Rockwell International

...where science gets down to business

Rockwell Electronic Calculators

Owner's Manual for Scientific Slide Rule

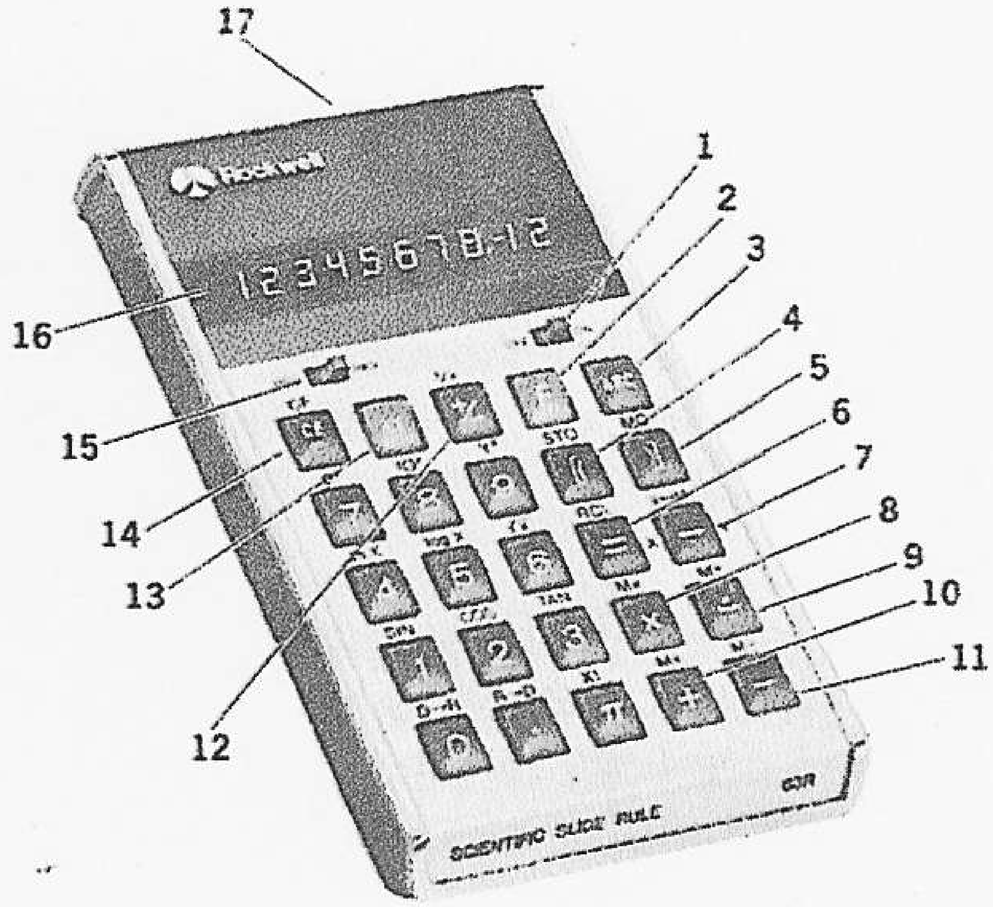
63R

ROCKWELL RELIABILITY IN CONSUMER ELECTRONIC PRODUCTS

Rockwell calculators are built by the same people who helped put men on the moon. People who have had wide experience with advanced electronics in a variety of important industries — including electronic calculators.

We're not only a pioneer in developing the microelectronic chips for calculators, We're a leading supplier of these chips to other calculator manufacturers here and abroad.

Add these credentials to our record of leadership in technologies as diverse as power tools, printing presses, business machines, aircraft, and Admiral television sets and appliances, and you have the company that's uniquely equipped to bring you such a complete line of electronic calculators.



1. ON/OFF Switch
2. Function Key
3. Inverse Trigonometric (ARC) Key
4. Open Parenthesis and Memory Store Key
5. Close Parenthesis and Memory Clear Key
6. Equal and Memory Recall Key
7. Display/Register and Display/Memory Exchange Key
8. Multiply and Multiply Memory Key
9. Divide and Divide Memory Key
10. Add and Add to Memory Key
11. Subtract and Subtract from Memory Key
12. Change Sign and Reciprocal Key
13. Exponent Entry Key
14. Entry Correction/Clear and Clear Function Key
15. Degree/Radian Mode Selection Switch
16. Display
17. Charger Jack

For quick reference to a specific feature or function, see Index, Page 88

If your problems involve trigonometric and logarithmic functions, now you have The Answer — the Rockwell 63R Scientific Slide Rule calculator.

Your Rockwell 63R Scientific Slide Rule calculator has been designed not only to perform the four basic functions of arithmetic, but also to compute a variety of advanced scientific functions required by engineers or those in related fields.

Whether you're an engineering professional or in a related field, or if you're a student of trigonometry, higher mathematics or physics, the Rockwell 63R Scientific Slide Rule is The Answer for you.

GENERAL INFORMATION

Your Rockwell 63R Scientific Slide Rule calculator is supplied with nickel-cadmium rechargeable internal batteries and a battery charger, Part No. 328R07-001 use only the charger furnished with your calculator.

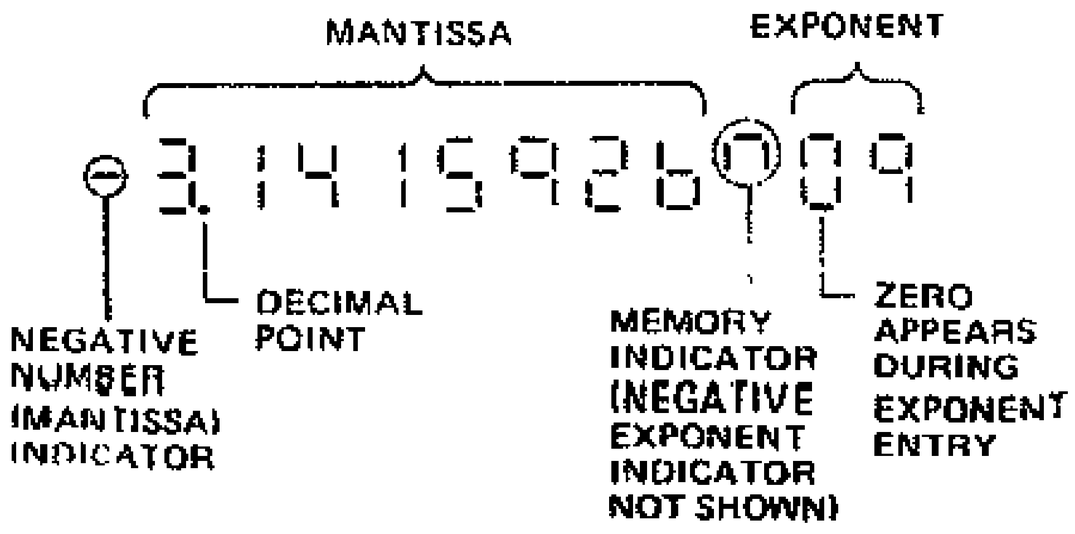
THE FOLLOWING CAUTIONS SHOULD BE NOTED IN ORDER TO PROLONG THE USEFUL RECHARGING LIFE OF THE BATTERIES. When the calculator is first purchased or has not been used for an extended period of time (as long as six months) the batteries should be fully charged for five hours with the calculator off before making extensive use of the calculator. In general, the calculator should not be used extensively with low batteries. Also, the batteries should not be continuously charged for periods greater than 72 hours.

To charge the nickel-cadmium batteries, simply plug the charger into the jack provided in your calculator and a standard 120-volt wall outlet. The calculator may be operated while the battery charger is connected. The calculator will operate from fully charged batteries for at least three hours. The need for recharging is indicated by the display becoming dim. With the calculator turned off, it

takes approximately five hours to fully charge the batteries from a fully discharged state. When the calculator is charged while being operated, it will require a much longer time to charge the batteries. When the batteries are in a fully discharged condition, the calculator may not function even though connected to the charger. Allow at least 10 minutes of charging with the calculator off to eliminate this condition.

DISPLAY

Your calculator 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 left-hand digit position. The calculator is now ready to accept key entries and perform calculations.



Your 63R has 12-character display capacity. The first position is reserved for the Negative Number Indicator. The next eight positions are for the number (mantissa). The tenth position is used for the Negative Exponent and Memory Indicators. The last two spaces are for the exponent.

The display example shown on the previous page is read as:

$$-3.14159265 \times 10^{9}$$

Your calculator can display entries and results in either scientific or floating point notation. Results between ± 1 to ± 99999999 are expressed in floating point notation; results outside of these limits are expressed in scientific notation.

Scientific notation is a means of expressing numbers as multiples of 10 to a power. For example, 3000 would be expressed as 3×10^3 in scientific notation. This would be entered into the calculator by depressing 3 [EE] 3, and the display would show [3. 03].

EXPLANATION OF INDICATORS

Negative Indicators

[-1.2345678-09] – lights to the left of the 8 digit mantissa to indicate negative numbers, and appears to the left of the exponent to indicate negative exponents.

Memory Busy Indicator

1.2345678□09 □ lights to the left of the exponent when the memory contains a nonzero number. If exponent is negative and memory is nonzero, the display will be: 1.2345678□09.

Overflow/Underflow Indicator

.X.X.X.X.X.X.X.X. .X.X all 12 decimal points and 10 digits light if the answer, entry or memory accumulation is larger than | 9.9999999 x 10^{99} | or smaller than | 1. x 10^{-99} | . The indication also occurs if scientific function calculations exceed or violate limits (see page 85). See Overflow/Underflow Conditions, page 22, for detailed information on calculator overflow and underflow.

OPERATION

The Rockwell 63R Scientific Slide Rule has 25 keys, including a unique "secondary function" key that allows keys to have two separate uses. The first (principal) use is identified on the face of the key; the 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 secondary 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.

EXPONENT ENTRY KEY

EE : Depressing the EE key instructs the calculator that the following number entry is an exponent of 10 (scientific notation).

PI KEY

π : Depressing the π key enters the 8-digit value of π (3.1415926) into the mantissa display.

NOTE: This key, following a number entry, clears the number entered and causes immediate entry of π, and vice versa.

ARITHMETIC FUNCTION KEYS

+ ADD, − SUBTRACT, X 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, inter-

mediate results are automatically displayed after these keys are depressed.

ANSWER KEY

[=] : Depressing the [=] key causes your answer to appear in the display and establishes a constant (see page 15), then terminates the calculation. The answer can be retained as the first number for your next calculation (see page 14). The [=] key can be used inside parentheses to execute arithmetic functions, and the answer used in a scientific function (see page 55).

OPEN BRACKET AND PARENTHESIS KEY

[((] : Depressing the [((] key once enters the open parenthesis; depressing it twice enters the open bracket and open parenthesis in sequence. Depressing this key actually causes storage of the intermediate result and prior function into the submemory, and conditions the calculator to solve subproblems within parentheses.

CLOSE PARENTHESIS AND BRACKET KEY

[))] : Depressing the [))] key once enters the close parenthesis; depressing it twice enters the close parenthesis and close bracket in sequence. Depressing this key actually causes execution of a prior function, display of the result of the sub-

problem within parentheses, and recall of the previous intermediate result and prior function stored in the submemories at the time the [((] key was depressed.

NOTE: An arithmetic function or [F](Y^X) key sequence must be used between successive parentheses operations. For example, the calculator will not infer multiplication from the following key sequence: (2 – 5)(3 + 7) =; the sequence must be (2 – 5) x (3 + 7) =.

CLEAR KEY

[CE C] : Depressing the [CE C] key clears the display of erroneous entries, cancels overflow conditions, or clears the calculator (except memory) of stored numbers and functions. (See Clear Operations, page 19, for detailed instructions on use of the [CE C] key.)

CHANGE SIGN KEY

[+/–] : Depressing the [+/–] key changes the sign of the displayed number. To enter a negative number, first enter the number and then press the [+/–] key. Depressing the [+/–] key after the [EE] key changes the sign of the exponent.

REGISTER EXCHANGE KEY

[←→] : Depressing the [←→] key interchanges the contents of the display (X) and the working register (Y).

INVERSE TRIGONOMETRIC KEY

[ARC] : Depressing the [ARC] key before the (SIN), (COS), or (TAN) key, instructs the calculator to determine the angle of the selected trigonometric function whose value is the displayed quantity.

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 29.

Techniques for recovery of data following unintentional depression of the wrong arithmetic function key or the [F] key are given under Recovery Techniques, page 44.

BASIC OPERATIONS

Your Rockwell 63R uses algebraic logic. This means that your calculator works the same way you think. Entries are made the same way you would write an algebraic equation. Notice that the display shows each new numerical entry as you depress the number entry keys.

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 example also illustrates 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

Answer Re-Entry

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: 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 63R 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.	(6 x 6) executed
[÷]	30.	((6 x 6) - 6) executed
[+]	5.	(((6 x 6) - 6) ÷ 6) executed
[=]	11.	

CONSTANT OPERATIONS

The automatic constant is another time-saving feature. This feature enables you to add, subtract, multiply or divide a group of numbers by the same

(constant) number repeatedly without re-entering the number for each new calculator. 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 arithmetic function key depressed before depressing the [=] key. To perform multiple operations with the saved constant, enter a new augend, minuend, multiplicand or dividend, and depress the [=] key for an answer. In all instances, the constant is retained until a different number is entered after an arithmetic function key is depressed.

Problem: $5 + 3 = 8$ $\qquad$ $2 + 3 = 5$

Keyboard Entry	Display	Comments
5	5.	Constant undetermined
[+] 3	3.	Constant addend = 3
[=]	8.	
2	2.	
[=]	5.	

CALCULATIONS USING PARENTHESIS KEYS

NOTE: In the following example, parentheses and brackets are entered in the same sequence as the problem is written.

Problem: $[(2 \times 3) + (3 \div 4)] \div [(3 + 5) \times (7 - 9)] = -0.421875 = -4.21875 \times 10^{-1}$

Keyboard Entry	Display	Comments
[[(] [(] 2	2.	
[X] 3	3.	
[)] [+] [(]	6.	(2 x 3) executed; addition operation established
3	3.	
[÷] 4	4.	
[)]	7.5 $\quad -1$	(3 ÷ 4) executed

Keyboard Entry	Display	Comments
[)] [÷] [(] [(]	6.75	(2 x 3) + (3 ÷ 4) executed; division operation established
3	3.	
[+] 5	5.	
[)] [X] [(]	8.	(3 + 5) executed; multiplication operation established
7	7.	
[−] 9	9.	
[)]	−2.	(7 − 9) executed
[)]	−16.	(3 + 5) x (7 − 9) executed
[=]	−4.21875	− 1

CLEAR OPERATIONS

There are three clear keys and they perform the following functions:

[CE C] clear entry/clear calculator, (CF) clear function, (MC) clear memory;

1. **Clear Entry (Enter Correction):** A single depression of the [CE C] key after entry of a number clears the displayed number but does not affect the stored constants or the operation in progress.

Example: 12 + 5.5 = 17.6

Keyboard Entry	Display	Comments
12	12.	
[+] 5.6	5.6	Error; wrong number entered
[CE C]	0.	Clear entry
5.5	5.5	
[=]	17.5	

2. **Clear Calculator (Except Memory):** A double depression of the [CE/C] key clears any operation in progress and clears the calculator except the memory.

Example: 2 + 3

Keyboard Entry	Display	Comments
2	2.	
[+] 3	3.	
[CE/C]	0.	Entry cleared
[CE/C]	0.	Calculator cleared

NOTE: Depressing [CE/C] key once after an arithmetic function key, answer key, π key or exchange key clears calculator.

3. **Clear Overflow/Underflow:** Depressing the [CE/C] key during an overflow/underflow (see Overflow/Underflow Conditions) cancels the overflow/underflow condition and clears the calculator of any operation in progress.

NOTE: Overflow/Underflow indication may be cancelled by depressing other keys than [CE/C] but the calculator will not be reset and successive computations could be in error.

4. **Clear Function:** Depressing the (CF) key after pressing the [F] or [ARC] key clears the secondary function operation and restores the previous condition (see page 45).

5. **Clear Memory:** Depressing the [F] and (MC) keys clears the memory (see page 31).

OVERFLOW/UNDERFLOW CONDITIONS

The following operations result in an overflow/underflow condition which causes the Overflow/Underflow Indicator, [.X.X.X.X.X.X.X.X. .X.X.], to light.

1. Any answer, subtotal or entry

   a. exceeding 9.9999999×10^{99} regardless of its arithmetic sign (absolute value greater than 9.9999999×10^{99}).
   b. less than $1. \times 10^{-99}$ regardless of its arithmetic sign (absolute value smaller than $1. \times 10^{-99}$.

2. Memory operation answer or subtotal outside of $1. \times 10^{-99} < |X| < 9.9999999 \times 10^{99}$.

3. Division by zero [.0.0.0.0.0.0.0.0. .0.0.] .

4. Computation of scientific functions outside of their or calculator limits (see page 85).

CHANGE SIGN OPERATION

Depressing the [+/-] key changes the sign of the number in the display. The Rockwell 63R Scientific Slide Rule allows sign change at any point in a calculation.

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

Keyboard Entry	Display	Comments
4 [X]	4.	
[X]	16.	

(Continued on page 24)

Keyboard Entry	Display	Comments
3	3.	
[+/−]	−3.	Negative Indicator lights
[÷]	−48.	
6	6.	
[=]	−8.	

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NOTE: For changing sign of exponent while entering scientific notation number, see page 27.

REGISTER EXCHANGE OPERATION

Another useful feature of your Rockwell 63R Scientific 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 which is 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.

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CONSTANT π KEY

The value of π may be entered into the display at any time by depressing the [π] key. The display will be 3.1415926.

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

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

Keyboard Entry	Display	Comments
6 [X]	6.	Diameter (D)
[X]	36.	D^2
[π]	3.1415926	
[÷]	113.09733	πD^2
4	4.	
[=]	28.274332	Area (A) in square feet

EXPONENT ENTRY KEY

Numbers may be entered into the 63R in scientific notation, that is expressed as a base number (mantissa) multiplied by 10 raised to an exponent: $X \cdot 10^Y$, where X is the base number and Y is the exponent. For example, 125 can be expressed as 1.25×10^2. The base number is 1.25 and the exponent is 2. The procedure for entering numbers in scientific notation is as follows:

1. Enter the base number, digit by digit (followed by [+/−] if the base number is negative).
   NOTE: A base of 1 is assumed if the base number is not entered before depressing [EE].
2. Depress [EE] key.
   NOTE: An exponent of 0 is assumed if the base number is entered and [EE] is depressed, but no exponent is entered.
3. Enter the one- or two-digit exponent (followed by [+/−] if the exponent is negative).
   NOTE: A maximum of two digits can be entered for the exponent. If more than two digits are entered, only the last two are retained. This enables entry of the correct exponent without clearing the base number.

The following examples illustrate the entry of a number in scientific notation:

Number:	Keyboard Entry	Display	Comments
1×10^{-6}	EE	1. 00	
	6	1. 06	
	+/-	1. −06	
	CE C	0.	To clear before entry of next number.
-3.14×10^{-9}	3.14	3.14	
	+/-	−3.14	
	EE	−3.14 00	
	9	−3.14 09	
	+/-	−3.14 −09	

KEY SECONDARY FUNCTIONS

Depressing the F or ARC key conditions the 63R Scientific Slide Rule to perform the secondary function of the next key depressed. The secondary function is cancelled after execution of a secondary function operation. Operation and uses of the keys in performing their secondary function are described in the following paragraphs.

NOTES:

1. **Secondary functions can be chained except for Y^X and X!, which must be enclosed in parentheses (see pages 42 and 43).**
2. **The display is momentarily blank during many operations using the scientific function keys. No keyboard entries should be attempted before the display turns on again.**

MEMORY OPERATIONS

Unlike the memory in many calculators, the memory in your Rockwell 63R can do a lot more than simply store a number to be used in later calculations. It gives you a second "invisible" calculator which operates inside the first. You can also multiply or divide the number in memory by the displayed number. At any

time, you can recall the number from memory into the display for use as a number entry for the calculation in progress. 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 displayed number to memory
(M—)	Subtract displayed number from memory
(Mx)	Multiply number in memory by the displayed number. The product is stored in memory
(M÷)	Divide the number in memory by the displayed number. The quotient is stored in memory
(RCL)	Recall number in memory into display. (This operation does not alter number in memory.)
(STO)	Store displayed number in memory. Any number previously in memory is replaced by the displayed number.
(X ↔ M)	Exchange number being displayed with number in memory
(MC)	Clear memory. The displayed number and any functions are not affected. (A non-zero memory is indicated by the symbol ⊓ between the mantissa and exponent displays. See page 6).

The following example illustrates how the contents of the memory is affected by each memory key.

Keyboard Entry	Display		Memory	Comments
6	6.		0*	
[F] (STO)	6.	⊓	6.	Memory indicator lights
[F] (Mx)	6.	⊓	36.	
[F] (M–)	6.	⊓	30.	
[F] (M÷)	6.	⊓	5.	

(Continued on page 32)

Keyboard Entry	Display		Memory	Comments
[+] [F] (RCL)	5.	⊓	5.	
[=]	11.	⊓	5.	
[F] (M+)	11.	⊓	16.	
[F] (X ↔ M)	16.	⊓	11.	
[F] (MC)	16.		0.	

*The memory is automatically cleared when the calculator is turned on. Consequently, the memory will contain zero if it has not been previously used. If the memory has been used and has not been cleared since turning the calculator on, the memory contains the last stored value.

DEGREE/RADIAN CONVERSIONS (D → R), (R → D)

Depressing the [F] key and then the (D → R) or (R → D) key will cause the number in the display to be converted from degrees to radians or vice versa.

Problem: π radians = 180^{o} = π radians

Keyboard Entry		Display
[π]		3.1415926
[F]	(R→D)	179.99999
[F]	(D→R)	3.1415925

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

Depressing the [F] key and then the (SIN), (COS) or (TAN) key will cause 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 determines whether the trigonometric functions are to be computed with angles expressed in degrees or radians.

Problem: $\sin 30^{o} = 0.5 = 5 \times 10^{-1}$

Keyboard Entry	Display	Comments
30	30.	DEG/RAD switch in DEG position
[F] (SIN)	5. –1	

Problem: $\cos 300^{o} = 0.5 = 5 \times 10^{-1}$

Keyboard Entry	Display	Comments
300	300.	DEG/RAD switch in DEG position
[F] (COS)	5. –1	

Problem: tan 2 radians = –2.18504

Keyboard Entry	Display	Comments
2	2.	DEG/RAD switch in RAD position
[F] (TAN)	–2.18504	

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

Depressing the [ARC] key and then the (SIN), (COS) or (TAN) key will cause 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: $\sin^{-1}(0.5) = 30^{o}$

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

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

Keyboard Entry	Display	Comments
.5	0.5	DEG/RAD switch in DEG position
[ARC] (COS)	60.	

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

Keyboard Entry	Display	Comments
1	1.	DEG/RAD switch in DEG position
[ARC] (TAN)	45.	

SQUARE ROOT ($\sqrt{x}$)

Depressing the [F] and ($\sqrt{x}$) keys cause 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.

RECIPROCALS (1/x)

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

Problem: $\frac{1}{20} = 0.05 = 5 \times 10^{-2}$

Keyboard Entry	Display
20	20.
[F] (1/x)	5. –2

COMMON LOGARITHMS FUNCTION (log X)

Depressing the [F] and (log X) keys cause 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.

NATURAL LOGARITHMS FUNCTION (ln X)

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

Problem: $\ln (32^3) = 3 \ln 32 = 10.39722$

Keyboard Entry	Display
32	32.
[F] (ln X)	3.46574
[x] 3	3.
[=]	10.39722

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

Depressing the [F] and (e^x) or [F] and (10^x) keys as desired cause the antilogarithms of the displayed number for the base e (e = 2.71828) or base 10 to be computed and displayed.

Problem: $10^2 = 100$

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

Problem: $e^{-3} = 0.0497871 = 4.97871 \times 10^{-2}$

Keyboard Entry	Display	
3	3.	
[+/-]	−3.	
[F] (e^x)	4.97871	−2

EXPONENTIAL FUNCTION (Y^x)

The exponential function raises Y (first number entered) to the power x (second number entered) for any real values of x. Depressing the [F] and (Y^x) keys cause the displayed number to be taken as the value of Y. The function is completed by entering x and pressing the [+], [−], [÷], [×], [)] or [=] key.

Problem: $3^4 = 81$

Keyboard Entry	Display
3	3.
[F] (Y^x)	3.
4	4.
[=]	81.

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

Keyboard Entry	Display	
32 [F] (Y^x)	32.	
5	5.	
[F] (1/x)	2.	−1
[=]	2.	

The Y^X function can be chained with other operations by use of parentheses as follows:

Problem: $3 \times (4^{2.5}) = 96$

Keyboard Entry	Display
3 [X] [(]	3.
4	4.
[F] (Y^X)	4.
2.5	2.5
[)]	32.
[=]	96.

FACTORIALS (X!)

Depressing the [F] and (X!) keys cause the factorial of the number being displayed to be computed and displayed.

Problem: 6! = 720

Keyboard Entry	Display
6	6.
[F] (X!)	720.

The X! function may be chained with other operations as follows:

Problem: 12 + (4!) = 36

Keyboard Entry	Display
12 [+] [(]	12.
4	4.
[F] (X!)	24.
[)]	24.
[=]	36.

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 the intended arithmetic function key and continue with your calculations. If constant multiplication or division is being performed, the constant will be replaced by 1.

Unintentional [+] or [−] : Depress 0, then the intended arithmetic function key and continue with your calculations. If constant addition or subtraction is being performed, the constant will be replaced by 0.

Unintentional [F] or [ARC] :

1. Depressing the (CF) key immediately after an unintentional [F] or [ARC] 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.	

(Continued on page 46)

2. Depressing the [ARC] or [F] key immediately after an unintentional [F] or [ARC] key causes the calculator to compute and display the trigonometric functions based on the last [F] or [ARC] key depression.

Problem: sin 45 = 0.707107 = 7.07107×10^{-1}

45	45. –1	DEG/RAD switch in DEG position
[ARC]	45.	Error!! Did not want to press [ARC]
[F] (SIN)	7.07107 –1	

SAMPLE PROBLEMS

Your Rockwell 63R Scientific 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 recommend that you gain familiarity with your Rockwell 63R 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 the following pages:

(Continued on page 48)

Statistics:

Problem: Find the mean (μ), variance (σ^2), standard deviation (σ), and standard error (σ_μ) of the mean of the following values of x, (10, 11, -3, 14, 18) (Note: n = 5)

Formulas:

a. $\mu = \sum_{i=1}^{n} \frac{X_i}{n}$

$\mu = 10$

b. $\sigma^2 = \frac{\sum_{i=1}^{n} X_i^2 - \frac{\left(\sum_{i=1}^{n} X_i\right)^2}{n}}{n}$

$\sigma^2 = 50$

c. $\sigma = \sqrt{\frac{\sum_{i=1}^{n} X_i^2 - \frac{\left(\sum_{i=1}^{n} X_i\right)^2}{n}}{n}}$

$\sigma = 7.0710678$

d. $\sigma_\mu = \frac{\sigma}{\sqrt{n}}$

$\sigma_\mu = 3.1622777$

(Continued on page 50)

Keyboard Entry	Display		Memory	Comments
10	10.		0.	
F (STO)	10.	n	10.	X_i summed in memory; using (STO) key clears memory and stores first X.
[x]	10.	n	10.	
[+] [(]	100.	n	10.	X_i^2 summed in display
11 [F] (M+)	11.	n	21.	
[X] [)]	121.	n	21.	
[+] [(]	221.	n	21.	
3 [+/-] [F] (M+)	−3.	n	18.	
[X] [)]	9.	n	18.	
[+] [(]	230.	n	18.	
14 [F] (M+)	14.	n	32.	
[X] [)]	196.	n	32.	
[+] [(]	426.	n	32.	
18 [F] (M+)	18.	n	50.	
[X] [)]	324.	n	50.	
[=]	750.	n	50.	
[F] (X↔ M)	50.	n	750.	Exchanged ΣX_i and ΣX_i^2
[÷]	50.	n	750.	

(Continued on page 52)

Keyboard Entry		Display		Memory	Comments
5		5.	n	750	n
[X]		10.	n	750.	Mean (μ) displayed
[↔]		5.	n	750.	
[ ]		50.	n	750.	$\mu \cdot n = \Sigma X_i$ displayed
[ ]		500.	n	750.	$\mu^2 \cdot n = \frac{(\Sigma X_i)}{n}$ displayed
[F]	(M-)	500.	n	250.	$(\Sigma X_i^2) - \frac{(\Sigma X_i)^2}{n}$ subtracted in memory
[F]	(RCL)	250.	n	250.	
[÷]	5	5.	n	250.	n
[=]		50.	n	250.	Variance (σ)
[F]	($\sqrt{X}$)	7.0710678	n	250.	Standard deviation (σ)
[÷]	5	5.	n	250.	n
[F]	($\sqrt{X}$)	2.2360679	n	250.	$\sqrt{n}$
[=]		3.1622777	n	250.	Standard error (σ_μ) of the mean

Combination with Fixed Arrangements:

Problem: What is the number of combinations of (n) things taken (r) at a time?

Formula: $\binom{n}{r} = \frac{n!}{r!\,(n-r)!}$ $\quad n = 10, r = 6 \quad \binom{n}{r} = 210$

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Keyboard Entry	Display	Comments
10	10.	
F (X!)	3628800.	10!
÷ ((((	3628800.	
6	6.	
F (X!)))	720.	6!
X ((	720.	
10 -	10.	
6	6.	
=	4.	= key used to execute (10 - 6)
F (X!)))	24.	(10 - 6)!
))	17280.	6! (10 - 6)!
=	210.	$\binom{n}{r}$

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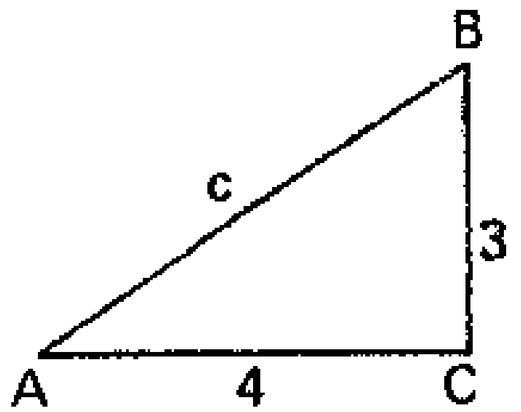
The Pythagorean Theorem:



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

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

$c = 5$

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Keyboard Entry	Display	Comments
3 [X]	3.	
[+] [((]	9.	
4 [X]	4.	
[))]	16.	
[=]	25.	
[F] [$\sqrt{X}$]	5.	Hypotenuse (c)

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Converting from Rectangular to Polar Coordinates:

Problem: Convert the point (24, 70) into polar coordinates.

Formulas:

Magnitude of Vector: $r = \sqrt{x^2 + y^2}$

angle θ = $\tan^{-1} \frac{y}{x}$

Where $x = 24$ and $y = 70$

$\theta = 71.07536^{O}$

$r = 74.$

(Continued on page 58)

Keyboard Entry	Display		Memory	Comments
70 [X]	70.			DEG/RAD switch in DEG position
[F] (STO)	70.	⊓	70.	y stored in memory
[+] [((	4900.	⊓	70.	y^2
24 [X]	24.	⊓	70.	x
[F] (M÷)	24.	⊓	2.9166666	y ÷ x executed and stored in memory
[)]	576.	⊓	2.9166666	x^2
[=]	5476.	⊓	2.9166666	$y^2 + x^2$

[F] ($\sqrt{x}$)	74.	⊓	2.9166666	Magnitude of vector (r)
[F] (RCL)	2.9166666	⊓	2.9166666	y/x recalled from memory
[ARC] (TAN)	71.0753	⊓	2.9166666	Angle θ (degrees) — The algorithm used does not give quadrant information. The answer should be checked and placed in the right quadrant by adding 180°.

Converting from Polar to Rectangular Coordinates:

Problem: Convert the point 74, 161° into rectangular coordinates.

Formulas: $x = r \cos\theta$
$y = r \sin\theta$
$r = 74$

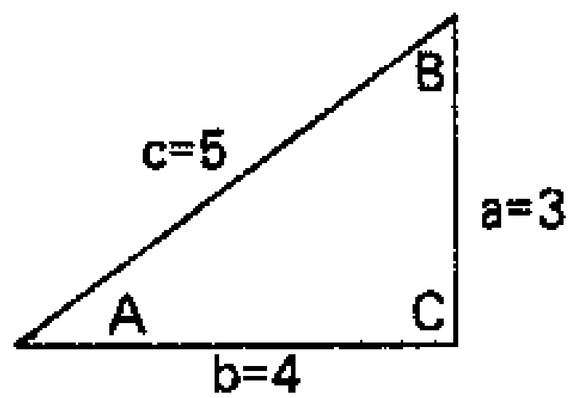
$\theta = 161^\circ$
$x = -69.968406$
$y = 24.092032$

(Continued on page 60)

Keyboard Entry	Display			Memory	Comments
161	161.				DEG/RAD switch in DEG position Angle (θ) (degrees)
[F] (STO)	161.	⌐		161.	θ stored in memory
[F] (COS)	−9.45519	□	1	161.	cos θ
[X] 74	74.	⌐		161.	Vector (r)
[=]	−69.968406	⌐		161.	x-coordinate
[↔] [X]	74.	⌐		161.	r brought back from working register
[F] (RCL)	161.	⌐		161.	θ recalled from memory
[F] (SIN)	3.25568	□	1	161.	sin θ
[=]	24.092032	⌐		161.	y-coordinate

Law of Cosines:

Problem: Given three sides of illustrated triangle, find angle A.



Formula: $a^2 = c^2 + b^2 - 2cb\cos A$

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

$$A = 36.8699^{o}$$

(Continued on page 62)

Keyboard Entry	Display		Memory	Comments
5 [×]	5.			c
[F] (STO)	5.	⊓	5.	
[+] [((]	25.	⊓	5.	c^2
4 [×]	4.	⊓	5.	b
[F] (Mx)	4.	⊓	20.	cb performed and stored in memory
[))]	16.	⊓	20.	b^2
[−] [((]	41.	⊓	20.	$c^2 + b^2$

3 [×]	3.	⊓	20.	a
[))]	9.	⊓	20.	a^2
[÷]	32.	⊓	20.	$c^2 + b^2 - a^2$
2 [F] (Mx)	2.	⊓	40.	2cb performed and stored in memory
[F] (RCL)	40.	⊓	40.	2cb recalled from memory
[=]	8.	◻ 1	40.	$(c^2 + b^2 - a^2)/2cb$
[ARC] (COS)	36.8699	⊓	40.	Angle A (degrees)
[F] (D → R)	6.4350115	◻ 1	40.	Angle A (radians)

Hyperbolic Functions:

Formulas:

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

2. $\cosh x = \frac{e^x + e^{-x}}{2}$

3. $\tanh x = \frac{e^x - e^{-x}}{e^x + e^{-x}}$

Because the solutions for Hyperbolic Functions are similar, the key sequence for only one function is shown.

Problem: $\tanh \frac{\pi}{4} = 0.65579421 = 6.5579421 \times 10^{-1}$

Keyboard Entry	Display	Memory	Comments
[π]	3.1415926		
[÷] 4	4.		
[=]	7.8539815 – 1		x
[F] (e^x) [−]	2.19328		e^x
[F] (STO)	2.19328	2.19328	
[F] (1/x)	4.5593813	2.19328	e^{-x}
[F] (M+)	4.5593813	2.6492181	$(e^x + e^{-x})$ in memory
[÷]	1.7373419	2.6492181	$(e^x - e^{-x})$ in display
[F] (RCL)	2.6492181	2.6492181	
[=]	6.5579421	2.6492181	tanh x

Inverse Hyperbolic Functions:

Formulas:

1. $\sinh^{-1}x = \text{Ln}\ x + (x^2 + 1)^{1/2}$

2. $\cosh^{-1}x = \text{Ln}\ x + (x^2 - 1)^{1/2}$

3. $\tanh^{-1}x = 1/2\ \text{Ln}\ \frac{1 + x}{1 - x}$

Because solutions for Inverse Hyperbolic Functions are similar, the key sequence for only one function is shown.

Problem: $\tanh^{-1}\ 0.7615942 = 1$

Keyboard Entry	Display		Memory	Comments
1 [+]	1.			
[F] (STO)	1.	⊓	1.	
.7615942	0.7615942	⊓	1.	x
[F] (M-)	7.615942	◻ 1	2.384058– 1	(1–x) in memory
[÷]	1.7615942	⊓	2.384058– 1	1 + x
[F] (RCL)	2.384058	◻ 1	2.384058– 1	
[=]	7.3890576	⊓	2.384058– 1	(1 + x) ÷ (1– x)
[F] (ln X)	2.	⊓	2.384058– 1	
[÷] 2	2.	⊓	2.384058– 1	
[=]	1.	⊓	2.384058– 1	$\tanh^{-1}x$

ENGINEERING

Parallel Resistors:

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

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

Keyboard Entry	Display		Comments
5	5.		R_1
[F] (1/x)	2.	−1	$1/R_1$
[+]	2.	−1	
20	20.		R_2
[F] (1/x)	5.	−2	$1/R_2$
[+]	2.5	−1	$1/R_1 + 1/R_2$
10	10.		R_3
[F] (1/x)	1.	−1	$1/R_3$
[=]	3.5	−1	$1/R_1 + 1/R_2 + 1/R_3$
[F] (1/x)	2.8571428		Equivalent Resistance (R_{eq})

RC Network:

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

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

Keyboard Entry	Display	Comments
25 [x] [(]	25.	V_i
1 [−] [(]	1.	

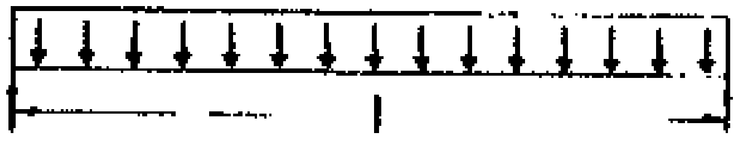
Keyboard Entry	Display	Comments
.015	0.015	t (15 ÷ 1000) = .015 seconds
[÷]	1.5	→ 2
[EE]	1. 00	
7	1. 07	
[+/-]	1. − 07	C (0.1 ÷ 10^6) = 1 x 10^{-7} farads
[÷]	150000.	t/C
50000	50000.	R

(Continued on page 72)

Keyboard Entry	Display	Comments
))	3.	t/RC
+/-	−3.	−t/RC
F (e^x)	4.97871 −2	$e^{-t/RC}$
))	9.502129 −1	$1-e^{-t/RC}$
=	23.755322	Voltage across capacitor (V_c)

Simple Supported Beam:

Problem: 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: $Y_c = \frac{5\,w\,l^4}{384\,EI}$

$E = 30 \times 10^6$ psi

$I = 1.2$ in.^{4}

$l = 200$ in.

$Y_c = 5.7870369$ in.

(Continued on page 74)

Keyboard Entry	Display		Comments
200	200.		Length (l)
[F] (Y^X)	200.		
4	4.		
[X]	1.6	9	l^4
5	5.		
[X]	8.	9	$5 \times l^4$
10	10.		load (w)
[÷]	8.	10	$5\ (w)\ l^4$
384	384.		
[÷]	2.0833333	8	$(5\ (w)\ l^4) \div 384$

Keyboard Entry	Display		Comments
30 [EE] 6	30.	06	Modulus of elasticity (E)
[÷]	6.9444443		$(5\ (w)\ l^4) \div (384E)$
1.2	1.2		Moment of inertia (I)
[=]	5.7870369		Deflection (Y_c) in inches

Shaft Stress:

Problem: 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 (σ_{max})?

Formula: $\sigma_{max} = \frac{16}{\pi d^3}(M + \sqrt{T^2 + M^2})$ $\sigma_{max} = 610.41325$ psi

(Continued on page 76)

Keyboard Entry	Display	Comments
1000	1000.	Bending moment (M)
[+] [((	1000.	
[X] [+] [((	1000000.	M^2
2000 [X]	2000.	Torque (T)
[))	4000000.	T^2
[))	5000000.	$M^2 + T^2$
[F] ($\sqrt{x}$)	2236.0679	$\sqrt{M^2 + T^2}$
[X]	3236.0679	$M + \sqrt{M^2 + T^2}$

16	16.	
[÷]	51777.086	$16\ (M + \sqrt{M^2 + T^2})$
[π]	3.1415926	π
[÷] [((	16481.158	$\frac{16}{\pi}\ (M + \sqrt{M^2 + T^2})$
3 [F] (Y^X)	3.	Diameter (d)
[))	27.	d^3
[=]	610.41325	Maximum stress in shaft (σ_{max})

Sound Pressure:

Problem: 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?

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

Keyboard Entry	Display		Comments
2	2.		
EE	2.	00	
4	2.	04	
+/–	2.	–04	Reference pressure (μ bar)
F (log x)	–3.69897		log (P_o)
+ ((	–3.69897		
133	133.		dB
÷ 20	20.		
))	6.65		dB/20
=	2.95103		(dB/20) + log (P_o)
F (10^x)	893.367		Sound pressure (μ bar)

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BUSINESS

A few basic business formulas are listed below. The symbols used in the formulas are as follows:

n	number of periods over which interest is compounded
i	interest rate per period (n)
PMT	payment per period (n)
PV	present value
FV	future value

Formulas: a) Compounded Lump Sum

$$FV = PV\ (1 + i)^n$$

b) Sinking Fund

$$FV = PMT\ \frac{(1 + i)^n - 1}{i}$$

c) Discounted Lump Sum

$$PV = \frac{FV}{(1 + i)^n}$$

d) Annuity

$$PV = PMT\ \frac{(1 + i)^n - 1}{i\ (1 + i)^n}$$

e) Loan Amortization/Amount of an Annuity

$$PMT = PV\ \frac{(i\ (1 + i)^n)}{((1 + i)^n - 1)}$$

f) Sinking Fund Payments

$$PMT = FV\ \frac{i}{(1 + i)^n - 1}$$

(Continued on page 82)

g) Number of periods to amortize a loan or number of periods in an annuity.

$$n = \frac{\ln \frac{PMT}{PMT - PV \cdot i}}{\ln (1 + i)}$$

82 Because the solutions of the business formulas are similar, the key sequence for only one function is shown:

Problem: Loan Amortization/Amount of an Annuity
S3000 is to be borrowed from a bank charging 10% interest per year. The loan is to be repaid in 24 monthly payments. What is the payment? Formula (e) is used.

Keyboard Entry	Display	Memory	Comments
3000	3000.		Amount borrowed (PV)
[×] [(] .1	0.1		Interest per year (i x 12)
[÷]	1. −1		
12	12.		
[×]	8.3333333 −3		Interest per month (i)
[(]	8.3333333 −3		
[+] 1	1.		
[F] (Y^X)	1.0083333		(1 + i)

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24		24.				Number of payments (n)
)]		1.22039				$(1 + i)^{24}$
F	(STO)	1.22039	⊓		1.22039	$(1 + i)^{24}$ stored for future use
)]		1.0169916	□	2	1.22039	$i\ (1 + i)^{24}$
÷		30.509748	⊓		1.22039	PV $i\ (1 + i)^{24}$
((F	(RCL)	1.22039	⊓		1.22039	$(1 + i)^{24}$ from memory
− 1		1.	⊓		1.22039	
)]		2.2039	□	1	1.22039	$(1 + i)^{24} - 1$
=		138.43526	⊓		1.22039	Load payment (PMT)

RANGE OF ACCURACY

Your Rockwell 63R Scientific Slide Rule is capable of performing scientific functions with great accuracy. Calculation of a scientific function may take up to seven seconds if a large argument (X) is used; in general, functions rarely take more than 1.5 seconds. The scientific function calculations will be correct to ±1 in the sixth significant digit, e.g., 0.008726$\underline{\underline{6}}$, including any suppressed trailing 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. Tan X accuracy may be less than six digits for $89.5^{o} \leqslant (X - 180^{o}n) \leqslant 90.5^{o}$ (corresponding radians) where $n = 0,1,2,3,\ldots$. If $|X| > 157.08$ radians or equivalent degrees for Sin X and Tan X, and $-158.08 > X > 155.51$ radians or

equivalent degrees for Cos X an overflow condition will occur and computation will be 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^{o} ($-\pi/2$ radians) $\leqslant$ arc sin X $\leqslant 90^{o}$ ($\pi/2$ radians), 0^{o} (0 radians) $\leqslant$ arc cos X $\leqslant 180^{o}$ (π radians).

The acceptable range of magnitude of X is $|X| \leqslant 1$. 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^{o} ($-\pi/2$ radians) $\leqslant$ arc tan X $\leqslant 90^{o}$ ($\pi/2$ radians). The acceptable range of magnitude of X is $1 \times 10^{-9} \leqslant X \leqslant 1 \times 10^{9}$ and $X = 0$.

LOGARITHMIC FUNCTIONS (ln x and log x)

Both natural and common logarithms may be calculated. The acceptable range of the argument is $1. \times 10^{-99} \leqslant X \leqslant 9.9999999 \times 10^{99}$. For values of $X \leqslant 0$, the calculator will overflow.

ANTILOGARITHMIC FUNCTIONS (e^{X} and 10^{X})

The range of the argument for e^{X} is $-227.95592 \leqslant X \leqslant 230.2585$; the range of the argument for 10^{X} is $-99 < X < 100$. 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 $0 \leqslant X \leqslant 9.9999999 \times 10^{99}$. If X is negative, the calculator will overflow.

EXPONENTIAL FUNCTION (Y^{X})

The range of Y is $1 \times 10^{-99} \leqslant Y \leqslant 9.9999999 \times 10^{99}$; the range of X is

$$\frac{\ln(1 \times 10^{-99})}{\ln Y} \leqslant X \leqslant \frac{\ln(9.9999999 \times 10^{99})}{\ln Y}$$

If the values of X and Y are outside of these ranges, the calculator will overflow or underflow.

FACTORIAL FUNCTION (X!)

The range of X is any positive integer from 1 to 69. If X is not a positive integer or outside of the range, the calculator will overflow.

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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 is returned prepaid within one year to one of the ROCKWELL Customer Service Centers. (The original packaging may be used for this purpose.) If a ROCKWELL battery charger is used with your calculator, return it with your calculator.

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 Customer Service Center. Batteries are excluded from this Warranty.

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 Customer Service Center.

Out-of-Warranty Service
If the calculator fails to operate satisfactorily beyond the one-year warranty period, ROCKWELL Customer Service Centers will repair and return the calculator to you at our prevailing service rates.

WARRANTY NOT VALID
OUTSIDE U.S.A. AND CANADA