use of this memory, you can perform chain operations involving complex mathematical problems with a minimum of key depressions. All of the memory operation keys are activated by depressing the [F] key. The functions of the memory operation keys are as follows:

Key	Function
(M+)	Add to memory.
(M−)	Subtract from memory.
(X← M)	Display number in memory.
(X→ M)	Store displayed number in memory. Any number previously in memory is destroyed.
(X ↔ M)	Exchange number being displayed with number in memory.
(M + X^2)	Add square of contents of displayed number in memory; display is not altered.

The following example illustrates use of the memory operation keys and the memory clearing procedure.

Keyboard Entry	Display	Memory	Comments
[C]	0.		
[F] (X→ M)	0.	0	Memory cleared: displayed number copied into memory; display not altered.
4	4.	0	
[F] (M+)	4.	4.	Displayed number added to memory; display not altered.
[F] (M + X^2)	4.	20.	Square of displayed number added to memory; display not altered.

Keyboard Entry	Display	Memory	Comments
[X]	4.	20.	Multiply operation established
3	3.	20.	
[F] (M–)	3.	17.	Displayed number subtracted from memory; display not altered
[+]	12.	17.	3 x 4 executed and addition operation established
[F] (X←M)	17.	17.	Contents of memory recalled to display; original number moved to working register
[=]	29.	17.	12 + 17 executed
[F] (X↔M)	17.	29.	Contents of memory exchanged with displayed number

CONSTANT π KEY

The value of π may be entered into the display at any time by depressing the [F] and (π) keys. The display will be 3.1415926.

Problem: Area of Circle: Find area (A) of a circle 6 feet in diameter (D)

Formula: $A = \frac{\pi D^2}{4}$ $A = 28.274332$

Keyboard Entry	Display	Comments
6	6.	Diameter
[x]	6.	
[x]	36.	D^2
[F] (π)	3.1415926	
[÷]	113.09733	πD^2
4	4.	
[=]	28.274332	Area

Problem: Degrees to Radians: Convert 200 degrees (d) to radians (r)

Formula: $r = \frac{d \pi}{180}$ $r = 3.4906584$ RAD

Keyboard Entry	Display	Comments
200	200.	Degrees (d)
[x] [F] (π)	3.1415926	
[÷]	628.31852	
180	180.	
[=]	3.4906584	Radians (r)

Problem: Radians to Degrees: Convert 10 radians (r) to degrees (d)

Formula: $d = \frac{180\,r}{\pi}$ $d = 572.9578°$

Keyboard Entry	Display	Comments
10	10.	Radians (r)
[x] 180	180.	
[÷]	1800.	
[F] (π)	3.1415926	
[=]	572.9578	Degrees (d)

TRIGONOMETRIC FUNCTIONS (SIN), (COS), (TAN)

Depressing the [F] key and then the (SIN), (COS) or (TAN) key causes the calculator to compute and display the trigonometric function for the value of the angle that was displayed.

DEG/RAD SWITCH: The position of the DEG/RAD switch selects whether the trigonometric functions are to be computed with angles expressed in degrees or radians.

Problem: $\sin 30° = 0.5$

Keyboard Entry	Display	Comments
30	30.	DEG/RAD switch in DEG position
[F] (SIN)	0.5	

Problem: cos 300° = 0.5

Keyboard Entry	Display	Comments
300	300.	DEG/RAD switch in DEG position
F (COS)	0.5	

Problem: tan 2 radians = −2.185042

2	2.	DEG/RAD switch in RAD position
F (TAN)	− 2.185042	Negative Number Indicator lights

Problem: sin $\frac{\pi}{6}$ radians = 0.5

Keyboard Entry	Display	Comments
F (π)	3.1415926	DEG/RAD switch in RAD position
÷ 6	6.	
=	0.5235987	
F (SIN)	0.5	

Problem: (2 x 3) + 3 (tan 15°) = 6.803848

Keyboard Entry	Display	Comments
2	2.	DEG/RAD switch in DEG position
[x] 3	3.	
[=] [F] (X → M)	6.	
15	15.	
[F] (TAN)	0.267949	
[x] 3	3.	
[+]	0.803847	

Keyboard Entry	Display	Comments
[F] (X ← M)	6.	
[=]	6.803847	

Some chain operations using scientific and arithmetic functions can be accomplished without the use of memory by rearranging the problem.

Problem: (2 x 3) + 3 (tan 15°) = (2 + tan 15°) 3 = 6.803848

15	15.	DEG/RAD switch in DEG position
[F] (TAN)	0.267949	
[+] 2	2.	
[x]	2.267949	
3	3.	
[=]	6.803847	

INVERSE TRIGONOMETRIC FUNCTIONS (ARC) (SIN), (ARC) (COS), (ARC) (TAN)

Depressing the [F] and (ARC) keys and then the (SIN), (COS) or (TAN) key causes the number in the display to be interpreted as the value of a trigonometric function and the inverse trigonometric function (the angle) to be calculated and displayed.

Problem: $\sin^{-1}(0.5) = 30^\circ$

Keyboard Entry	Display	Comments
.5	0.5	DEG/RAD switch in DEG position
[F] (ARC) (SIN)	30.	

Problem: $\cos^{-1}(0.5) = 60^\circ$

Keyboard Entry	Display	Comments
.5	0.5	DEG/RAD switch in DEG position
[F] (ARC) (COS)	59.99999	

Problem: $\tan^{-1}(1) = 45^\circ$

1	1.	DEG/RAD switch in DEG positon
[F] (ARC) (TAN)	44.99999	

(Continued on page 50)

Model 10R
8-digit Electronic Calculator*
Basic Answer features: 8 digits • 4 function (+ − x ÷) • Algebraic logic • Floating decimal • Repeat function

Model 20R
Electronic Calculator with Memory and Percent*
• All Basic Answer features PLUS • Fully addressable memory • Automatic constants • % key • Automatic mark-on and discount

Model 30R
Slide Rule Memory Electronic Calculator*
• All Basic Answer features PLUS • Fully addressable memory • Automatic constants • % key • Automatic mark-on and discount • Register exchange • Sign change • Reciprocals • Squares • Square roots

Model 51R
Universal Converter Electronic Calculator
• All Basic Answer features PLUS • 2 fully addressable memories • 2-place or floating decimal • Automatic constants • Fraction calculations • 224 fixed conversions plus programmable conversion • AC charger and case

Model 61R
Advanced Slide Rule Electronic Calculator
• All Basic Answer features PLUS • Fully addressable memory • Automatic constants • Register exchange • Sign change • Reciprocals • Sum of squares • Square roots • Log functions • Trig functions in degrees or radians • Powers • AC charger and case

Model 80R
10-digit Printer Electronic Calculator
• 4 functions • Commercial logic • 10 digits plus 2 columns of symbols • Thermal printer • Floating decimal or dollar decimal with override • Automatic constant and repeat • Subtotals, group totals and grand totals

*Model 01R Accessory Kit (AC Adapter and Carrying Case) Available at Extra Cost.

Problem: $\frac{\pi}{2} + \tan^{-1}(1) = 2.3561945$ radians

Keyboard Entry	Display	Comments
1	1.	DEG/RAD switch in RAD position
[F] (ARC) (TAN)	0.785398	
[F] (X→ M)	0.785398	
[F] (π)	3.1415926	
[÷] 2	2.	
[+]	1.5707963	
[F] (X← M)	0.785398	
[=]	2.3561943	Radians

SQUARE ROOT ($\sqrt{x}$)

Depressing the [F] and ($\sqrt{x}$) keys causes the square root of the number being displayed to be computed and displayed.

Problem: $\sqrt{\sqrt{81}} = 3$

Keyboard Entry	Display
81	81.
[F] ($\sqrt{x}$)	9.
[F] ($\sqrt{x}$)	3.

The $\sqrt{x}$ function can also be used in chain operations.

Problem: $\sqrt{4} + \sqrt{9} = 5$

4	4.
[F] ($\sqrt{x}$)	2.
[+] 9	9.
[F] ($\sqrt{x}$)	3.
[=]	5.

RECIPROCALS (1/x)

Depressing the [F] and (1/x) keys causes the reciprocal of the number being displayed to be computed and displayed.

Problem: $\frac{1}{20} = 0.05$

Keyboard Entry	Display
20	20.
[F] (1/x)	0.05

The 1/x function can also be used in chain operations.

Problem: $\frac{1}{20} + \frac{1}{10} = 0.15$

Keyboard Entry	Display
20	20.
[F] (1/x)	0.05
[+] 10	10.
[F] (1/x)	0.1
[=]	0.15

COMMON LOGARITHMS FUNCTION (log X)

Depressing the [F] and (log X) keys causes the common logarithm of the displayed number to be computed and displayed.

Problem: $\log_{10} 100 = 2$

Keyboard Entry	Display
100	100.
[F] (log X)	2.

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NATURAL LOGARITHMS FUNCTION (ln X)

Depressing the [F] and (ln X) keys causes the natural logarithm of the displayed number to be computed and displayed.

Problem: $\ln (32^3) = 3 \ln 32 = 10.397211$

Keyboard Entry	Display
32	32.
[F] (ln X)	3.465737
[×] 3	3.
[=]	10.397211

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ANTILOGARITHMS FUNCTIONS (e^x), (10^x)

Depressing the [F] and (e^x) or [F] and (10^x) keys as desired causes the antilogarithms of the displayed number for the bases e (e = 2.718281) or 10 to be computed and displayed.

Problem: $10^2 = 100$

Keyboard Entry	Display	Comments
2	2.	
[F] (10^x)	100.	

Problem: $e^{-3} = 0.049787$

3	3.		
[+/-]	–	3.	Negative Number Indicator lights
[F] (e^x)		0.049787	

EXPONENTIAL FUNCTION (X^y)

The exponential function raises X (first number entered) to the power y (second number entered) for any real values of y. Depressing the [F] and (X^y) keys causes the displayed number to be taken as the value of X and the natural log of X to be computed and displayed. The function is completed by entering y and pressing the [=] key.

Problem: $3^3 = 27$

Keyboard Entry	Display	Comments
3	3.	
[F] (X^y)	1.098613	ln 3
3	3.	
[=]	27.00005	

The (X^y) key may be chained with the (1/x), (π) or ($\sqrt{x}$) key.

Problem: $\sqrt[5]{32} = 32^{1/5} = 2$

Keyboard Entry	Display	Comments
32	32.	
[F] (X^y)	3.465737	ln 32
5	5.	
[F] ($1/x$)	0.2	
[=]	2.	

$\sin^y(x)$ can be computed easily.

Problem: $\sin^{1/3}(38°) = 0.850708$

Keyboard Entry	Display	Comments
38	38.	DEG/RAD switch in DEG position
[F] (SIN)	0.615661	
[F] (X^y)	− 0.485058	Negative Number Indicator lights
3	3.	
[F] ($1/x$)	0.3333333	
[=]	0.850709	

RECOVERY TECHNIQUES

Occasionally you may unintentionally depress one of the function keys. The following techniques allow easy correction without loss of the displayed number.

Unintentional [x] or [÷]: Depress 1, then [=]. If constant multiplication or division is being performed, the constant is replaced by 1.

Unintentional [+] or [−]: Depress 0, then [=]. If constant addition of subtraction is being performed, the constant is replaced by 0.

Clear Function (CF)

Depressing the (CF) key immediately after an unintentional [F] key clears the calculator of secondary function operation.

Problem: 4 x 3 = 12

Keyboard Entry	Display	Comments
4	4.	
[x] 3	3.	
[F]	3.	Error!! Did not want to press [F]
(CF)	3.	
[=]	12.	

Data Recovery (DR)

Depressing the [F] and (DR) keys immediately after a digit entry recalls the last number displayed. The selected function remains set. If only one digit has been entered, the [F] (DR) key sequence recalls the previous result to the display. If more than one digit has been entered, the [F] (DR) key sequence eliminates the last digit. If more digits are to be entered or primary functions are to be executed, the (CF) key must be depressed to clear the function.

Keyboard Entry	Display	Comments
45	45.	DEG/RAD switch in DEG position
(SIN)	451.	Error!! Forgot to press [F]
[F] (DR)	45.	
(SIN)	0.707107	
12346	12346.	Error!! Did not want 6
[F] (DR)	1234.	
(CF)	1234.	
5	12345.	

SAMPLE PROBLEMS

Your Rockwell 61R Advanced Slide Rule calculator is a versatile problem solving tool. Several practical examples were chosen from different fields of interest to familiarize you with your calculator. We recommended that you gain familiarity with your Rockwell 61R by working the sample problems.

MATHEMATICS

Many problems can be arranged so that two parallel calculations are performed with one entry of data: one in the display, the other in memory. Some examples of this procedure are shown on following pages.

Problem:
Statistics:
Find the mean (M), variance (V), standard deviation (SD), and standard error (SE) of the mean of the following values of X (10, 11, −3, 14, 18) (Note: n = 5)

Formulas: a. $M = \frac{\Sigma X_i}{n}$ b. $V = \frac{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}}{n-1}$

$M = 10.$ $V = 62.5$

c. $SD = \sqrt{\frac{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}}{n-1}}$ d. $SE = \frac{SD}{\sqrt{n}}$

$SD = 7.9056941$ $SE = 3.535534$

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Keyboard Entry		Display	Memory	Comments
[C] [F] (X→ M)		0.	0	Display and memory cleared
10 [F] (M + X^2)		10.	100.	X_1^2 added to memory
[+]		10.	100.	
11 [F] (M + X^2)		11.	221.	X_2^2 added to memory
[+]		21.	221.	$X_1 + X_2$ displayed
3 [+/−]	−	3.	221.	Negative Number Indicator lights
[F] (M + X^2)	−	3.	230.	X_3^2 added to memory
[+]		18.	230.	$X_1 + X_2 + X_3$ displayed
14 [F] (M + X^2)		14.	426.	X_4^2 added to memory
[+]		32.	426.	$X_1 + X_2 + X_3 + X_4$ displayed
18 [F] (M + X^2)		18.	750.	X_5^2 added to memory

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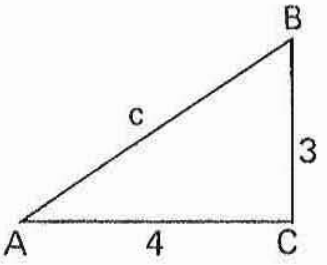
(Continued on page 66)

Keyboard Entry	Display	Memory	Comments
[÷]	50.	750.	ΣX_i displayed
5	5.	750.	n
[×]	10.	750.	Mean (M) displayed
[↔]	5.	750.	
[=]	50.	750.	$M \bullet n = \Sigma X_i$ displayed
[=]	500.	750.	$M^2 \bullet n = \frac{(\Sigma X_i)}{n}$ displayed
[F] (M−)	500.	250.	$\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}$ subtracted from memory
[F] (X ← M)	250.	250.	
[÷] 4	4.	250.	(n − 1)
[=]	62.5	250.	Variance (V)
[F] ($\sqrt{X}$)	7.9056941	250.	Standard deviation (SD)
[÷] 5	5.	250.	n
[F] ($\sqrt{X}$)	2.2360679	250.	$\sqrt{n}$
[=]	3.535534	250.	Standard error (SE) of the mean

Problem:

Given right triangle ABC with sides 3 and 4, find the hypotenuse c.



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Formula:

$c = \sqrt{3^2 + 4^2}$

$c = 5$

Keyboard Entry	Display	Memory	Comments
[C]	0.		
[F] (X→ M)	0.	0	Memory cleared
3 [F] (M + X^2)	3.	9.	3^2 added to memory
4 [F] (M + X^2)	4.	25.	4^2 added to memory
[F] (X← M)	25.	25.	Sum of squares recalled from memory
[F] ($\sqrt{X}$)	5.	25.	Hypotenuse (c)

Problem:
Converting From Rectangular to Polar Coordinates:
Convert the point (24, 70) into polar coordinates.

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Formulas:

Magnitude of Vector

$V = \sqrt{x^2 + y^2}$

angle $\sigma =$

$\tan^{-1}\left(\frac{y}{x}\right)$

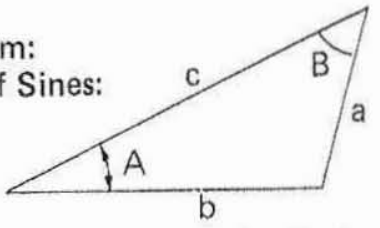
Where x = 24 and y = 70

$\sigma = 71.07536°$

V = 74.

Keyboard Entry	Display	Memory	Comments
C [F] (X→ M)	0.	0	Display and memory cleared
70 [F] (M + X^2)	70.	4900.	Y^2 added to memory
[÷] 24 [F] (M + X^2)	24.	5476.	X^2 added to memory
[=]	2.9166666	5476.	Y/X
[F] (ARC) (TAN)	71.07536	5476.	Angle σ (degrees)
[F] (X ← M)	5476.	5476.	$Y^2 + X^2$ recalled from memory
[F] ($\sqrt{X}$)	74.	5476.	Magnitude of vector (V)

Problem:
Law of Sines:



Given the above triangle, find angle B.

Formula:

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

or

$$\sin B = \frac{b \sin A}{a}$$

Where

$A = 30°$
$a = 75$
$b = 105$

$$B = \sin^{-1}\left(\frac{b \sin A}{a}\right)$$

$B = 44.42701°$

Keyboard Entry	Display	Comments
30	30.	DEG/RAD switch in DEG position
F (SIN)	0.5	sin A
x 105	105.	Length of side b
÷	52.5	b sin A
75	75.	Length of side a
=	0.7	sin B
F (ARC) (SIN)	44.42701	Angle B in degrees

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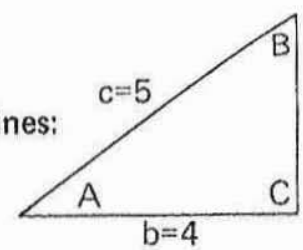
Problem:
Law of Cosines:



Given three sides of the above triangle, find angle A.

Formula:

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$a^2 = c^2 + b^2 - 2cb\ \cos A$ $\qquad A = \cos^{-1}\left(\frac{c^2 + b^2 - a^2}{2cb}\right)$ $\qquad A = 36.8699°$

Keyboard Entry	Display	Memory	Comments
C F (X→ M)	0.	0	Display and memory cleared
3 X	3.		a

(Continued on Page 74)

Keyboard Entry	Display	Memory	Comments
= F (M−)	9.	− 9.	a^2 subtracted from memory
4	4.	− 9.	b
F ($M + X^2$)	4.	7.	b^2 added to memory
X 5	5.	7.	c
F ($M + X^2$)	5.	32.	c^2 added to memory
X	20.	32.	c b
2	2.	32.	
÷	40.	32.	2 cb
F ($X \leftarrow M$)	32.	32.	$c^2 + b^2 - a^2$ recalled from memory
↔	40.	32.	2 cb
=	0.8	32.	cos A
F (ARC) (COS)	36.8699	32.	Angle A (degrees)

Problem:
Hyperbolic Functions: sinh 2.1 = 4.021856

Formula: $\sinh a = \frac{e^a - e^{-a}}{2}$

Keyboard Entry	Display	Comments
2.1	2.1	a
F (e^x)	8.166168	e^a
−	8.166168	
F (1/x)	0.1224564	e^{-a}
÷	8.0437116	$e^a - e^{-a}$
2	2.	
=	4.0218558	sinh a

Problem:
Hyperbolic Functions: cosh 1.3 = 1.970914

Formula: $\cosh a = \frac{e^a + e^{-a}}{2}$

Keyboard Entry	Display	Comments
1.3	1.3	a
[F] (e^x)	3.669295	e^a
[+]	3.669295	
[F] (1/x)	0.2725319	e^{-a}
[÷]	3.9418269	$e^a + e^{-a}$
2	2.	
[=]	1.9709134	cosh a

Problem:
Hyperbolic Functions: $\tanh \frac{\pi}{4} = 0.655794$

Formula: $\tanh a = \frac{e^a - e^{-a}}{e^a + e^{-a}}$

Keyboard Entry	Display	Memory	Comments
[F] (π)	3.1415926		
[÷] 4	4.		
[=]	0.7853981		a
[F] (e^x)	2.193279		e^a
[F] (X → M)	2.193279	2.193279	
[−]	2.193279	2.193279	
[F] (1/x)	0.4559383	2.193279	e^{-a}
[F] (M+)	0.4559383	2.6492173	

(Continued on page 78)

Keyboard Entry	Display	Memory	Comments
[÷]	1.7373407	2.6492173	$e^a - e^{-a}$
[F] (X ← M)	2.6492173	2.6492173	$e^a + e^{-a}$
[=]	0.6557939	2.6492173	tanh a

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Problem:
Inverse Hyperbolic Functions: $\sinh^{-1}$ 1.3356469=1.1

Formula: $\sinh^{-1} a = \ln (a + \sqrt{a^2 + 1})$

Keyboard Entry	Display	Memory	Comments
1	1.		
[F] (X→M)	1.	1.	
1.3356469	1.3356469	1.	a
[F] (M + X^2)	1.3356469	2.7839526	
[+]	1.3356469	2.7839526	
[F] (X ← M)	2.7839526	2.7839526	$a^2 + 1$
[F] ($\sqrt{X}$)	1.668518	2.7839526	$\sqrt{a^2 + 1}$
[=]	3.0041649	2.7839526	$a + \sqrt{a^2 + 1}$
[F] (ln X)	1.1	2.7839526	$\sinh^{-1} a$

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Problem:
Inverse Hyperbolic Functions: $\cosh^{-1}$ 1.3374385 = 0.8

Formula: $\cosh^{-1} a = \ln (a + \sqrt{a^2 - 1})$

[C] [F] (X→M)	0.	0	
[1] [F] (M−)	1.	− 1.	
1.3374385	1.3374385	− 1.	a

(Continued on page 80)

Keyboard Entry	Display	Memory	Comments
[F] (M + X^2)	1.3374385	0.7887417	
[+]	1.3374385	0.7887417	
[F] (X ← M)	0.7887417	0.7887417	$a^2 - 1$
[F] ($\sqrt{X}$)	0.8881113	0.7887417	$\sqrt{a^2 - 1}$
[=]	2.2255498	0.7887417	$a + \sqrt{a^2 - 1}$
[F] (ln X)	0.800003	0.7887417	$\cosh^{-1} a$

Problem:
Inverse Hyperbolic Functions: $\tanh^{-1} 0.7615942 = 1.$
Formula: $\tanh^{-1} a = \frac{1}{2} \ln \frac{1 + a}{1 - a}$

Keyboard Entry	Display	Memory	Comments
[C] [F] (X → M)	0.	0	
1	1.	0	
[F] (X → M)	1.	1.	
[+]	1.	1.	
.7615942	0.7615942	1.	a
[F] (M−)	0.7615942	0.2384058	
[÷]	1.7615942	0.2384058	1 + a
[F] (X ← M)	0.2384058	0.2384058	1 − a
[=]	7.3890576	0.2384058	(1 + a)/(1 − a)
[F] (ln X)	2.	0.2384058	$\ln \frac{1 + a}{1 - a}$
[÷] 2	2.	0.2384058	
[=]	1.	0.2384058	$\tanh^{-1} a$

ENGINEERING

Problem:

Parallel Resistors: Three resistors of 5 ohms, 20 ohms and 10 ohms are connected in parallel. What is the equivalent resistance?

Formula: $R_{eq} = \dfrac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$ $\quad R_{eq} = 2.8571428$ ohms

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Keyboard Entry	Display	Comments
5	5.	R_1
[F] (1/x)	0.2	$1/R_1$
[+]	0.2	
20	20.	R_2
[F] (1/x)	0.05	$1/R_2$
[+]	0.25	$1/R_1 + 1/R_2$
10	10.	R_3
[F] (1/x)	0.1	$1/R_3$
[=]	0.35	$1/R_1 + 1/R_2 + 1/R_3$
[F] (1/x)	2.8571428	Equivalent Resistance (R_{eq})

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Problem:

RC Network:

A step voltage (V_i) of 25 volts is applied across series RC network with R = 50,000 ohms and C = 0.1 microfarads. What is the voltage (V_c) across the capacitor after 15 milliseconds?

Formula: $V_c = V_i \ (1 - e^{-t/RC})$ $V_c = 23.755325$ volts

Keyboard Entry		Display	Comments
.015		0.015	t (15 ÷ 1000) = 0.015 seconds
÷ .0000001		0.0000001	C (0.1 ÷ 10^6) = 0.0000001 farads
÷		150000.	t/C
50000		50000.	R
=		3.	t/RC
+/-	–	3.	– t/RC
F (e^x)		0.049787	$e^{-t/RC}$
– 1		1.	
↔		0.049787	
×		0.950213	$(1 - e^{-t/RC})$
25		25.	V_i
=		23.755325	Voltage across capacitor (V_c)

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Problem:

Simply Supported Beam:

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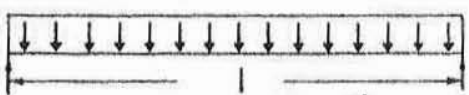
A beam simply supported at the ends carries a uniformly distributed load (w) of 10 pounds per inch across its full length. Find the maximum deflection (Y_c).



Formula: $Y_c = \frac{5\ w\ l^4}{384\ EI}$ $E = .3 \times 10^8$ psi $I = 1.2$ in^4 $l = 200$ in.

Keyboard Entry		Display	Comments
200		200.	Length (l)
[x]		200.	l
[x]		40000.	l^2
[x]		8000000.	l^3
[x]	•	16.000000	l^4; overflow; answer to be times 10^8
[C]		16.000000	$l^4 \div 10^8$
[5]		5.	
[x]		80.	$5 \times l^4 \div 10^8$
10		10.	Load (w)
[÷]		800.	$5 \times (w)\ l^4 \div 10^8$

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384	384	
[÷]	2.0833333	$(5\ (w)\ l^4 \div 10^8)\ 384$
.3	0.3	Entry scaled by 10^8
[÷]	6.9444443	$(5\ (w)\ l^4) \div (384\ E)$
1.2	1.2	Moment of inertia (I)
[=]	5.7870369	Deflection (Y_c) in inches

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Problem:
Shaft Stress:
A shaft 3 inches in diameter (d) has a 1000 inch-pounds bending moment (M) and a 2000 inch-pounds torque (T). What is the maximum stress?

Formula: $\sigma_{max} = \frac{16}{\pi d^3}\left(M + \sqrt{T^2 + M^2}\right)$ $\sigma_{max} = 610.41323$ psi

Keyboard Entry	Display	Memory	Comments
[C] [F] (X → M)	0.	0	Memory cleared
1000	1000.	0	Bending moment (M)
[F] ($M + X^2$)	1000.	1000000.	M^2 added to memory
[+]	1000.	1000000.	
2000	2000.	1000000.	Torque (T)
[F] ($M + X^2$)	2000.	5000000.	T^2 added to memory
[F] (X ← M)	5000000.	5000000.	$T^2 + M^2$
[F] ($\sqrt{x}$)	2236.0679	5000000.	$\sqrt{T^2 + M^2}$
[x]	3236.0679	5000000.	$M + \sqrt{T^2 + M^2}$
16	16.	5000000.	
[÷]	51777.086	5000000.	$16\left(M + \sqrt{T^2 + M^2}\right)$
[F] (π)	3.1415926	5000000.	
[÷]	16481.158	5000000.	$\frac{16}{\pi}\left(M + \sqrt{T^2 + M^2}\right)$
3	3.	5000000.	Diameter (d)
[÷]	5493.7193	5000000.	$\frac{16}{(\pi d)}\left(M + \sqrt{T^2 + M^2}\right)$
[÷]	1831.2397	5000000.	$\frac{16}{(\pi d^2)}\left(M + \sqrt{T^2 + M^2}\right)$
[=]	610.41323	5000000.	Maximum stress in shaft (σ_{max})

Problem:
Sound Pressure:
What is the sound pressure (P) of a jet airplane taking off that was measured to have sound pressure level of 133 decibels (db), where reference pressure (P_o) is 2×10^{-4} μ bar?

Formula: $P = \text{anti-log}_{10} \left(\frac{db}{20} + \log P_o\right)$ $P = 893.367$ μ bars

Keyboard Entry		Display	Memory	Comments
.0002		0.0002		Reference pressure (μ bar)
[F] (log X)	–	3.69897		log P_o; Negative Number Indicator lights
[F] (X → M)	–	3.69897	– 3.69897	
133		133.	– 3.69897	db
[÷] 20		20.	– 3.69897	
[+]		6.65	– 3.69897	$\frac{db}{20}$
[F] (X ← M)	–	3.69897	– 3.69897	Negative Number Indicator lights
[=]		2.95103	– 3.69897	$\left(\frac{db}{20} + \log P_o\right)$
[F] (10^x)		893.367	– 3.69897	Sound pressure (μ bar)

RANGE OF ACCURACY

Your Rockwell 61R Advanced Slide Rule is capable of performing the following scientific functions with great accuracy. All calculations take less than three seconds; in general, functions rarely take more than 1.5 seconds. The six leftmost digits displayed will be correct to within ±1 in the sixth digit displayed, including any suppressed zeros necessary to achieve six digits (except for the few instances noted in the following paragraphs).

TRIGONOMETRIC FUNCTIONS

Sin X, Cos X, and Tan X may be calculated with X in degrees or radians according to the position of the DEG/RAD switch. The result will have the correct algebraic sign. The range of magnitude for sin and cos functions is $-360° \leq X \leq +360°$ (2π radians). For values of X outside of this range, the accuracy may be less than six digits and the computation time greater than 3 seconds. Tan X accuracy may be less than six digits for $89.5° \leq (|X| - 180° n) \leq 90.5°$ (corresponding radians) where n = 0, 1, 2, 3, . . . If X is

large enough to cause an overflow in an intermediate result, the overflow condition occurs and computation is terminated.

INVERSE TRIGONOMETRIC FUNCTIONS

For Arc Sin X and Arc Cos X, the result is displayed in degrees or radians (according to the position of the DEG/RAD switch) with the correct algebraic sign and the following principal angles: $-90°$ ($-\pi/2$ radians) $\leq$ arc sin X $\leq 90°$ ($\pi/2$ radians), $0°$ (0 radians) $\leq$ arc cos X $\leq 180°$ (π radians).

The acceptable range of magnitude of X is $|X| \leq 1$. For values of $|X| > 1$, the calculator will overflow.

Arc Tan X: The result will be displayed in degrees or radians (according to the position of the DEG/RAD switch) with the correct algebraic sign and with the following principal angles: $-90°$ ($-\pi/2$ radians) $\leq$ arc tan X $\leq 90°$ ($\pi/2$ radians). The acceptable range of magnitude of X is $0.0000001 \leq |X| \leq 99999999$ and X = 0.

LOGARITHMETIC FUNCTIONS (ln X and log X)

Both natural and common logarithms may be calculated. The acceptable range of the argument is $0.0000001 \leq X \leq 99999999$. For values of $X \leq 0$, the calculator will overflow.

ANTILOGARITHMETIC FUNCTIONS (e^x and 10^x)

The range of the argument for e^x is $0.000001 \leq X \leq \ln 99999999$ (approximately); the range of the argument for 10^x is $-6 \leq X < 8$. If the value of X is outside of these ranges, the calculator will overflow or underflow.

SQUARE ROOT FUNCTION ($\sqrt{x}$)

The range of the argument is $0 \leq X \leq 99999999$. If X is negative, the calculator will overflow.

EXPONENTIAL FUNCTION (x^y)

The range of X is $0.0000001 \leq X \leq 99999999$; the range of y is $\frac{\ln 0.000001}{\ln X} \leq y \leq \frac{\ln 99999999}{\ln X}$.

The calculation is in two parts according to the formula $X^y = e^{y \ln x}$.

NOTES

Consumer Warranty

Rockwell International Corporation Electronic Calculator

This electronic calculator from ROCKWELL is warranted to be free from defects in materials and workmanship under normal use and service for one year from the date of retail purchase. Rockwell will, free of charge, repair or replace (at its option) any part(s) which are found to have become defective through normal use, provided that the calculator and charger are returned prepaid within one year to one of the Rockwell Customer Service Centers. (The original packaging is ideal for this purpose.)

To assure proper handling and servicing of your calculator under the one-year warranty, you must send with your calculator a copy of the sales receipt (or other proof of purchase date). Calculators returned without proof of purchase date will be serviced out-of-warranty at our prevailing service rates.

This Warranty does not extend to any article which has been subject to misuse, neglect or accident, or if the Serial Number has been altered or defaced, or if the calculator has been serviced by anyone other than a Rockwell Consumer Service Center.

This Warranty contains the entire obligation of Rockwell and no other warranties express or implied or statutory are given. In no event shall Rockwell be liable for consequential damages.

For service under this Warranty, send your Rockwell electronic calculator prepaid, with copy of sales receipt or other proof of purchase date, to your nearest Rockwell Consumer Service Center.

Out-of-Warranty Service

If the calculator fails to operate satisfactorily beyond the one-year warranty period, Rockwell International Service Centers will repair and return the calculator to you for a nominal sum.