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- P - 65

MATH PAC 2

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INTRODUCTION

Programs for your HP-65 Math Pac 2 have been selected from the areas of number theory, complex analysis, numerical analysis and miscellaneous higher functions.

Each program includes a general description, formulas used in the program solution, numerical examples, and user instructions. Program listings and register allocations are given in the back of the Pac.

Some related individual programs were combined on one card when it seemed they might be useful together. In this way more programs could be included in the Pac.

We hope you find the HP-65 Math Pac 2 a useful tool for your computational work, and welcome your comments, requests and suggestions—these are our most important source of future user-oriented programs.

FORMAT OF USER INSTRUCTIONS

The following is an example of a set of User Instructions.

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Clear registers		A	
3	Perform 3-4 for $i=1, \dots, n$	a_i	$\uparrow$	
4		b_i	B	
5			C	Answer
	(To run a new case, go to 2)			

To follow the instructions, start with line 1 and read from left to right, performing indicated operations as you proceed. Lines having no numbers contain special notes to the user and are inside parentheses in the INSTRUCTIONS column. The message "To run a new case, go to 2" following line 5 in the above example is a special note.

Lines are read in sequential order except where the INSTRUCTIONS column directs otherwise. For example, "go to 2" means to jump to line 2. Repeated processes—used in most cases for a long string of input/output data—are outlined with a bold border together with a "Perform" instruction. In the above example, "Perform 3-4 for $i=1, \dots, n$ " means to execute the loop (line 3 and line 4) n times. The first time, the dummy variable i takes the value 1; the second time i takes the value 2; etc.

Normally, as in the above example, the first instruction is "Enter program" which means load the preprogrammed magnetic card (for instructions of loading a card, see "Entering A Program" on P. 7). Some instructions are self-contained and can be carried out by just reading the INSTRUCTIONS column alone, e.g., "Enter program". But some instructions depend on the information supplied by the DATA and/or KEYS columns. In line 2 of the example above, "Clear registers" appears in the INSTRUCTIONS column and **A** appears in the KEYS column, which means you have to clear the working registers by pressing the **A** key.

The DATA column specifies the input data to be supplied. Invalid arguments which result in division by zero, finding square root of a negative number, etc. will result in flashing zeros. Arguments out of the designated program range will result in incorrect answers or flashing zeros. When a computed value exceeds the calculator range, an overflow or underflow occurs and halts the program.

The KEYS column specifies the keys to be pressed. $\boxed{\uparrow}$ is the symbol used to denote the $\boxed{\text{ENTER}\uparrow}$ key. All other key designations are identical to those appearing on the HP-65. Ignore any blank positions in the KEYS column.

The DISPLAY column may show counters, intermediate or final results. In line 5 of the example, the answer will be displayed after pressing the $\boxed{\text{C}}$ key.

ENTERING A PROGRAM

From the card case supplied with this application pac, select a program card.

Set W/PRGM-RUN switch to RUN.

Turn the calculator ON. You should see 0.00

Gently insert the card (printed side up) in the right, lower slot as shown. When the card is part way in, the motor engages it and passes it out the left side of the calculator. Sometimes the motor engages but does not pull the card in. If this happens, push the card a little farther into the machine. Do not impede or force the card; let it move freely. (The display will flash if the card reads improperly. In this case, press **CLX** and reinsert the card.)

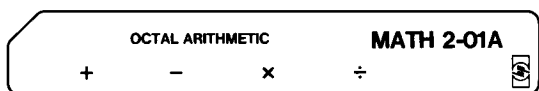


When the motor stops, remove the card from the left side of the calculator and insert it in the upper "window slot" on the right side of the calculator.

The program is now stored in the calculator. It remains stored until another program is entered or the calculator is turned off.



OCTAL ARITHMETIC



Given octal integers x , y , this program computes

$$y_8 \circ x_8$$

where operation $\circ$ can be $+$, $-$, $\times$ or $\div$.

Examples:

1. $213_8 + 37507_8 = 37722_8$
2. $12_8 - 37_8 = -25_8$
3. $12345_8 \times 4567_8 = 61341563_8$
4. $16_8 \div 4_8 = 3.40_8$

Note: This program will accept non-octal input arguments containing the digits 8 or 9. A number such as 981_8 will be treated the same as 1201_8 ($8_8 = 10_8$, $9_8 = 11_8$).

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Add	y		
3		x		
4	Subtract	y		
5		x		
6	Multiply	y		
7		x		
8	Divide	y		
9		x		

INTEGER BASE CONVERSION

INTEGER BASE CONVERSION

MATH 2-02A



This program can be used to convert an integer n in base B_1 to an equivalent integer in base B_2 , where B_1, B_2 are integers such that $2 \leq B_i \leq 10$ ($i = 1, 2$).

n is first converted to a decimal integer then the decimal integer is converted to an integer in base B_2 .

- Notes:**
1. A non-integer entry is truncated to an integer which then is converted to its equivalent integer in the specified base.
 2. This program will accept "invalid" input arguments; e.g., 981_8 will be treated the same as 1201_8 ($8_8 = 10_8$, $9_8 = 11_8$).

Examples:

1. $110_2 = 6_8$

2. $346_{10} = 2341_5$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		n		
3		B_1		
4		B_2		

BASE CONVERSION

BASE CONVERSION

MATH 2-03A



This program converts a positive decimal number Q to its equivalent number R in base a ($Q_{10} \rightarrow R_a$), or converts a positive number R in base a to a decimal number Q ($R_a \rightarrow Q_{10}$).

The base a can be any integer such that $2 \leq a \leq 99$.

A number such as $4B6_{16}$ cannot be represented directly on the display because the display is strictly numeric. Therefore, some convention must be adopted to represent numbers R_a when $a > 10$. We use the convention of allocating two digit locations for each single character in R_a when $a > 10$.

For example, $4B6_{16}$ is represented as 041106_{16} by our convention (in hexadecimal system, $A = 10$, $B = 11$, $C = 12$, $D = 13$, $E = 14$, $F = 15$).

When displayed, this number may appear as 41106 or with an exponent

4.1106 04

which is interpreted as $4.B6 \times 16^2$.

The displayed exponent 4 is in base 10 and only serves to locate the decimal point (in the same manner as for decimal numbers).

When base $a > 10$ (as in the above example), divide the displayed exponent by 2 to get the true exponent of the number. When the displayed exponent is an odd integer, shift the decimal point of the displayed number one place (to the left or right) and adjust its exponent accordingly to make the true exponent an integer.

For example, the displayed number

1.112 -03

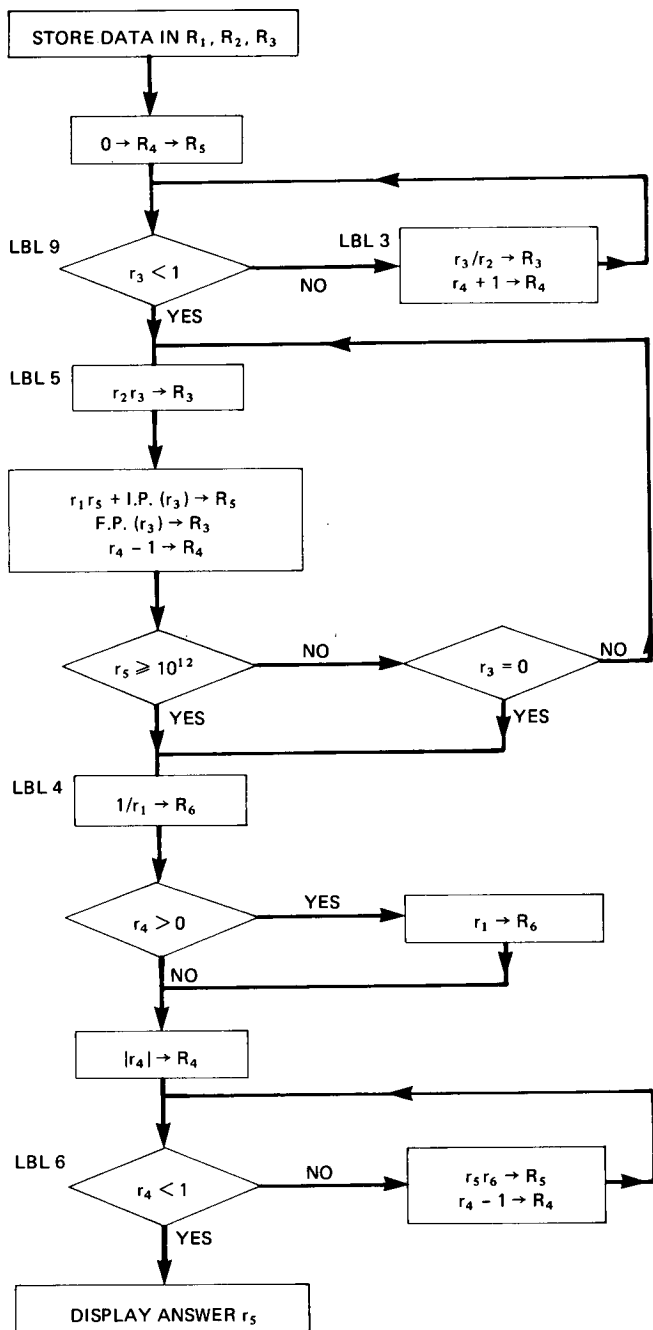
is interpreted as $B.C \times 16^{-2}$ or $0.BC \times 16^{-1}$.

- Notes:**
1. When the magnitude of the number is very large or very small, it takes a long time to execute this program. For integer (with base $a < 10$), use *Math 2-02A, Integer Base Conversion*.
 2. This program will accept "invalid" input arguments; e.g., 981_8 will be treated the same as 1201_8 ($8_8 = 10_8$, $9_8 = 11_8$).

Examples:

1. $0.2937_{10} = 0.226277543_8$
(Press **DSP** **□** **9** to see the number)
2. $1.23_{10} \times 10^{-12} = 1.5A36A_{16} \times 16^{-10}$
(After pressing **DSP** **9**, display shows 1.051003061-20)
3. $7.200067_8 \times 8^{-10} = 6.752284070_{10} \times 10^{-9}$
(Press 7.200067 **EEX** **CHS** 10 to enter the number $7.200067_8 \times 8^{-10}$ in the calculator.)
4. $D.2EE4_{16} \times 16^{12} = 3.710731485_{10} \times 10^{15}$
(Press 13.02141404 **EEX** 24 to enter the number $D.2EE4_{16} \times 16^{12}$.)

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Convert $Q_{10} \rightarrow R_a$	Q		
3	If $a \leq 10$, $c=10$; if $a > 10$, $c=100$	c		
4		a		R
5	Convert $R_a \rightarrow Q_{10}$	R		
6		a		
7	If $a \leq 10$, $c=10$; if $a > 10$, $c=100$	c		Q



Note: I. P. = Integer Part
F. P. = Fractional Part

COMPLEX ARITHMETIC

COMPLEX ARITHMETIC				MATH 2-04A	
+	-	x	÷	xzy	

$$1. (x_1 + iy_1) + (x_2 + iy_2) = (x_1 + x_2) + i(y_1 + y_2)$$

$$2. (x_1 + iy_1) - (x_2 + iy_2) = (x_1 - x_2) + i(y_1 - y_2)$$

$$3. (x_1 + iy_1)(x_2 + iy_2) = r_1 r_2 e^{i(\theta_1 + \theta_2)}$$

$$\text{where } x_1 + iy_1 = r_1 e^{i\theta_1}$$

$$x_2 + iy_2 = r_2 e^{i\theta_2}$$

$$4. \frac{x_1 + iy_1}{x_2 + iy_2} = \frac{r_1}{r_2} e^{i(\theta_1 - \theta_2)}, \quad x_2 + iy_2 \neq 0$$

Notation: Let $a + ib$ be the answer.

Examples:

1. $(3 + 4i) + (7.4 - 5.6i) = 10.40 - 1.60i$

2. $(3 + 4i) - (7.4 - 5.6i) = -4.40 + 9.60i$

3. $(3.1 + 4.6i)(5 - 12i) = 70.70 - 14.20i$

4. $\frac{3 + 4i}{7 - 2i} = 0.25 + 0.64i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Add	y_1		
3		x_1		
4		y_2		
5		x_2		a
6				b
7	Subtract	y_1		
8		x_1		
9		y_2		
10		x_2		a
11				b
12	Multiply	y_1		
13		x_1		
14		y_2		
15		x_2		a
16				b
17	Divide	y_1		
18		x_1		
19		y_2		
20		x_2		a
21				b

COMPLEX FUNCTIONS $|z|$, z^2 , $\sqrt{z}$, $1/z$

COMPLEX FUNCTIONS				MATH 2-05A	
$ z $	z^2	$\sqrt{z}$	$1/z$	$x \pm y$	

Suppose $z = x + iy$, then

$$|z| = \sqrt{x^2 + y^2}$$

$$z^2 = (x^2 - y^2) + i(2xy)$$

$$\sqrt{z} = \begin{cases} \pm \sqrt{x} i & \text{if } y = 0 \text{ and } x < 0 \\ \pm \left[\sqrt{\frac{x+r}{2}} + i \frac{y}{2\sqrt{\frac{x+r}{2}}} \right] & \text{otherwise} \end{cases}$$

$$\frac{1}{z} = \frac{x}{r^2} - i \frac{y}{r^2} \quad (z \neq 0)$$

where $r = \sqrt{x^2 + y^2}$

Notation: Let $a + ib$ be the answer.

Examples:

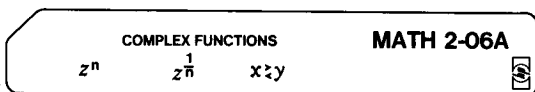
1. $|3 + 4i| = 5.00$

2. $(7 - 2i)^2 = 45.00 - 28.00i$

3. $\sqrt{7 + 6i} = \pm(2.85 + 1.05i)$

4. $\frac{1}{2 + 3i} = 0.15 - 0.23i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute $ z $	y		
3		x	A	$ z $
4	Compute z^2	y		
5		x	B	a
6			E	b
7	Compute $\sqrt{z}$	y		
8		x	C	a
9			E	b
10	Compute $1/z$	y		
11		x	D	a
12			E	b

COMPLEX FUNCTIONS $z^n, z^{1/n}$ 

Suppose $z = x + iy = re^{i\theta}$ then

$$z^n = r^n e^{i n \theta} = r^n (\cos n\theta + i \sin n\theta) = a + ib$$

$$z^{1/n} = r^{1/n} \left(\cos \frac{\theta + 360k}{n} + i \sin \frac{\theta + 360k}{n} \right) = x_k + iy_k$$

where θ is in degrees

n is a positive integer

and $k = 0, 1, \dots, n - 1$.

Restriction: $z \neq 0$

Examples:

1. $(3 + 4.5i)^5 = 926.44 - 4533.47i$

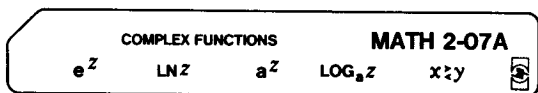
2. $5 + 3i$ has three cube roots:

$$x_0 + iy_0 = 1.77 + 0.32i$$

$$x_1 + iy_1 = -1.16 + 1.37i$$

$$x_2 + iy_2 = -0.61 - 1.69i$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute z^n	y	↑	
3		x	↑	
4		n	A	a
5			C	b
6	Compute $z^{1/n}$	y	↑	
7		x	↑	
8		n	B	x_0
9			R/S	y_0
10	Perform 10-11 for $k=1,2,\dots,n-1$		R/S	x_k
11			R/S	y_k
	(Subroutine B sets machine in			
	DEG mode)			

COMPLEX FUNCTIONS e^z , $\ln z$, a^z , $\log_a z$ 

Suppose $z = x + iy = re^{i\theta}$, then

1. $e^z = e^x (\cos y + i \sin y)$, where y is in radians

2. $\ln z = \ln r + i\theta$, where $z \neq 0$

3. $a^z = e^{z \ln a}$, where $a > 0$

4. $\log_a z = \frac{\ln z}{\ln a}$, where $a > 0, z \neq 0$

Notation: Let $u + iv$ be the answer.

Reference: Complex Analysis, L. V. Ahlfors, McGraw-Hill, 1966

Examples:

1. $e^{3+4i} = -13.13 - 15.20i$

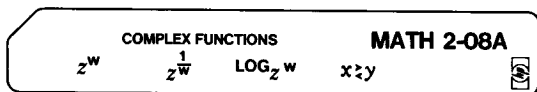
2. $\ln i = 1.57i$

3. $2^{3+4i} = -7.46 + 2.89i$

4. $\log_2 (-7.46 + 2.89i) = 3.00 + 4.00i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute e^z	y		
3		x	A	u
4			E	v
5	Compute $\ln z$	y		
6		x	B	u
7			E	v
8	Compute a^z	y		
9		x		
10		a	C	u
11			E	v
12	Compute $\log_a z$	y		
13		x		
14		a	D	u
15			E	v
	(Machine now is in RAD mode)			

COMPLEX FUNCTIONS z^w , $z^{1/w}$, $\log_z w$



Suppose $z = x + iy$, $w = u + iv$, then

1. $z^w = e^{w \ln z}$, where $z \neq 0$
2. $z^{1/w} = e^{\ln z / w}$, where $z \neq 0$, $w \neq 0$
3. $\log_z w = \frac{\ln w}{\ln z}$, where $z \neq 0$, $w \neq 0$

Notation: Let $a + ib$ be the answer.

Examples:

1. $(1 + i)^{(2-i)} = 1.49 + 4.13i$

2. $(1.49 + 4.13i)^{\frac{1}{2-i}} = 1.00 + 1.00i$

3. $\log_{(1+i)} (1.49 + 4.13i) = 2.00 - 1.00i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute z^w	v	↑	
3		u	↑	
4		y	↑	
5		x	A	a
6			D	b
7	Compute $z^{1/w}$	v	↑	
8		u	↑	
9		y	↑	
10		x	B	a
11			D	b
12	Compute $\log_z w$	v	↑	
13		u	↑	
14		y	↑	
15		x	C	a
16			D	b
	(Machine now is in RAD mode)			

COMPLEX TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS $\sin z$, $\sinh z$, $\csc z$, $\operatorname{csch} z$



Suppose $z = x + iy$, then

$$1. \sin z = \sin x \cosh y + i \cos x \sinh y$$

$$2. \sinh z = -i \sin iz$$

$$3. \csc z = \frac{1}{\sin z}$$

$$4. \operatorname{csch} z = i \csc iz$$

Restriction: z can not be a singular point of the function or
flashing zeros will result.

Notes: 1. All angles are in radians.
2. Let $a + ib$ be the answer.

Reference: Handbook of Mathematical Functions, Abramowitz and
Stegun, National Bureau of Standards, 1968

Examples:

1. $\sin(2 + 3i) = 9.15 - 4.17i$

2. $\sinh(3 - 2i) = -4.17 - 9.15i$

3. $\csc(2 + 3i) = 0.09 + 0.04i$

4. $\operatorname{csch}(1 + 2i) = -0.22 - 0.64i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute $\sin z$	y		
3		x	A	a
4			R/S	b
5	Compute $\sinh z$	y		
6		x	B	a
7			R/S	b
8	Compute $\csc z$	y		
9		x	C	a
10			R/S	b
11	Compute $\operatorname{csch} z$	y		
12		x	D	a
13			R/S	b
	(Machine now is in RAD mode)			

COMPLEX TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS $\cos z$, $\cosh z$, $\sec z$, $\operatorname{sech} z$

COMPLEX TRIGONOMETRIC
AND HYPERBOLIC FUNCTIONS

MATH 2-10A

$\cos z$

$\cosh z$

$\sec z$

$\operatorname{sech} z$



Suppose $z = x + iy$, then

$$1. \cos z = \cos x \cosh y - i \sin x \sinh y$$

$$2. \cosh z = \cos iz$$

$$3. \sec z = \frac{1}{\cos z}$$

$$4. \operatorname{sech} z = \sec iz$$

Restriction: z can not be a singular point of the function or flashing zeros will result.

Notes: 1. All angles are in radians.

2. Let $a + ib$ be the answer.

Examples:

1. $\cos 2 = -0.42$

2. $\cosh (1 + 2i) = -0.64 + 1.07i$

3. $\sec (2 + 3i) = -0.04 + 0.09i$

4. $\operatorname{sech} (1 + 2i) = -0.41 - 0.69i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute $\cos z$	y		
3		x	A	a
4			R/S	b
5	Compute $\cosh z$	y		
6		x	B	a
7			R/S	b
8	Compute $\sec z$	y		
9		x	C	a
10			R/S	b
11	Compute $\operatorname{sech} z$	y		
12		x	D	a
13			R/S	b
	(Machine now is in RAD mode)			

COMPLEX TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS $\tan z$, $\tanh z$, $\cot z$, $\coth z$

COMPLEX TRIGONOMETRIC
AND HYPERBOLIC FUNCTIONS

MATH 2-11A

TAN Z

TANH Z

COT Z

COTH Z



Suppose $z = x + iy$, then

$$1. \tan z = \frac{\sin 2x + i \sinh 2y}{\cos 2x + \cosh 2y}$$

$$2. \tanh z = \frac{\sinh 2x + i \sin 2y}{\cosh 2x + \cos 2y}$$

$$3. \cot z = \frac{\sin 2x - i \sinh 2y}{\cosh 2y - \cos 2x}$$

$$4. \coth z = \frac{\sinh 2x - i \sin 2y}{\cosh 2x - \cos 2y}$$

Restriction: z can not be a singular point of the function or
flashing zeros will result.

- Notes:**
1. All angles are in radians.
 2. Let $a + ib$ be the answer.

Examples:

1. $\tan 4 = 1.16$
2. $\tanh (1 + 2i) = 1.17 - 0.24i$
3. $\cot (4 + 0.01i) = 0.86 - 0.02i$
4. $\coth (1 + 2i) = 0.82 + 0.17i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute $\tan z$	y	$\uparrow$	
3		x	A	a
4			R/S	b
5	Compute $\tanh z$	y	$\uparrow$	
6		x	B	a
7			R/S	b
8	Compute $\cot z$	y	$\uparrow$	
9		x	C	a
10			R/S	b
11	Compute $\coth z$	y	$\uparrow$	
12		x	D	a
13			R/S	b
	(Machine now is in RAD mode)			

COMPLEX INVERSE TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS

$\sin^{-1} z, \sinh^{-1} z, \csc^{-1} z, \operatorname{csch}^{-1} z$

COMPLEX INVERSE TRIGONOMETRIC
AND HYPERBOLIC FUNCTIONS

MATH 2-12A

$\sin^{-1} z$

$\sinh^{-1} z$

$\csc^{-1} z$

$\operatorname{csch}^{-1} z$



Suppose $z = x + iy$, then

$$1. \sin^{-1} z = k\pi + (-1)^k \sin^{-1} \beta + (-1)^k i \operatorname{sgn}(y) \ln [\alpha + (\alpha^2 - 1)^{1/2}]$$

where

$$\alpha = \frac{1}{2} \sqrt{(x+1)^2 + y^2} + \frac{1}{2} \sqrt{(x-1)^2 + y^2}$$

$$\beta = \frac{1}{2} \sqrt{(x+1)^2 + y^2} - \frac{1}{2} \sqrt{(x-1)^2 + y^2}$$

$$\operatorname{sgn}(y) = \begin{cases} 1 & \text{if } y \geq 0 \\ -1 & \text{if } y < 0 \end{cases}$$

k is an integer.

$$2. \sinh^{-1} z = -i \sin^{-1} iz$$

$$3. \csc^{-1} z = \sin^{-1} \frac{1}{z} \quad (z \neq 0)$$

$$4. \operatorname{csch}^{-1} z = i \csc^{-1} iz \quad (z \neq 0)$$

Notes: 1. All angles are in radians.

2. Inverse trigonometric and hyperbolic functions are multiple-valued functions. The programs will compute one answer only ($k = 0$).

3. Let $a + ib$ be the answer.

Examples:

1. $\sin^{-1}(5 + 8i) = 0.56 + 2.94i$

2. $\sinh^{-1}(3.14 + 10.3i) = 3.07 + 1.27i$

3. $\csc^{-1}(5 + 8i) = 0.06 - 0.09i$

4. $\operatorname{csch}^{-1}(3.14 + 10.3i) = 0.03 - 0.09i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute $\sin^{-1} z$	y	$\uparrow$	
3		x	A	a
4			R/S	b
5	Compute $\sinh^{-1} z$	y	$\uparrow$	
6		x	B	a
7			R/S	b
8	Compute $\csc^{-1} z$	y	$\uparrow$	
9		x	C	a
10			R/S	b
11	Compute $\operatorname{csch}^{-1} z$	y	$\uparrow$	
12		x	D	a
13			R/S	b
	(Machine now is in RAD mode)			

COMPLEX INVERSE TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS

$\cos^{-1} z$, $\cosh^{-1} z$, $\sec^{-1} z$, $\operatorname{sech}^{-1} z$

COMPLEX INVERSE TRIGONOMETRIC
AND HYPERBOLIC FUNCTIONS

MATH 2-13A

$\cos^{-1} z$ $\cosh^{-1} z$ $\sec^{-1} z$ $\operatorname{sech}^{-1} z$



Suppose $z = x + iy$, then

$$1. \cos^{-1} z = 2k\pi \pm \left\{ \cos^{-1} \beta - i \operatorname{sgn}(y) \ln [\alpha + (\alpha^2 - 1)^{1/2}] \right\}$$

where

$$\alpha = \frac{1}{2} \sqrt{(x+1)^2 + y^2} + \frac{1}{2} \sqrt{(x-1)^2 + y^2}$$

$$\beta = \frac{1}{2} \sqrt{(x+1)^2 + y^2} - \frac{1}{2} \sqrt{(x-1)^2 + y^2}$$

$$\operatorname{sgn}(y) = \begin{cases} 1 & \text{if } y \geq 0 \\ -1 & \text{if } y < 0 \end{cases}$$

k is an integer.

$$2. \cosh^{-1} z = i \cos^{-1} z$$

$$3. \sec^{-1} z = \cos^{-1} \frac{1}{z} \quad (z \neq 0)$$

$$4. \operatorname{sech}^{-1} z = i \sec^{-1} z \quad (z \neq 0)$$

Notes: 1. All angles are in radians.

2. Inverse trigonometric and hyperbolic functions are multiple-valued functions. The program will compute one answer only ($k = 0$).

3. Let $a + bi$ be the answer.

Examples:

1. $\cos^{-1}(0.9) = 0.45$

2. $\cosh^{-1}(5 + 8i) = 2.94 + 1.01i$

3. $\sec^{-1}(5) = 1.37$

4. $\operatorname{sech}^{-1}(5 + 8i) = -0.09 + 1.51i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute $\cos^{-1} z$	y		
3		x		a
4				b
5	Compute $\cosh^{-1} z$	y		
6		x		a
7				b
8	Compute $\sec^{-1} z$	y		
9		x		a
10				b
11	Compute $\operatorname{sech}^{-1} z$	y		
12		x		a
13				b
	(Machine now is in RAD mode)			

COMPLEX INVERSE TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS

$\tan^{-1} z$, $\tanh^{-1} z$, $\cot^{-1} z$, $\coth^{-1} z$

COMPLEX INVERSE TRIGONOMETRIC
AND HYPERBOLIC FUNCTIONS

MATH 2-14A

$\tan^{-1}z$

$\tanh^{-1}z$

$\cot^{-1}z$

$\coth^{-1}z$

$x \pm y$



Suppose $z = x + iy$

$$1. \tan^{-1} z = \frac{1}{2} \left[(2k+1)\pi - \tan^{-1} \frac{1+y}{x} - \tan^{-1} \frac{1-y}{x} \right] \\ + \frac{i}{4} \ln \left[\frac{(1+y)^2 + x^2}{(1-y)^2 + x^2} \right] \quad (z^2 \neq -1)$$

where k is an integer.

$$2. \tanh^{-1} z = -i \tan^{-1} iz \quad (z^2 \neq 1)$$

$$3. \cot^{-1} z = \frac{\pi}{2} - \tan^{-1} z \quad (z^2 \neq -1)$$

$$4. \coth^{-1} z = i \cot^{-1} iz \quad (z^2 \neq 1)$$

Notes: 1. All angles are in radians.

2. Inverse trigonometric and hyperbolic functions are multiple-valued functions. The program will compute one answer only ($k = 0$).

3. Let $a + ib$ be the answer.

Examples:

1. $\tan^{-1}(5) = 1.37$

2. $\tanh^{-1}(8 - 5i) = 0.09 - 1.51i$

3. $\cot^{-1}(5 + 8i) = 0.06 - 0.09i$

4. $\coth^{-1}(-7i) = 0.14i$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute $\tan^{-1} z$	y		
3		x	A	a
4			E	b
5	Compute $\tanh^{-1} z$	y		
6		x	B	a
7			E	b
8	Compute $\cot^{-1} z$	y		
9		x	C	a
10			E	b
11	Compute $\coth^{-1} z$	y		
12		x	D	a
13			E	b
	(Machine now is in RAD mode)			

POLYNOMIAL EVALUATION (COMPLEX)POLYNOMIAL EVALUATION
(COMPLEX)

MATH 2-15A



Given a polynomial (with complex coefficients) of the form

$$f(z) = c_0 z^n + c_1 z^{n-1} + \dots + c_{n-1} z + c_n$$

this program evaluates $f(z_0) = a + ib$ for any complex number z_0

where $c_k = a_k + ib_k \quad k = 0, 1, 2, \dots, n$

$$z_0 = x_0 + iy_0$$

Example:

$$f(z) = (3 + 4i)z^4 + 18z^3 + (-2 + i)z^2 - 10z + (5 - 7i)$$

For $z_0 = 2 + i$

$$f(z_0) = -106.00 + 220.00i$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		b_0	↑	
3		a_0	↑	
4		y_0	↑	
5		x_0	A	
6	Perform 6-7 for $k = 1, 2, \dots, n - 1$	b_k	↑	
7		a_k	B	
8		b_n	↑	
9		a_n	C	a
10			R/S	b

INTERSECTIONS OF A LINE AND A CONIC SECTION

INTERSECTIONS OF A LINE
AND A CONIC SECTION

MATH 2-16A1



INTERSECTIONS OF A LINE
AND A CONIC SECTION

MATH 2-16A2



The program finds the intersections (x_1, y_1) , (x_2, y_2) of

$$\begin{cases} ax + by + c = 0 \\ Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0 \end{cases}$$

$$x_1 = -(by_1 + c)/a \quad (\text{if } a \neq 0)$$

$$y_1 = \frac{-\beta + \sqrt{\beta^2 - 4\alpha\gamma}}{2\alpha}$$

$$x_2 = -(by_2 + c)/a$$

$$y_2 = \frac{-\beta - \sqrt{\beta^2 - 4\alpha\gamma}}{2\alpha}$$

where

$$\alpha = \frac{Ab^2}{a^2} - \frac{Bb}{a} + C$$

$$\beta = \frac{2Abc}{a^2} - \frac{Bc}{a} - \frac{Db}{a} + E$$

$$\gamma = \frac{Ac^2}{a^2} - \frac{Dc}{a} + F$$

- Notes:**
1. This program also handles the case when $a = 0$ (and $b \neq 0$). It solves the problem by interchanging the roles of x and y .
 2. If $Q = \beta^2 - 4\alpha\gamma < 0$ there are no real solutions; display will show all 9's.
 3. If there is only one intersection, display will show flashing zeros. This program will not find the intersection in this case.

Examples:

$$1. \quad \begin{cases} 3x + 4y + 5 = 0 \\ 2x^2 - 3xy + y^2 + x + 10y + 7 = 0 \end{cases}$$

$$\begin{cases} x_1 = -0.82 \\ y_1 = -0.64 \end{cases}$$

$$\begin{cases} x_2 = 1.00 \\ y_2 = -2.00 \end{cases}$$

$$2. \quad \begin{cases} y - 1 = 0 \\ x^2 + y^2 = 4 \end{cases}$$

$$\begin{cases} x_1 = 1.73 \\ y_1 = 1.00 \end{cases}$$

$$\begin{cases} x_2 = -1.73 \\ y_2 = 1.00 \end{cases}$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program on card 1			
2		a	↑	
3		b	↑	
4		c	A	
5		A	↑	
6		B	↑	
7		C	B	
8		D	↑	
9		E	↑	
10		F	R/S	
11	Enter program on card 2		A	x_1
12			R/S	y_1
13			R/S	x_2
14			R/S	y_2

VECTOR PRODUCTS AND ANGLE BETWEEN VECTORS

VECTOR PRODUCTS AND
ANGLE BETWEEN VECTORS

MATH 2-17A

$$x_1, x_2, x_3$$

$$y_1, y_2, y_3$$

$$\vec{x} \cdot \vec{y}$$

$$\vec{x} \times \vec{y}$$



$\vec{x} = (x_1, x_2, x_3)$, $\vec{y} = (y_1, y_2, y_3)$ are two vectors in a 3-dimensional space.

dot product $\vec{x} \cdot \vec{y} = x_1 y_1 + x_2 y_2 + x_3 y_3$

cross product $\vec{z} = \vec{x} \times \vec{y} = (x_2 y_3 - x_3 y_2, x_3 y_1 - x_1 y_3, x_1 y_2 - x_2 y_1)$
 $= (z_1, z_2, z_3)$

angle between $\vec{x}$ and $\vec{y}$

$$\theta = \cos^{-1} \left(\frac{\vec{x} \cdot \vec{y}}{|\vec{x}| |\vec{y}|} \right)$$

where

$$|\vec{x}| = \sqrt{x_1^2 + x_2^2 + x_3^2}$$

$$|\vec{y}| = \sqrt{y_1^2 + y_2^2 + y_3^2}$$

Examples:

$$\vec{x} = (2.34, 5.17, 7.43)$$

$$\vec{y} = (0.072, 0.231, 0.409)$$

$$\vec{x} \cdot \vec{y} = 4.40$$

$$\theta = 7.82^\circ = 0.14 \text{ radians} = 8.68 \text{ grads}$$

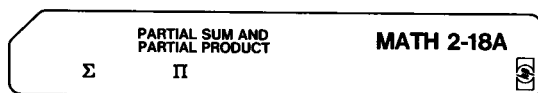
$$|\vec{x}| = 9.35$$

$$|\vec{y}| = 0.48$$

$$\vec{x} \times \vec{y} = (0.40, -0.42, 0.17)$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		x_1	↑	
3		x_2	↑	
4		x_3	A	
5		y_1	↑	
6		y_2	↑	
7		y_3	B	
8	Compute $\vec{x} \cdot \vec{y}$ and θ		C	$\vec{x} \cdot \vec{y}$
9			R/S	θ
10			R/S	$ \vec{x} $
11			R/S	$ \vec{y} $
12	Compute $\vec{x} \times \vec{y}$		D	z_1
13			R/S	z_2
14			R/S	z_3

PARTIAL SUM AND PARTIAL PRODUCT



This program will evaluate sums or products of the form

$$\sum_{k=n}^N f(k, x) \text{ or } \prod_{k=n}^N f(k, x)$$

and, in particular, sums or products of the form

$$\sum_{k=n}^N g(k) \text{ or } \prod_{k=n}^N g(k)$$

Note: $f(k, x)$ or $g(k)$ must be programmed in the calculator by the user. Assuming the value in the X register to be k and the value in register R_1 to be x , 42 memory locations, the stack registers and registers R_4 , R_5 , R_6 , R_7 , R_9 are available for evaluating the function.

Examples:

1. $\sum_{k=1}^{10} x^k = 0.999023438$ for $x = 0.5$

Keys for $f(k, x)$: **RCL** **1** **9** **$x \div y$** **9** **y^x**

2. $\prod_{k=1}^{10} k = 10! = 3628800.00$

Keys for $g(k)$: none

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2			GTO C	
3	Switch to PRGM mode			
4	Enter $f(k, x)$ or $g(k)$		RTN	
5	Switch to RUN mode			
	(For partial product, go to 9)			
6	Compute partial sum	n	↑	
7		N	↑	
8	In the case of $g(k)$, let $x = 1$.	x	A	Σ
9	Compute partial product	n	↑	
10		N	↑	
11		x	B	Π
	(For new values of n, N, x, go			
	to 6 or 9. For a new function,			
	go to 2)			

GAUSSIAN QUADRATURE FOR $\int_a^b f(x) dx$

GAUSSIAN QUADRATURE FOR $\int_a^b f(x) dx$

MATH 2-19A1



GAUSSIAN QUADRATURE FOR $\int_a^b f(x) dx$

MATH 2-19A2



The program computes the value

$$\int_a^b f(x) dx$$

for finite a , b and single-valued function $f(x)$ by the six point Gauss-Legendre quadrature formula

$$\int_a^b f(x) \cong \frac{b-a}{2} \sum_{i=1}^6 w_i f\left(\frac{z_i(b-a) + b+a}{2}\right)$$

where $z_1 = -z_2 = .2386191861$

$z_3 = -z_4 = .6612093865$

$z_5 = -z_6 = .9324695142$

$w_1 = w_2 = .4679139346$

$w_3 = w_4 = .360761573$

$w_5 = w_6 = .1713244924$

Note: $f(x)$ must be programmed in the calculator by the user. Assuming the value in the X register to be x , 18 memory locations and the stack registers are available for $f(x)$.

Reference: Applied Numerical Methods, Carnahan, Luther and Wilks, John Wiley and Sons, 1969

Examples:

$$1. \int_1^{10} \frac{dx}{x} \cong 2.30$$

Keys for $f(x)$: **[g]** **[1/x]**

Correct answer is $\ln 10$.

$$2. \int_e^{e^2} \frac{dx}{x(\ln x)^3} \cong 0.37$$

Keys for $f(x)$: **[↑]** **[f]** **[LN]** **3** **[g]** **[y^x]** **[x]** **[g]** **[1/x]**

Correct answer is $\frac{3}{8}$.

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program on card 1			
2			A	
3	Enter program on card 2			
4			GTO A	
5	Switch to PRGM mode			
6	Enter $f(x)$			
7	Switch to RUN mode			
8		a	↑	
9		b	C	
	(For new values of a, b, go to 8.			
	For a new $f(x)$, go to 3.)			

GAUSSIAN QUADRATURE FOR $\int_a^\infty f(x) dx$

GAUSSIAN QUADRATURE FOR $\int_a^\infty f(x) dx$

MATH 2-20A



This program computes the value

$$\int_a^\infty f(x) dx$$

for finite a and single-valued function $f(x)$ by the six point Gauss-Legendre quadrature formula

$$\int_a^\infty f(x) dx \cong \frac{1}{2} \sum_{i=1}^6 \frac{4w_i}{(1+z_i)^2} f\left(\frac{2}{1+z_i} + a - 1\right)$$

where $z_1 = -z_2 = .2386191861$

$z_3 = -z_4 = .6612093865$

$z_5 = -z_6 = .9324695142$

$w_1 = w_2 = .4679139346$

$w_3 = w_4 = .360761573$

$w_5 = w_6 = .1713244924$

Note: $f(x)$ must be programmed in by the user. Assuming the value in the X register to be x , 24 memory locations and the stack registers are available for $f(x)$.

Reference: Applied Numerical Methods, Carnahan, Luther and Wilks, John Wiley and Sons, 1969

Examples:

$$1. \int_0^{\infty} e^{-x} x^{0.8} dx \cong 0.92$$

Keys for $f(x)$: **CHS** **f⁻¹** **LN** **9** **LSTX** **CHS** **.8** **9**
y^x **X**

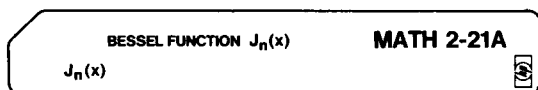
Correct answer is $\Gamma(1.8) = 0.931383771$

$$2. \int_0^{\infty} \frac{dx}{(x^2 + 1)(x^2 + 4)^2} \cong 0.05$$

Keys for $f(x)$: **f⁻¹** **√x** **1** **+** **↑** **↑** **3** **+** **f⁻¹** **√x**
X **9** **1/x**

Correct answer is $\frac{5\pi}{288}$.

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program <i>Math 2-19A1</i>			
2			A	
3	Enter program <i>Math 2-20A</i>			
4			GTO A	
5	Switch to PRGM mode			
6	Enter $f(x)$			
7	Switch to RUN mode			
8		a	C	
	(For a new value of a, go to 8.)			
	For a new $f(x)$, go to 3.)			

BESSEL FUNCTION $J_n(x)$ 

This program computes the value of the Bessel function $J_n(x)$ by using a numerical method which makes use of the recurrence relation

$$J_{n-1}(x) = \frac{2n}{x} J_n(x) - J_{n+1}(x)$$

the summation relation

$$J_0(x) + 2 \sum_{i=1}^{\infty} J_{2i}(x) = 1$$

and the fact that

$$\lim_{n \rightarrow \infty} J_n(x) = 0$$

First let

$$m = \text{INT} \left\{ 1 + 3x^{\frac{1}{12}} + 9x^{\frac{1}{3}} + \max(n, x) \right\}$$

where INT means “integer part of”.

Then set

$$T_m = a \qquad T_{m+1} = 0$$

where a is an arbitrary non-zero constant.

Then the series of terms, T_k , $0 \leq k \leq m$, is computed by successively applying the relation

$$T_{k-1}(x) = \frac{2k}{x} T_k(x) - T_{k+1}(x)$$

starting with $k = m$.

$J_n(x)$ is then found by dividing the term $T_n(x)$ by the normalizing constant

$$K = T_0(x) + 2 \sum_{i=1}^p T_{2i}(x)$$

where

$$p = \begin{cases} \frac{m}{2} & \text{if } m \text{ is even} \\ \frac{m-1}{2} & \text{if } m \text{ is odd} \end{cases}$$

Note that all the T_k are proportional to a , hence K and the result are independent of a .

Note: $J_0(x) = 1$ for $x \leq 10^{-6}$ but it is out of range for this program.

Examples:

1. $J_0(4.7) = -0.27$

2. $J_5(9.2) = -0.10$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		n	↑	
3		x	A	

KELVIN FUNCTIONS

KELVIN FUNCTIONS

MATH 2-22A



$$\text{ber}(x) = 1 - \frac{\left(\frac{1}{4}x^2\right)^2}{(2!)^2} + \frac{\left(\frac{1}{4}x^2\right)^4}{(4!)^2} - \dots$$

$$\text{bei}(x) = \frac{1}{4}x^2 - \frac{\left(\frac{1}{4}x^2\right)^3}{(3!)^2} + \frac{\left(\frac{1}{4}x^2\right)^5}{(5!)^2} - \dots$$

This program computes successive partial sums of the series. The program stops and displays the last partial sum as the answer, when two consecutive partial sums are equal or more than 50 terms have been added.

- Notes:**
1. When x is too large, computing a new term of the series might cause an overflow, in that case, display shows all 9's and the program stops.
 2. $\text{ber}(-x) = \text{ber}(x)$, $\text{bei}(-x) = \text{bei}(x)$

Examples:

1. $\text{ber}(4.4) = -3.93$
2. $\text{bei}(0.6) = 0.09$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	For ber (x)	0		
3		x		
4	For bei (x)	1		
5		x		

EULER ϕ FUNCTION

EULER ϕ FUNCTION	MATH 2-23A
$\phi(n)$	

$\Phi(n)$ is the number of integers not exceeding and relatively prime to n , where n is a non-negative integer.

Suppose

$$n = p_1^{m_1} p_2^{m_2} \dots p_k^{m_k}$$

where p_i ($i = 1, 2, \dots, k$) are distinct primes dividing n , then

$$\begin{aligned}\Phi(n) &= n \prod_{i=1}^k \left(1 - \frac{1}{p_i}\right) \\ &= \prod_{i=1}^k (p_i^{m_i} - p_i^{m_i-1})\end{aligned}$$

Examples:

1. $\Phi(30) = 8.00$
2. $\Phi(251) = 250.00$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		n	A	

GAMMA FUNCTION

GAMMA FUNCTION

MATH 2-24A1



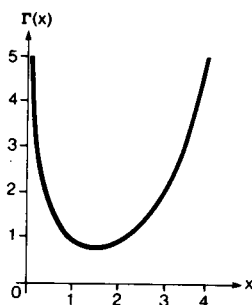
GAMMA FUNCTION

MATH 2-24A2



This program approximates the value of gamma function $\Gamma(x)$ for $1 \leq x < 70$.

$$\Gamma(x) = \int_0^{\infty} t^{x-1} e^{-t} dt$$



$$1. \Gamma(x) = (x-1) \Gamma(x-1)$$

2. For $1 \leq x \leq 2$, polynomial approximation can be used.

$$\Gamma(x) \cong 1 + b_1(x-1) + b_2(x-1)^2 + \dots + b_8(x-1)^8$$

where $b_1 = -0.577191652$, $b_2 = 0.988205891$

$$b_3 = -0.897056937, \quad b_4 = 0.918206857$$

$$b_5 = -0.756704078, \quad b_6 = 0.482199394$$

$$b_7 = -0.193527818, \quad b_8 = 0.035868343$$

Note: This program can be used to find the generalized factorial $x!$ for $0 \leq x < 69$.

$$x! = \Gamma(x+1)$$

Examples:

$$1. \Gamma(5.25) = 35.21$$

$$2. 7! = \Gamma(8) = 5040.00$$

$$3. 2.34! = \Gamma(3.34) = 2.80$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program on card 1			
2			A	
3	Enter program on card 2			
4		x	A	
	(For a new value of x, go to 4.)			

INCOMPLETE GAMMA FUNCTION

INCOMPLETE GAMMA FUNCTION

MATH 2-25A

 $\gamma(a, x)$ 

$$\gamma(a, x) = \int_0^x e^{-t} t^{a-1} dt$$

$$= x^a e^{-x} \sum_{n=0}^{\infty} \frac{x^n}{a(a+1) \dots (a+n)}$$

where $a > 0, x > 0$.

This program computes successive partial sums of the series. The program stops when two consecutive partial sums are equal, and displays the last partial sum as the answer.

Note: When x is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

Examples:

1. $\gamma(1, 2) = 0.86$

2. $\gamma(1, 0.1) = 0.10$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		a	↑	
3		x	A	

ERROR FUNCTION AND COMPLEMENTARY ERROR FUNCTION

ERROR FUNCTION AND
COMPLEMENTARY ERROR FUNCTION
erf x

MATH 2-26A



$$\text{Error function erf } x = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt$$

$$= \frac{2}{\sqrt{\pi}} e^{-x^2} \sum_{n=0}^{\infty} \frac{2^n}{1 \cdot 3 \cdot \dots \cdot (2n+1)} x^{2n+1}$$

Complementary error function

$$\text{erfc } x = 1 - \text{erf } x$$

where $x > 0$

This program computes successive partial sums of the series. The program stops when two consecutive partial sums are equal, and displays the last partial sum as the answer.

Note: When x is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

Example:

$$\text{erf}(1.34) = 0.94$$

$$\text{erfc}(1.34) = 0.06$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		x	A	erf
3			R/S	erfc

CONFLUENT HYPERGEOMETRIC FUNCTION

CONFLUENT
HYPERGEOMETRIC FUNCTION

M

MATH 2-27A



$$M(a, b, x) = 1 + \frac{a}{b} x + \frac{(a)_2}{(b)_2} \frac{x^2}{2!} + \dots + \frac{(a)_n}{(b)_n} \frac{x^n}{n!} + \dots$$

where $(a)_0 = 1$

$$(a)_n = a(a+1) \dots (a+n-1)$$

$$(b)_0 = 1$$

$$(b)_n = b(b+1) \dots (b+n-1)$$

$$b \neq -m \quad (m = 0, 1, 2, \dots)$$

This program computes successive partial sums of the series. The program stops when two consecutive partial sums are equal, and displays the last partial sum as the answer.

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

Examples:

1. $M(0.6, 0.8, 0.1) = 1.08$

2. $M(-1, 1, 8) = -7.00$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		a	↑	
3		b	↑	
4		x	A	

GAUSSIAN HYPERGEOMETRIC FUNCTION

GAUSSIAN
HYPERGEOMETRIC FUNCTION

F

MATH 2-28A



$$F(a, b; c; x) = F(b, a; c; x)$$

$$= \sum_{k=0}^{\infty} \frac{(a)_k (b)_k x^k}{(c)_k k!}$$

where $|x| < 1$.

The series is not defined if $c = -m$ ($m = 0, 1, 2, \dots$) except when a or b is equal to $-l$ ($l = 0, 1, 2, \dots$) with $l < m$.

This program computes successive partial sums of the series. The program stops when two consecutive partial sums are equal, and displays the last partial sum as the answer.

Notation: $(d)_0 = 1$

$$(d)_k = d(d+1)(d+2) \dots (d+k-1)$$

where $d = a, b, \text{ or } c$

Some special cases are:

1. $F\left(-n, n; \frac{1}{2}; x\right) = T_n(1-2x)$
2. $F(-n, n+1; 1; x) = P_n(1-2x)$
3. $F\left(-n, n+2\alpha; \alpha + \frac{1}{2}; x\right) = \frac{n!}{(2\alpha)_n} C_n^{(\alpha)}(1-2x)$
4. $F(-n, \alpha+1+\beta+n; \alpha+1; x) = \frac{n!}{(\alpha+1)_n} P_n^{(\alpha, \beta)}(1-2x)$

where $T_n, P_n, C_n^{(\alpha)}, P_n^{(\alpha, \beta)}$ denote Chebyshev, Legendre's, Gegenbauer's and Jacobi's polynomials respectively.

Note: Displayed flashing zeros indicate that

1. The series is undefined for the set of input arguments.

or

2. The program has not found the sum of the series to desired accuracy after the first 400 terms have been added. This is likely to occur when $|x|$ is near 1 (the series converges slowly in that region).

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

Example:

$$F(1, 1; 2; 0.3) = 1.19$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		a	↑	
3		b	↑	
4		c	↑	
5		x	A	

Chebyshev Polynomial

CHEBYSHEV POLYNOMIAL

MATH 2-29A

 $T_n(x)$ 

This program computes the value of the Chebyshev polynomial $T_n(x)$ by using the recurrence equation

$$T_{n+1}(x) = 2xT_n(x) - T_{n-1}(x)$$

where starting values are $T_0(x) = 1$, $T_1(x) = x$ and n is a non-negative integer.

Example:

$$T_3(0.4) = -0.94$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		n	↑	
3		x	A	

LEGENDRE POLYNOMIAL

LEGENDRE POLYNOMIAL

MATH 2-30A

 $P_n(x)$ 

This program computes the value of the Legendre polynomial $P_n(x)$ by using the recurrence equation

$$P_{n+1}(x) = \frac{(2n+1)xP_n(x) - nP_{n-1}(x)}{n+1}$$

where starting values are $P_0(x) = 1$, $P_1(x) = x$ and n is a non-negative integer.

Example:

$$P_{10}(0.98) = 0.16$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		n	↑	
3		x	A	

HERMITE POLYNOMIAL

HERMITE POLYNOMIAL

MATH 2-31A

 $H_n(x)$ 

This program computes the value of the Hermite polynomial $H_n(x)$ by using the recurrence equation

$$H_{n+1}(x) = 2x H_n(x) - 2n H_{n-1}(x)$$

where the starting values are $H_0(x) = 1$, $H_1(x) = 2x$ and n is a non-negative integer.

Example:

$$H_5(3) = 3816.00$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		n	↑	
3		x	A	

LAGUERRE POLYNOMIAL

LAGUERRE POLYNOMIAL

MATH 2-32A

 $L_n(x)$ 

This program computes the value of the Laguerre polynomial $L_n(x)$ by using the recurrence equation

$$L_{n+1}(x) = [(2n + 1 - x) L_n(x) - nL_{n-1}(x)] / (n + 1)$$

where the starting values are $L_0(x) = 1$, $L_1(x) = 1 - x$, and n is a non-negative integer.

Example:

$$L_6(3) = -0.01$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		n	↑	
3		x	A	

SINE INTEGRAL

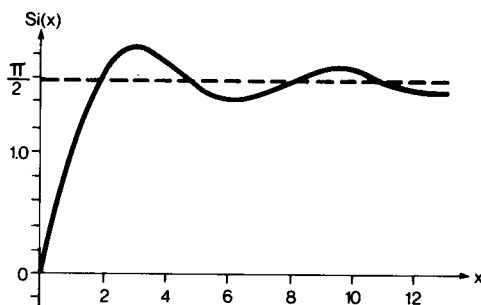
SINE INTEGRAL	MATH 2-33A
Si(x)	

Sine integral

$$\text{Si}(x) = \int_0^x \frac{\sin t}{t} dt = \sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)(2n+1)!}$$

where x is real.

This program computes successive partial sums of the series. The program stops when two consecutive partial sums are equal, and displays the last partial sum as the answer.



- Notes:**
1. When x is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.
 2. $\text{Si}(-x) = -\text{Si}(x)$

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

Examples:

1. $\text{Si}(0.69) = 0.67$
2. $\text{Si}(9.8) = 1.67$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		x	A	

COSINE INTEGRAL

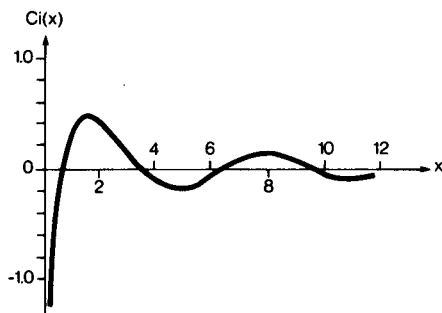
COSINE INTEGRAL Ci(x)	MATH 2-34A
--------------------------	----------------

Cosine integral

$$Ci(x) = \gamma + \ln x + \int_0^x \frac{\cos t - 1}{t} dt = \gamma + \ln x + \sum_{n=1}^{\infty} \frac{(-1)^n x^{2n}}{2n(2n)!}$$

where $x > 0$, and $\gamma = 0.5772156649$ is the Euler's constant.

This program computes successive partial sums of the series. When two consecutive partial sums are equal, the value is used as the sum of the series.



Notes: 1. When x is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

2. $Ci(-x) = Ci(x) - i\pi$ for $x > 0$.

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

Examples:

1. $Ci(1.38) = 0.46$

2. $Ci(5) = -0.19$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		x	A	

EXPONENTIAL INTEGRAL

EXPONENTIAL INTEGRAL

MATH 2-35A

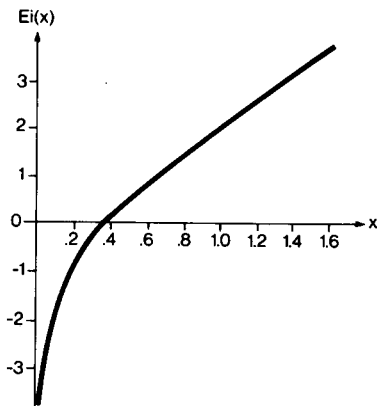
Ei(x)



$$\text{Ei}(x) = \int_{-\infty}^x \frac{e^t}{t} dt = \gamma + \ln x + \sum_{n=1}^{\infty} \frac{x^n}{n \cdot n!}$$

where $x > 0$ and $\gamma = 0.5772156649$ is Euler's constant.

This program computes successive partial sums of the series. When two consecutive partial sums are equal, the value is used as the sum of the series.



Note: When x is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

Examples:

1. $Ei(1.59) = 3.57$

2. $Ei(0.61) = 0.80$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		x	A	

FRESNEL INTEGRALS

FRESNEL INTEGRALS

MATH 2-36A

C(x)

S(x)



Fresnel cosine integral

$$C(x) = \int_0^x \cos\left(\frac{\pi}{2} t^2\right) dt$$

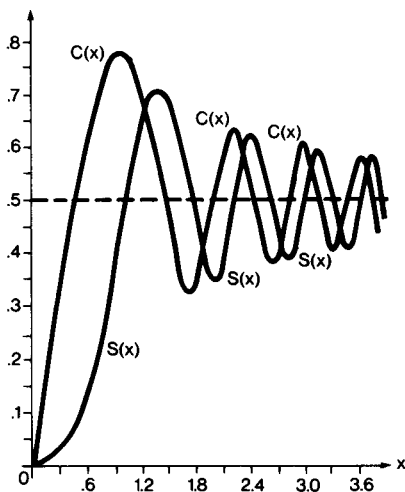
$$= \sum_{n=0}^{\infty} \frac{(-1)^n \left(\frac{\pi}{2}\right)^{2n}}{(2n)! (4n+1)} x^{4n+1}$$

Fresnel sine integral

$$S(x) = \int_0^x \sin\left(\frac{\pi}{2} t^2\right) dt$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n \left(\frac{\pi}{2}\right)^{2n+1}}{(2n+1)! (4n+3)} x^{4n+3}$$

This program computes successive partial sums of the series. The program stops when two consecutive partial sums are equal, and displays the last partial sum as the answer.



Notes: 1. This program requires $|x| < 3.6$ or flashing zeros will result. As $|x|$ varies from 0 to 3.6, the accuracy of the answer will decrease from 10 digits to 2 or 3 digits.

$$2. \lim_{x \rightarrow \infty} C(x) = \lim_{x \rightarrow \infty} S(x) = \frac{1}{2}$$

$$3. C(-x) = -C(x), S(-x) = -S(x)$$

Reference: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968

Examples:

$$1. C(0.42) = 0.42$$

$$2. S(-3) = -0.50$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2	Compute C(x)	x	A	
3	Compute S(x)	x	B	

COMPLETE ELLIPTIC INTEGRALS

COMPLETE ELLIPTIC INTEGRALS

MATH 2-37A

CEI



The generalized complete elliptic integral of the second kind is defined as

$$\text{CEI}(k; A, B) = \int_0^{\pi/2} \frac{A + (B - A) \sin^2 t}{\sqrt{1 - k^2 \sin^2 t}} dt \quad (0 \leq k < 1)$$

To evaluate the integral, let

$$u_0 = 1, v_0 = \sqrt{1 - k^2}, a_0 = A, b_0 = B$$

be the starting values. Compute the sequences of numbers

$$u_{i+1} = u_i + v_i$$

$$v_{i+1} = 2\sqrt{u_i v_i}$$

$$a_{i+1} = a_i + \frac{b_i}{u_i}$$

$$b_{i+1} = 2(a_i v_i + b_i)$$

The process is stopped at the n^{th} step such that

$$u_{n-1} (1 - 10^{-9}) \leq v_{n-1}$$

Then the integral is computed by

$$\text{CEI}(k; A, B) = \frac{\pi}{4} \frac{a_{n+1}}{u_n}$$

Some important special cases are:

1. $A = 1, B = 1$

Complete elliptic integral of the first kind

$$K(k) = \int_0^{\pi/2} \frac{dt}{\sqrt{1 - k^2 \sin^2 t}}$$

2. $A = 1, B = 0$

$$B(k) = \int_0^{\pi/2} \frac{1 - \sin^2 t}{\sqrt{1 - k^2 \sin^2 t}} dt$$

3. $A = 0, B = 1$

$$D(k) = \int_0^{\pi/2} \frac{\sin^2 t}{\sqrt{1 - k^2 \sin^2 t}} dt$$

Note: Special values are displayed for invalid arguments:

1. If $k^2 > 1$, display = 10^{99}

2. If $k^2 = 1$

$$\text{display} = \begin{cases} 10^{99} & \text{if } B > 0 \\ -10^{99} & \text{if } B < 0 \\ A & \text{if } B = 0 \end{cases}$$

References: 1. Numerical Calculation of Elliptic Integrals and Elliptic Functions, R. Bulirsch, Handbook Series Special Functions, Numerical Mathematik 7, 1965

2. Tables of Higher Functions, Jahnke-Emde-Losch, McGraw-Hill, 1960

Example:

$$\text{CEI}(0.5; 1, 1) = K(0.5) = 1.69$$

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		k	↑	
3		A	↑	
4		B	A	

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INTEGER BASE CONVERSION

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	81	÷	34 06	RCL 6
11	A	41	↑	34 04	RCL 4
33 03	STO 3	31	f	81	÷
35 08	g R↓	83	INT	33 06	STO 6
33 02	STO 2	51	—	71	x
35 08	g R↓	35 00	g LST X	33	STO
71	x	34 05	RCL 5	61	+
00	0	34 02	RCL 2	02	2
33 01	STO 1	81	÷	00	0
01	1	33 05	STO 5	34 05	RCL 5
33 05	STO 5	71	x	35 21	g x≠y
83	·	33	STO	22	GTO
01	1	61	+	03	3
33 04	STO 4	01	1	34 02	RCL 2
33 06	STO 6	44	CLX	24	RTN
23	LBL	35 07	g x≥y	35 01	g NOP
01	1	35 21	g x≠y	35 01	g NOP
35 00	g LST X	22	GTO	35 01	g NOP
34 04	RCL 4	02	2	35 01	g NOP
71	x	33 02	STO 2	35 01	g NOP
34 02	RCL 2	34 01	RCL 1	35 01	g NOP
33	STO	31	f	35 01	g NOP
71	x	83	INT	35 01	g NOP
05	5	23	LBL	35 01	g NOP
35 08	g R↓	03	3	35 01	g NOP
35	g	41	↑	35 01	g NOP
06	ABS	41	↑	35 01	g NOP
01	1	34 03	RCL 3	35 01	g NOP
35 22	g x≤y	81	÷	35 01	g NOP
22	GTO	31	f	35 01	g NOP
01	1	83	INT	35 01	g NOP
35 00	g LST X	33 05	STO 5		
23	LBL	34 03	RCL 3		
02	2	71	x		
34 04	RCL 4	51	—		

R₁	Used	R₄	Used	R₇
R₂	Used	R₅	Used	R₈
R₃	Used	R₆	Used	R₉ Used

BASE CONVERSION

CODE	KEYS
23	LBL
11	A
33 02	STO 2
35 08	g R↓
33 01	STO 1
35 08	g R↓
33 03	STO 3
00	0
33 04	STO 4
33 05	STO 5
34 03	RCL 3
23	LBL
09	9
01	1
35 22	g $x \leq y$
22	GTO
03	3
23	LBL
05	5
34 02	RCL 2
34 03	RCL 3
71	x
33 03	STO 3
31	f
83	INT
34 05	RCL 5
34 01	RCL 1
71	x
61	+
33 05	STO 5
34 03	RCL 3
32	f^{-1}
83	INT
33 03	STO 3
01	1

CODE	KEYS
33	STO
51	—
04	4
34 05	RCL 5
43	EEX
01	1
02	2
35 22	g $x \leq y$
22	GTO
04	4
00	0
34 03	RCL 3
35 21	g $x \neq y$
22	GTO
05	5
23	LBL
04	4
34 01	RCL 1
35	g
04	$1/x$
33 06	STO 6
00	0
34 04	RCL 4
35 24	g $x > y$
34 01	RCL 1
33 06	STO 6
34 04	RCL 4
35	g
06	ABS
33 04	STO 4
23	LBL
06	6
34 04	RCL 4
01	1
35 24	g $x > y$

CODE	KEYS
34 05	RCL 5
84	R/S
34 06	RCL 6
33	STO
71	x
05	5
01	1
33	STO
51	—
04	4
22	GTO
06	6
23	LBL
03	3
33	STO
61	+
04	4
44	CLX
34 02	RCL 2
81	÷
33 03	STO 3
22	GTO
09	9
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R₁	Used	R₄	Used	R₇
R₂	Used	R₅	Used	R₈
R₃	Used	R₆	Used	R₉ Used

COMPLEX ARITHMETIC

CODE	KEYS
23	LBL
11	A
35 07	$g \times \dot{z} y$
35 08	$g R \downarrow$
61	+
35 08	$g R \downarrow$
61	+
35 09	$g R \uparrow$
24	RTN
23	LBL
12	B
35 07	$g \times \dot{z} y$
35 08	$g R \downarrow$
51	—
35 08	$g R \downarrow$
35 07	$g \times \dot{z} y$
51	—
35 09	$g R \uparrow$
24	RTN
23	LBL
13	C
31	f
01	$R \rightarrow P$
35 08	$g R \downarrow$
35 08	$g R \downarrow$
31	f
01	$R \rightarrow P$
35 07	$g \times \dot{z} y$
35 08	$g R \downarrow$
71	x
35 08	$g R \downarrow$
61	+
35 09	$g R \uparrow$
32	f^{-1}
01	$R \rightarrow P$

[illegible][illegible]

R_1	R_4	R_7
R_2	R_5	R_8
R_3	R_6	R_9 Used

COMPLEX FUNCTIONS $|z|$, z^2 , $\sqrt{z}$, $1/z$

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	01	R→P	01	1
11	A	34 08	RCL 8	34 08	RCL 8
31	f	61	+	35 22	$g x \leq y$
01	R→P	02	2	22	GTO
24	RTN	81	÷	02	2
23	LBL	31	f	31	f
12	B	09	$\sqrt{x}$	09	$\sqrt{x}$
33 08	STO 8	33 06	STO 6	24	RTN
35 07	$g x \rightleftarrows y$	02	2	23	LBL
33 07	STO 7	71	x	02	2
71	x	34 07	RCL 7	35	g
02	2	35 07	$g x \rightleftarrows y$	06	ABS
71	x	81	÷	31	f
34 08	RCL 8	34 06	RCL 6	09	$\sqrt{x}$
32	f^{-1}	24	RTN	35 07	$g x \rightleftarrows y$
09	$\sqrt{x}$	23	LBL	24	RTN
34 07	RCL 7	14	D	23	LBL
32	f^{-1}	33 08	STO 8	15	E
09	$\sqrt{x}$	32	f^{-1}	35 07	$g x \rightleftarrows y$
51	—	09	$\sqrt{x}$	24	RTN
24	RTN	35 07	$g x \rightleftarrows y$	35 01	g NOP
23	LBL	33 07	STO 7	35 01	g NOP
13	C	32	f^{-1}	35 01	g NOP
33 08	STO 8	09	$\sqrt{x}$	35 01	g NOP
35 07	$g x \rightleftarrows y$	61	+	35 01	g NOP
33 07	STO 7	34 07	RCL 7	35 01	g NOP
00	0	35 07	$g x \rightleftarrows y$	35 01	g NOP
35 23	$g x = y$	81	÷	35 01	g NOP
22	GTO	42	CHS	35 01	g NOP
01	1	35 00	g LST X	35 01	g NOP
23	LBL	34 08	RCL 8	35 01	g NOP
03	3	35 07	$g x \rightleftarrows y$	35 01	g NOP
35 08	$g R \downarrow$	81	÷	35 01	g NOP
35 07	$g x \rightleftarrows y$	24	RTN	35 01	g NOP
31	f	23	LBL	35 01	g NOP

R ₁	R ₄	R ₇	y
R ₂	R ₅	R ₈	x
R ₃	R ₆	R ₉	Used

COMPLEX FUNCTIONS e^z , $\ln z$, a^z , $\log_a z$

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	01	R→P	35 01	g NOP
11	A	24	RTN	35 01	g NOP
35	g	23	LBL	35 01	g NOP
42	RAD	14	D	35 01	g NOP
32	f^{-1}	31	f	35 01	g NOP
07	LN	07	LN	35 01	g NOP
32	f^{-1}	33 01	STO 1	35 01	g NOP
01	R→P	35 08	g R↓	35 01	g NOP
24	RTN	35	g	35 01	g NOP
23	LBL	42	RAD	35 01	g NOP
12	B	31	f	35 01	g NOP
35	g	01	R→P	35 01	g NOP
42	RAD	31	f	35 01	g NOP
31	f	07	LN	35 01	g NOP
01	R→P	34 01	RCL 1	35 01	g NOP
31	f	81	÷	35 01	g NOP
07	LN	35 07	g $x \rightarrow y$	35 01	g NOP
24	RTN	34 01	RCL 1	35 01	g NOP
23	LBL	81	÷	35 01	g NOP
13	C	35 07	g $x \rightarrow y$	35 01	g NOP
35	g	24	RTN	35 01	g NOP
42	RAD	23	LBL	35 01	g NOP
35 08	g R↓	15	E	35 01	g NOP
33 01	STO 1	35 07	g $x \rightarrow y$	35 01	g NOP
35 07	g $x \rightarrow y$	24	RTN	35 01	g NOP
35 09	g R↑	35 01	g NOP	35 01	g NOP
31	f	35 01	g NOP	35 01	g NOP
07	LN	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
35 00	g LST X	35 01	g NOP	35 01	g NOP
34 01	RCL 1	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
32	f^{-1}	35 01	g NOP	35 01	g NOP
07	LN	35 01	g NOP	35 01	g NOP
32	f^{-1}	35 01	g NOP	35 01	g NOP

R ₁	Used	R ₄	R ₇
R ₂		R ₅	R ₈
R ₃		R ₆	R ₉ Used

COMPLEX FUNCTIONS z^w , $z^{\frac{1}{w}}$, $\log_z w$

CODE	KEYS
23	LBL
11	A
35	g
42	RAD
31	f
01	R→P
31	f
07	LN
31	f
01	R→P
35 08	g R↓
35 08	g R↓
31	f
01	R→P
35 07	g x↔y
35 08	g R↓
71	x
35 08	g R↓
61	+
35 09	g R↑
32	f ⁻¹
01	R→P
32	f ⁻¹
07	LN
32	f ⁻¹
01	R→P
24	RTN
23	LBL
12	B
33 03	STO 3
35 08	g R↓
33 04	STO 4
35 08	g R↓
33 01	STO 1
32	f ⁻¹

CODE	KEYS
09	√x
35 07	g x↔y
33 02	STO 2
32	f ⁻¹
09	√x
61	+
34 02	RCL 2
35 07	g x↔y
81	÷
42	CHS
35 00	g LST X
34 01	RCL 1
35 07	g x↔y
81	÷
34 04	RCL 4
34 03	RCL 3
11	A
24	RTN
23	LBL
13	C
35	g
42	RAD
31	f
01	R→P
31	f
07	LN
31	f
01	R→P
35 08	g R↓
35 08	g R↓
31	f
01	R→P
31	f
07	LN
31	f

CODE	KEYS
01	R→P
35 07	g x↔y
35 08	g R↓
35 07	g x↔y
81	÷
35 08	g R↓
51	-
35 09	g R↑
32	f ⁻¹
01	R→P
24	RTN
23	LBL
14	D
35 07	g x↔y
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R ₁	Used	R ₄	Used	R ₇
R ₂	Used	R ₅		R ₈
R ₃	Used	R ₆		R ₉ Used

COMPLEX TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS $\sin z$, $\sinh z$, $\csc z$, $\operatorname{csch} z$

CODE	KEYS
	23 LBL
	11 A
33	01 STO 1
	35 g
	42 RAD
	31 f
	04 SIN
35	07 $g \times \Rightarrow y$
33	02 STO 2
	32 f^{-1}
	07 LN
	41 $\uparrow$
	35 g
	04 $1/x$
	61 +
	02 2
	81 $\div$
	71 x
33	03 STO 3
34	01 RCL 1
	31 f
	05 COS
34	02 RCL 2
	32 f^{-1}
	07 LN
	41 $\uparrow$
	35 g
	04 $1/x$
	51 —
	02 2
	81 $\div$
	71 x
34	03 RCL 3
	24 RTN
35	07 $g \times \Rightarrow y$

CODE	KEYS
84	R/S
23	LBL
12	B
35 07	$g \times \frac{1}{y}$
42	CHS
11	A
42	CHS
35 07	$g \times \frac{1}{y}$
24	RTN
35 07	$g \times \frac{1}{y}$
84	R/S
23	LBL
13	C
11	A
15	E
24	RTN
35 07	$g \times \frac{1}{y}$
84	R/S
23	LBL
14	D
35 07	$g \times \frac{1}{y}$
42	CHS
11	A
15	E
35 07	$g \times \frac{1}{y}$
42	CHS
24	RTN
35 07	$g \times \frac{1}{y}$
84	R/S
23	LBL
15	E
33 01	STO 1
32	f^{-1}
09	$\sqrt{x}$
35 07	$g \times \frac{1}{y}$

[illegible]

R₁	Used	R₄		R₇	
R₂	Used	R₅		R₈	
R₃	Used	R₆		R₉	Used

COMPLEX TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS $\cos z$, $\cosh z$, $\sec z$, $\operatorname{sech} z$

CODE	KEYS
23	LBL
11	A
33 01	STO 1
35	g
42	RAD
31	f
05	COS
35 07	$g \rightarrow y$
33 02	STO 2
32	f^{-1}
07	LN
41	$\uparrow$
35	g
04	$1/x$
61	+
02	2
81	$\div$
71	x
33 03	STO 3
34 01	RCL 1
31	f
04	SIN
34 02	RCL 2
32	f^{-1}
07	LN
41	$\uparrow$
35	g
04	$1/x$
51	-
02	2
81	$\div$
71	x
42	CHS
34 03	RCL 3
24	RTN

CODE	KEYS
35 07	$g \times \dot{z} y$
84	R/S
23	LBL
12	B
35 07	$g \times \dot{z} y$
42	CHS
11	A
24	RTN
35 07	$g \times \dot{z} y$
84	R/S
23	LBL
13	C
11	A
15	E
24	RTN
35 07	$g \times \dot{z} y$
84	R/S
23	LBL
14	D
35 07	$g \times \dot{z} y$
42	CHS
11	A
15	E
24	RTN
35 07	$g \times \dot{z} y$
84	R/S
23	LBL
15	E
33 01	STO 1
32	f^{-1}
09	$\sqrt{x}$
35 07	$g \times \dot{z} y$
33 02	STO 2
32	f^{-1}
09	$\sqrt{x}$

[illegible]

R₁	Used	R₄	R₇
R₂	Used	R₅	R₈
R₃	Used	R₆	R₉ Used

COMPLEX TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS $\tan z$, $\tanh z$, $\cot z$, $\coth z$

CODE	KEYS
23	LBL
11	A
15	E
34 03	RCL 3
34 02	RCL 2
34 04	RCL 4
61	+
81	$\div$
34 01	RCL 1
23	LBL
01	1
35 00	g LST X
81	$\div$
24	RTN
35 07	$g x \rightarrow y$
84	R/S
23	LBL
12	B
35 07	$g x \rightarrow y$
15	E
34 01	RCL 1
34 02	RCL 2
34 04	RCL 4
61	+
81	$\div$
34 03	RCL 3
22	GTO
01	1
23	LBL
13	C
15	E
34 03	RCL 3
34 04	RCL 4
34 02	RCL 2
51	-

CODE	KEYS
81	$\div$
42	CHS
34 01	RCL 1
22	GTO
01	1
23	LBL
14	D
35 07	$g x \rightarrow y$
15	E
34 01	RCL 1
34 04	RCL 4
34 02	RCL 2
51	-
81	$\div$
42	CHS
34 03	RCL 3
22	GTO
01	1
23	LBL
15	E
35	g
42	RAD
02	2
71	x
31	f
04	SIN
33 01	STO 1
35 00	g LST X
31	f
05	COS
33 02	STO 2
35 08	$g R \downarrow$
35 08	$g R \downarrow$
02	2
71	x

CODE	KEYS
32	f^{-1}
07	LN
41	$\uparrow$
35	g
04	$1/x$
33 04	STO 4
51	-
02	2
81	$\div$
33 03	STO 3
34 04	RCL 4
61	+
33 04	STO 4
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R ₁	Used	R ₄	Used	R ₇	
R ₂	Used	R ₅		R ₈	
R ₃	Used	R ₆		R ₉	Used

COMPLEX INVERSE TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS

 $\sin^{-1} z, \sinh^{-1} z, \csc^{-1} z, \operatorname{csch}^{-1} z$

CODE	KEYS
35 07	$g \times \dot{z} y$
42	CHS
11	A
42	CHS
35 07	$g \times \dot{z} y$
84	R/S
35 07	$g \times \dot{z} y$
84	R/S
23	LBL
11	A
35	g
42	RAD
33 01	STO 1
35 07	$g \times \dot{z} y$
33 02	STO 2
35 07	$g \times \dot{z} y$
01	1
61	+
31	f
01	R→P
33 03	STO 3
34 02	RCL 2
34 01	RCL 1
01	1
51	—
31	f
01	R→P
33 04	STO 4
34 03	RCL 3
61	+
02	2
81	÷
33 01	STO 1
32	f^{-1}
09	$\sqrt{x}$

CODE	KEYS
01	1
51	—
31	f
09	$\sqrt{x}$
34 01	RCL 1
61	+
31	f
07	LN
33 05	STO 5
34 02	RCL 2
01	1
61	+
01	1
35 24	$g \times > y$
42	CHS
35 01	g NOP
34 05	RCL 5
71	x
34 03	RCL 3
34 04	RCL 4
51	—
02	2
81	÷
32	f^{-1}
04	SIN
24	RTN
35 07	$g \times \dot{z} y$
84	R/S
23	LBL
13	C
15	E
11	A
24	RTN
35 07	$g \times \dot{z} y$
84	R/S

CODE	KEYS
23	LBL
14	D
35 07	$g \times \dot{z} y$
42	CHS
15	E
11	A
35 07	$g \times \dot{z} y$
42	CHS
24	RTN
35 07	$g \times \dot{z} y$
84	R/S
23	LBL
15	E
33 01	STO 1
32	f^{-1}
09	$\sqrt{x}$
35 07	$g \times \dot{z} y$
33 02	STO 2
32	f^{-1}
09	$\sqrt{x}$
61	+
34 02	RCL 2
35 07	$g \times \dot{z} y$
81	÷
42	CHS
35 00	g LST X
34 01	RCL 1
35 07	$g \times \dot{z} y$
81	÷
24	RTN

R₁	Used	R₄	Used	R₇
R₂	Used	R₅	Used	R₈
R₃	Used	R₆		R₉ Used

COMPLEX INVERSE TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS

$$\cos^{-1} z, \cosh^{-1} z, \sec^{-1} z, \operatorname{sech}^{-1} z$$

CODE	KEYS
23	LBL
11	A
35	g
42	RAD
33 01	STO 1
35 07	g $\times \rightarrow y$
33 02	STO 2
35 07	g $\times \rightarrow y$
01	1
61	+
31	f
01	R $\rightarrow$ P
33 03	STO 3
34 02	RCL 2
34 01	RCL 1
01	1
51	-
31	f
01	R $\rightarrow$ P
33 04	STO 4
34 03	RCL 3
61	+
02	2
81	$\div$
33 01	STO 1
32	f^{-1}
09	$\sqrt{x}$
01	1
51	-
31	f
09	$\sqrt{x}$
34 01	RCL 1
61	+
31	f
07	LN

CODE	KEYS
42	CHS
33 05	STO 5
34 02	RCL 2
01	1
61	+
01	1
35 24	g $\times \rightarrow y$
42	CHS
35 01	g NOP
34 05	RCL 5
71	x
34 03	RCL 3
34 04	RCL 4
51	-
02	2
81	$\div$
32	f^{-1}
05	COS
24	RTN
35 07	g $\times \rightarrow y$
84	R/S
23	LBL
12	B
11	A
35 07	g $\times \rightarrow y$
42	CHS
24	RTN
35 07	g $\times \rightarrow y$
84	R/S
23	LBL
13	C
15	E
11	A
24	RTN
35 07	g $\times \rightarrow y$

CODE	KEYS
84	R/S
23	LBL
14	D
15	E
11	A
35 07	g $\times \rightarrow y$
42	CHS
24	RTN
35 07	g $\times \rightarrow y$
84	R/S
23	LBL
15	E
33 01	STO 1
32	f^{-1}
09	$\sqrt{x}$
35 07	g $\times \rightarrow y$
33 02	STO 2
32	f^{-1}
09	$\sqrt{x}$
61	+
34 02	RCL 2
35 07	g $\times \rightarrow y$
81	$\div$
42	CHS
35 00	g LST X
34 01	RCL 1
35 07	g $\times \rightarrow y$
81	$\div$
24	RTN
35 01	g NOP

R ₁	Used	R ₄	Used	R ₇
R ₂	Used	R ₅	Used	R ₈
R ₃	Used	R ₆		R ₉ Used

$\tan^{-1} z, \tanh^{-1} z, \cot^{-1} z, \coth^{-1} z$ [illegible]

R₁	Used	R₄		R₇	
R₂	Used	R₅		R₈	
R₃		R₆		R₉	Used

INTERSECTIONS OF A LINE AND A CONIC SECTION (CARD 1)

CODE	KEYS
23	LBL
11	A
32	f^{-1}
51	SF 1
33 06	STO 6
35 08	g R↓
33 02	STO 2
35 08	g R↓
33 03	STO 3
00	0
35 21	g $x \neq y$
84	R/S
35 01	g NOP
31	f
51	SF 1
34 03	RCL 3
34 02	RCL 2
33 03	STO 3
35 07	g $x \geq y$
33 02	STO 2
84	R/S
23	LBL
12	B
33	STO
09	9
35 08	g R↓
33 04	STO 4
35 08	g R↓
33 01	STO 1
31	f
61	TF 1
13	C
35 01	g NOP
34 02	RCL 2
32	f^{-1}

CODE	KEYS
09	$\sqrt{x}$
71	x
34 03	RCL 3
32	f^{-1}
09	$\sqrt{x}$
81	÷
34 04	RCL 4
34 03	RCL 3
81	÷
34 02	RCL 2
71	x
51	-
34	RCL
09	9
61	+
41	↑
61	+
33 05	STO 5
34 01	RCL 1
02	2
71	x
34 02	RCL 2
71	x
34 03	RCL 3
81	÷
34 04	RCL 4
51	-
34 06	RCL 6
71	x
34 03	RCL 3
81	÷
33 07	STO 7
84	R/S
34 07	RCL 7
35 08	g R↓

CODE	KEYS
33	STO
09	9
35 08	g R↓
33 08	STO 8
35 08	g R↓
33 07	STO 7
32	f^{-1}
61	TF 1
34 02	RCL 2
84	R/S
33 08	STO 8
35 09	g R↑
33 07	STO 7
35 07	g $x \geq y$
35 08	g R↓
34 02	RCL 2
84	R/S
23	LBL
13	C
34	RCL
09	9
33 01	STO 1
35 07	g $x \geq y$
33	STO
09	9
34 01	RCL 1
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1	A	R_4	B	R_7	D
R_2	b	R_5	2α	R_8	E
R_3	a	R_6	c	R_9	C, F

INTERSECTIONS OF A LINE AND A CONIC SECTION (CARD 2)

CODE	KEYS
23	LBL
11	A
71	x
34 03	RCL 3
81	$\div$
51	-
33	STO
61	+
08	8
34 01	RCL 1
34 06	RCL 6
32	f^{-1}
09	$\sqrt{x}$
71	x
34 03	RCL 3
32	f^{-1}
09	$\sqrt{x}$
81	$\div$
34 07	RCL 7
34 06	RCL 6
71	x
34 03	RCL 3
81	$\div$
51	-
34	RCL
09	9
61	+
33 01	STO 1
34 08	RCL 8
34 05	RCL 5
81	$\div$
42	CHS
41	$\uparrow$
32	f^{-1}
09	$\sqrt{x}$

CODE	KEYS
34 01	RCL 1
41	$\uparrow$
61	+
34 05	RCL 5
81	$\div$
51	-
00	0
35 24	$g x > y$
22	GTO
01	1
35 08	$g R \downarrow$
31	f
09	$\sqrt{x}$
33 01	STO 1
61	+
33 04	STO 4
35 07	$g x \geq y$
34 01	RCL 1
51	-
33 07	STO 7
12	B
33 08	STO 8
34 04	RCL 4
12	B
31	f
61	TF 1
22	GTO
08	8
84	R/S
34 04	RCL 4
84	R/S
34 08	RCL 8
84	R/S
34 07	RCL 7
84	R/S

CODE	KEYS
23	LBL
08	8
34 04	RCL 4
84	R/S
35 07	$g x \geq y$
84	R/S
34 07	RCL 7
84	R/S
34 08	RCL 8
84	R/S
23	LBL
01	1
09	9
09	9
09	9
32	f^{-1}
07	LN
84	R/S
23	LBL
12	B
34 02	RCL 2
71	x
34 06	RCL 6
61	+
34 03	RCL 3
81	$\div$
42	CHS
24	RTN
35 01	g NOP
35 01	g NOP

R_1	$A, \gamma, \sqrt{Q}$	R_4	B, y_1	R_7	D, y_2
R_2	b	R_5	2α	R_8	E, B, x_2
R_3	a	R_6	C	R_9	C, F

VECTOR PRODUCTS AND ANGLE BETWEEN VECTORS

CODE	KEYS
23	LBL
11	A
33 03	STO 3
35 08	g R↓
33 02	STO 2
35 08	g R↓
33 01	STO 1
24	RTN
23	LBL
12	B
33 06	STO 6
35 08	g R↓
33 05	STO 5
35 08	g R↓
33 04	STO 4
24	RTN
23	LBL
13	C
34 01	RCL 1
34 04	RCL 4
71	x
34 02	RCL 2
34 05	RCL 5
71	x
61	+
34 03	RCL 3
34 06	RCL 6
71	x
61	+
84	R/S
34 01	RCL 1
15	E
34 02	RCL 2
15	E
61	+

CODE	KEYS
34 03	RCL 3
15	E
61	+
31	f
09	$\sqrt{x}$
33 07	STO 7
34 04	RCL 4
15	E
34 05	RCL 5
15	E
61	+
34 06	RCL 6
15	E
61	+
31	f
09	$\sqrt{x}$
33 08	STO 8
71	x
81	÷
32	f^{-1}
05	COS
84	R/S
34 07	RCL 7
84	R/S
34 08	RCL 8
24	RTN
23	LBL
14	D
34 02	RCL 2
34 06	RCL 6
71	x
34 03	RCL 3
34 05	RCL 5
71	x
51	—

CODE	KEYS
33 07	STO 7
34 01	RCL 1
34 05	RCL 5
71	x
34 02	RCL 2
34 04	RCL 4
71	x
51	—
34 03	RCL 3
34 04	RCL 4
71	x
34 01	RCL 1
34 06	RCL 6
71	x
51	—
34 07	RCL 7
84	R/S
35 08	g R↓
84	R/S
35 08	g R↓
24	RTN
23	LBL
15	E
32	f^{-1}
09	$\sqrt{x}$
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R₁	x_1	R₄	y_1	R₇	$ \vec{x} $
R₂	x_2	R₅	y_2	R₈	$ \vec{y} $
R₃	x_3	R₆	y_3	R₉	Used

PARTIAL SUM AND PARTIAL PRODUCT

CODE	KEYS
23	LBL
11	A
14	D
00	0
33 03	STO 3
34 02	RCL 2
23	LBL
01	1
13	C
34 03	RCL 3
61	+
33 03	STO 3
01	1
34 02	RCL 2
61	+
33 02	STO 2
35	g
83	DSZ
22	GTO
01	1
34 03	RCL 3
24	RTN
23	LBL
12	B
14	D
01	1
33 03	STO 3
34 02	RCL 2
23	LBL
02	2
13	C
34 03	RCL 3
71	x
33 03	STO 3
01	1

[illegible][illegible]

R₁	x	R₄	R₇
R₂	Used	R₅	R₈ Used
R₃	Σ, Π	R₆	R₉

GAUSSIAN QUADRATURE FOR $\int_a^b f(x) dx$ (CARD 2)

CODE	KEYS
33 08	STO 8
35 07	$g \times \div y$
61	+
33 07	STO 7
35 00	g LST X
34 08	RCL 8
35 07	$g \times \div y$
51	-
33 08	STO 8
00	0
33	STO
09	9
32	f^{-1}
51	SF1
23	LBL
01	1
12	B
34 01	RCL 1
34 02	RCL 2
33 01	STO 1
35 07	$g \times \div y$
33 02	STO 2
34 04	RCL 4
34 05	RCL 5
33 04	STO 4
35 07	$g \times \div y$
33 05	STO 5
12	B
34 01	RCL 1
34 03	RCL 3
33 01	STO 1
35 07	$g \times \div y$
33 03	STO 3
34 04	RCL 4
34 06	RCL 6

CODE	KEYS
33 04	STO 4
35 07	$g \times \frac{1}{y}$
33 06	STO 6
12	B
31	f
61	TF1
22	GTO
02	2
34 01	RCL 1
42	CHS
33 01	STO 1
34 02	RCL 2
42	CHS
33 02	STO 2
34 03	RCL 3
42	CHS
33 03	STO 3
31	f
51	SF1
22	GTO
01	1
23	LBL
02	2
34	RCL
09	9
34 08	RCL 8
71	x
02	2
81	$\div$
84	R/S
23	LBL
12	B
34 01	RCL 1
34 08	RCL 8
71	x

[illegible]

R₁	z₁ (z₂)	R₄	w₁	R₇	a + b
R₂	z₃ (z₄)	R₅	w₃	R₈	b, b - a
R₃	z₅ (z₆)	R₆	w₅	R₉	Used

BESSEL FUNCTION $J_n(x)$

CODE	KEYS	CODE	KEYS	CODE	KEYS
33 01	STO 1	09	9	34 06	RCL 6
43	EEX	71	x	33	STO
42	CHS	71	x	61	+
09	9	35 00	g LST X	04	4
09	9	31	f	34 03	RCL 3
33 06	STO 6	09	$\sqrt{x}$	34 08	RCL 8
00	0	61	+	02	2
33 03	STO 3	01	1	34 01	RCL 1
33 04	STO 4	61	+	81	÷
35 09	g R↑	34 01	RCL 1	71	x
33 05	STO 5	34 05	RCL 5	34 06	RCL 6
35 22	g $x \leq y$	35 24	g $x > y$	33 03	STO 3
22	GTO	35 01	g NOP	71	x
01	1	35 07	g $x \rightarrow y$	35 07	g $x \rightarrow y$
35	g	35 08	g R↓	51	-
04	$1/x$	61	+	33 06	STO 6
61	+	31	f	34 08	RCL 8
35	g	83	INT	01	1
05	y^x	23	LBL	51	-
02	2	03	3	22	GTO
71	x	33 08	STO 8	03	3
35 07	g $x \rightarrow y$	34 05	RCL 5	23	LBL
35 22	g $x \leq y$	35 23	g $x = y$	02	2
44	CLX	34 06	RCL 6	34 04	RCL 4
84	R/S	33 07	STO 7	02	2
23	LBL	00	0	71	x
01	1	34 08	RCL 8	34 06	RCL 6
34 01	RCL 1	35 23	g $x = y$	61	+
06	6	34 07	RCL 7	81	÷
35	g	22	GTO	84	R/S
04	$1/x$	02	2		
35	g	81	÷		
05	y^x	32	f^{-1}		
41	↑	83	INT		
41	↑	35 23	g $x = y$		

R_1	x	R_4	$\sum T_{2i}$	R_7	T_n
R_2		R_5	n	R_8	counter k
R_3	T_{k+1}	R_6	$10^{-99}, T_k$	R_9	Used

KELVIN FUNCTIONS

CODE	KEYS
23	LBL
11	A
41	↑
71	x
41	↑
71	x
33 03	STO 3
35 00	g LST X
04	4
81	÷
35 08	g R↓
44	CLX
33 02	STO 2
35 07	g x↗y
33 01	STO 1
35 23	g x=y
01	1
35 08	g R↓
35 09	g R↑
33 05	STO 5
23	LBL
01	1
41	↑
33 04	STO 4
34 05	RCL 5
61	+
35 23	g x=y
24	RTN
24	RTN
43	EEX
02	2
34 02	RCL 2
02	2
61	+
33 02	STO 2

CODE	KEYS
35 24	g x>y
34 04	RCL 4
24	RTN
34 01	RCL 1
61	+
41	↑
71	x
35 00	g LST X
51	-
41	↑
71	x
08	8
00	0
71	x
05	5
42	CHS
34 03	RCL 3
71	x
35 07	g x↗y
81	÷
34 05	RCL 5
71	x
33 05	STO 5
34 04	RCL 4
61	+
22	GTO
01	1
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

CODE	KEYS
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R ₁	0 or 1	R ₄	Used	R ₇	
R ₂	Used	R ₅	Used	R ₈	
R ₃	x ⁴	R ₆		R ₉	Used

EULER Φ FUNCTION

CODE	KEYS
23	LBL
11	A
33 01	STO 1
01	1
33 02	STO 2
33 04	STO 4
02	2
33 03	STO 3
23	LBL
01	1
34 01	RCL 1
34 03	RCL 3
81	÷
34 03	RCL 3
35 24	g x>y
22	GTO
02	2
35 08	g R↓
31	f
83	INT
35 00	g LST X
35 24	g x>y
22	GTO
03	3
33 01	STO 1
34 04	RCL 4
34 03	RCL 3
33 04	STO 4
35 21	g x≠y
01	1
51	—
33	STO
71	x
02	2
22	GTO

[illegible][illegible]

R₁	Used	R₄	Used	R₇	
R₂	Used	R₅		R₈	
R₃	Used	R₆		R₉	Used

GAMMA FUNCTION (CARD 1)

CODE	KEYS
23	LBL
11	A
83	•
00	0
03	3
05	5
08	8
06	6
08	8
03	3
04	4
03	3
33 01	STO 1
83	•
01	1
09	9
03	3
05	5
02	2
07	7
08	8
01	1
08	8
42	CHS
33 02	STO 2
83	•
04	4
08	8
02	2
01	1
09	9
09	9
03	3
09	9
04	4

CODE	KEYS
33 03	STO 3
83	•
07	7
05	5
06	6
07	7
00	0
04	4
00	0
07	7
08	8
42	CHS
33 04	STO 4
83	•
09	9
01	1
08	8
02	2
00	0
06	6
08	8
05	5
07	7
33 05	STO 5
83	•
08	8
09	9
07	7
00	0
05	5
06	6
09	9
03	3
07	7
42	CHS

CODE	KEYS
33 06	STO 6
83	•
09	9
08	8
08	8
02	2
00	0
05	5
08	8
09	9
01	1
33 07	STO 7
83	•
05	5
07	7
07	7
01	1
09	9
01	1
06	6
05	5
02	2
42	CHS
33 08	STO 8
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R ₁	b ₈	R ₄	b ₅	R ₇	b ₂
R ₂	b ₇	R ₅	b ₄	R ₈	b ₁
R ₃	b ₆	R ₆	b ₃	R ₉	

GAMMA FUNCTION (CARD 2)

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	34 06	RCL 6	35 01	g NOP
11	A	61	+	35 01	g NOP
41	↑	71	x	35 01	g NOP
01	1	34 07	RCL 7	35 01	g NOP
51	—	61	+	35 01	g NOP
00	0	71	x	35 01	g NOP
35 24	g x>y	83	·	35 01	g NOP
00	0	05	5	35 01	g NOP
81	÷	07	7	35 01	g NOP
35 07	g x↔y	07	7	35 01	g NOP
01	1	01	1	35 01	g NOP
33 08	STO 8	09	9	35 01	g NOP
23	LBL	01	1	35 01	g NOP
02	2	06	6	35 01	g NOP
35 07	g x↔y	05	5	35 01	g NOP
35 24	g x>y	02	2	35 01	g NOP
22	GTO	42	CHS	35 01	g NOP
01	1	61	+	35 01	g NOP
41	↑	71	x	35 01	g NOP
41	↑	01	1	35 01	g NOP
41	↑	61	+	35 01	g NOP
34 01	RCL 1	34 08	RCL 8	35 01	g NOP
71	x	71	x	35 01	g NOP
34 02	RCL 2	84	R/S	35 01	g NOP
61	+	23	LBL	35 01	g NOP
71	x	01	1	35 01	g NOP
34 03	RCL 3	33	STO	35 01	g NOP
61	+	71	x	35 01	g NOP
71	x	08	8	35 01	g NOP
34 04	RCL 4	35 07	g x↔y	35 01	g NOP
61	+	51	—	35 01	g NOP
71	x	01	1		
34 05	RCL 5	22	GTO		
61	+	02	2		
71	x	35 01	g NOP		

R ₁	b ₈	R ₄	b ₅	R ₇	b ₂
R ₂	b ₇	R ₅	b ₄	R ₈	Used
R ₃	b ₆	R ₆	b ₃	R ₉	Used

ERROR FUNCTION AND COMPLEMENTARY ERROR FUNCTION

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	32	f^{-1}	35 01	g NOP
11	A	07	LN	35 01	g NOP
33 01	STO 1	71	x	35 01	g NOP
41	$\uparrow$	81	$\div$	35 01	g NOP
71	x	84	R/S	35 01	g NOP
02	2	01	1	35 01	g NOP
71	x	35 07	$g x \rightarrow y$	35 01	g NOP
33 02	STO 2	51	—	35 01	g NOP
01	1	24	RTN	35 01	g NOP
33 03	STO 3	35 01	g NOP	35 01	g NOP
34 01	RCL 1	35 01	g NOP	35 01	g NOP
23	LBL	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
34 02	RCL 2	35 01	g NOP	35 01	g NOP
34 03	RCL 3	35 01	g NOP	35 01	g NOP
02	2	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
33 03	STO 3	35 01	g NOP	35 01	g NOP
81	$\div$	35 01	g NOP	35 01	g NOP
34 01	RCL 1	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
33 01	STO 1	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
35 21	$g x \neq y$	35 01	g NOP	35 01	g NOP
22	GTO	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
02	2	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
35	g	35 01	g NOP	35 01	g NOP
02	π	35 01	g NOP	35 01	g NOP
31	f	35 01	g NOP	35 01	g NOP
09	$\sqrt{x}$	35 01	g NOP	35 01	g NOP
34 02	RCL 2	35 01	g NOP	35 01	g NOP
02	2	35 01	g NOP	35 01	g NOP
81	$\div$	35 01	g NOP	35 01	g NOP

R ₁	Used	R ₄	R ₇
R ₂	$2x^2$	R ₅	R ₈
R ₃	Used	R ₆	R ₉ Used

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	35 01	g NOP	35 01	g NOP
11	A	35 01	g NOP	35 01	g NOP
33 01	STO 1	35 01	g NOP	35 01	g NOP
35 08	g R↓	35 01	g NOP	35 01	g NOP
33 02	STO 2	35 01	g NOP	35 01	g NOP
35 08	g R↓	35 01	g NOP	35 01	g NOP
33 03	STO 3	35 01	g NOP	35 01	g NOP
00	0	35 01	g NOP	35 01	g NOP
33 04	STO 4	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
33 05	STO 5	35 01	g NOP	35 01	g NOP
23	LBL	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
34 01	RCL 1	35 01	g NOP	35 01	g NOP
34 03	RCL 3	35 01	g NOP	35 01	g NOP
34 04	RCL 4	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
34 02	RCL 2	35 01	g NOP	35 01	g NOP
34 04	RCL 4	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
81	÷	35 01	g NOP	35 01	g NOP
34 04	RCL 4	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
33 04	STO 4	35 01	g NOP	35 01	g NOP
81	÷	35 01	g NOP	35 01	g NOP
34 05	RCL 5	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
33 05	STO 5	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
35 21	g $x \neq y$	35 01	g NOP	35 01	g NOP
22	GTO	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
24	RTN	35 01	g NOP		

R₁	x	R₄	Used	R₇	
R₂	b	R₅	Used	R₈	
R₃	a	R₆		R₉	Used

GAUSSIAN HYPERGEOMETRIC FUNCTION

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	33 05	STO 5	35 01	g NOP
11	A	81	$\div$	35 01	g NOP
33 01	STO 1	34 06	RCL 6	35 01	g NOP
35 08	g R $\downarrow$	71	x	35 01	g NOP
33 02	STO 2	33 06	STO 6	35 01	g NOP
35 08	g R $\downarrow$	61	+	35 01	g NOP
33 03	STO 3	35 23	g x=y	35 01	g NOP
35 08	g R $\downarrow$	24	RTN	35 01	g NOP
33 04	STO 4	35 01	g NOP	35 01	g NOP
04	4	35	g	35 01	g NOP
00	0	83	DSZ	35 01	g NOP
00	0	22	GTO	35 01	g NOP
33 08	STO 8	01	1	35 01	g NOP
00	0	00	0	35 01	g NOP
33 05	STO 5	81	$\div$	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
33 06	STO 6	35 01	g NOP	35 01	g NOP
23	LBL	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
34 01	RCL 1	35 01	g NOP	35 01	g NOP
34 05	RCL 5	35 01	g NOP	35 01	g NOP
34 04	RCL 4	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
34 05	RCL 5	35 01	g NOP	35 01	g NOP
34 03	RCL 3	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
34 02	RCL 2	35 01	g NOP	35 01	g NOP
34 05	RCL 5	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
81	$\div$	35 01	g NOP	35 01	g NOP
34 05	RCL 5	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP

R₁	x	R₄	a	R₇	
R₂	c	R₅	Used	R₈	Used
R₃	b	R₆	Used	R₉	Used

Chebyshev Polynomial

CODE	KEYS
23	LBL
11	A
33 01	STO 1
02	2
33 02	STO 2
71	x
33 03	STO 3
44	CLX
35 07	$g\ x \rightleftharpoons y$
35 22	$g\ x \leq y$
01	1
24	RTN
01	1
33 04	STO 4
35 23	$g\ x = y$
34 01	RCL 1
24	RTN
23	LBL
01	1
44	CLX
34 03	RCL 3
34 01	RCL 1
71	x
34 04	RCL 4
35 00	$g\ \text{LST } X$
33 04	STO 4
35 08	$g\ R \downarrow$
51	—
33 01	STO 1
44	CLX
34 02	RCL 2
01	1
61	+
33 02	STO 2
35 22	$g\ x \leq y$

[illegible][illegible]

R₁	Used	R₄	Used	R₇
R₂	Used	R₅		R₈
R₃	2x	R₆		R₉ Used

LEGENDRE POLYNOMIAL

CODE	KEYS
23	LBL
11	A
33 02	STO 2
33 05	STO 5
44	CLX
35 07	$g \times \overline{\neq} y$
33 01	STO 1
35 22	$g \times \leq y$
01	1
24	RTN
01	1
33 04	STO 4
35 07	$g \times \overline{\neq} y$
35 22	$g \times \leq y$
34 02	RCL 2
24	RTN
02	2
33 03	STO 3
23	LBL
01	1
34 05	RCL 5
34 02	RCL 2
71	x
41	↑
41	↑
34 04	RCL 4
51	—
61	+
35 00	$g \text{ LST } X$
34 05	RCL 5
33 04	STO 4
44	CLX
34 03	RCL 3
81	÷
51	—

[illegible][illegible]

R₁	n	R₄	Used	R₇
R₂	x	R₅	Used	R₈
R₃	Used	R₆		R₉ Used

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	61	+	35 01	g NOP
11	A	33 03	STO 3	35 01	g NOP
33 02	STO 2	35 07	g $x \rightarrow y$	35 01	g NOP
02	2	35 21	g $x \neq y$	35 01	g NOP
71	x	22	GTO	35 01	g NOP
33 04	STO 4	01	1	35 01	g NOP
44	CLX	34 04	RCL 4	35 01	g NOP
35 07	g $x \rightarrow y$	24	RTN	35 01	g NOP
35 22	g $x \leq y$	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
24	RTN	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
33 01	STO 1	35 01	g NOP	35 01	g NOP
33 03	STO 3	35 01	g NOP	35 01	g NOP
35 07	g $x \rightarrow y$	35 01	g NOP	35 01	g NOP
35 22	g $x \leq y$	35 01	g NOP	35 01	g NOP
34 04	RCL 4	35 01	g NOP	35 01	g NOP
24	RTN	35 01	g NOP	35 01	g NOP
23	LBL	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
34 01	RCL 1	35 01	g NOP	35 01	g NOP
34 04	RCL 4	35 01	g NOP	35 01	g NOP
33 01	STO 1	35 01	g NOP	35 01	g NOP
34 02	RCL 2	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
35 07	g $x \rightarrow y$	35 01	g NOP	35 01	g NOP
34 03	RCL 3	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
51	—	35 01	g NOP	35 01	g NOP
02	2	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
33 04	STO 4	35 01	g NOP	35 01	g NOP
44	CLX	35 01	g NOP	35 01	g NOP
34 03	RCL 3	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP		

R₁	Used	R₄	Used	R₇	
R₂	x	R₅		R₈	
R₃	Used	R₆		R₉	Used

LAGUERRE POLYNOMIAL

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	34 03	RCL 3	35 01	g NOP
11	A	81	$\div$	35 01	g NOP
41	$\uparrow$	34 05	RCL 5	35 01	g NOP
01	1	33 04	STO 4	35 01	g NOP
33 04	STO 4	35 08	g R $\downarrow$	35 01	g NOP
61	+	51	-	35 01	g NOP
33 02	STO 2	33 05	STO 5	35 01	g NOP
02	2	34 01	RCL 1	35 01	g NOP
33 03	STO 3	34 03	RCL 3	35 01	g NOP
35 07	g x $\rightleftarrows$ y	01	1	35 01	g NOP
51	-	61	+	35 01	g NOP
33 05	STO 5	33 03	STO 3	35 01	g NOP
44	CLX	35 22	g x $\leq$ y	35 01	g NOP
35 07	g x $\rightleftarrows$ y	22	GTO	35 01	g NOP
35 22	g x $\leq$ y	01	1	35 01	g NOP
01	1	34 05	RCL 5	35 01	g NOP
24	RTN	24	RTN	35 01	g NOP
33 01	STO 1	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
35 07	g x $\rightleftarrows$ y	35 01	g NOP	35 01	g NOP
35 22	g x $\leq$ y	35 01	g NOP	35 01	g NOP
34 05	RCL 5	35 01	g NOP	35 01	g NOP
24	RTN	35 01	g NOP	35 01	g NOP
23	LBL	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
34 05	RCL 5	35 01	g NOP	35 01	g NOP
34 04	RCL 4	35 01	g NOP	35 01	g NOP
51	-	35 01	g NOP	35 01	g NOP
34 05	RCL 5	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
34 02	RCL 2	35 01	g NOP	35 01	g NOP
34 05	RCL 5	35 01	g NOP	35 01	g NOP
71	x	35 01	g NOP	35 01	g NOP
34 04	RCL 4	35 01	g NOP	35 01	g NOP
51	-	35 01	g NOP	35 01	g NOP

R ₁	n	R ₄	Used	R ₇	
R ₂	1 + x	R ₅	Used	R ₈	
R ₃	Used	R ₆		R ₉	Used

SINE INTEGRAL

CODE	KEYS
23	LBL
11	A
33 03	STO 3
41	↑
71	x
42	CHS
33 01	STO 1
01	1
33 02	STO 2
34 03	RCL 3
23	LBL
01	1
34 01	RCL 1
34 02	RCL 2
01	1
61	+
81	÷
35 00	g LST X
01	1
61	+
33 02	STO 2
81	÷
34 03	RCL 3
71	x
33 03	STO 3
34 02	RCL 2
81	÷
61	+
35 21	g $x \neq y$
22	GTO
01	1
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP

[illegible][illegible]

R₁	-x²	R₄	R₇
R₂	Used	R₅	R₈
R₃	Used	R₆	R₉ Used

COSINE INTEGRAL

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	33 02	STO 2	35 01	g NOP
11	A	81	÷	35 01	g NOP
41	↑	34 03	RCL 3	35 01	g NOP
71	x	71	x	35 01	g NOP
42	CHS	33 03	STO 3	35 01	g NOP
33 01	STO 1	34 02	RCL 2	35 01	g NOP
01	1	81	÷	35 01	g NOP
33 03	STO 3	61	+	35 01	g NOP
00	0	35 21	g x≠y	35 01	g NOP
33 02	STO 2	22	GTO	35 01	g NOP
35 00	g LST X	01	1	35 01	g NOP
31	f	24	RTN	35 01	g NOP
07	LN	35 01	g NOP	35 01	g NOP
83	·	35 01	g NOP	35 01	g NOP
05	5	35 01	g NOP	35 01	g NOP
07	7	35 01	g NOP	35 01	g NOP
07	7	35 01	g NOP	35 01	g NOP
02	2	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
05	5	35 01	g NOP	35 01	g NOP
06	6	35 01	g NOP	35 01	g NOP
06	6	35 01	g NOP	35 01	g NOP
04	4	35 01	g NOP	35 01	g NOP
09	9	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
23	LBL	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
34 01	RCL 1	35 01	g NOP	35 01	g NOP
34 02	RCL 2	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP
81	÷	35 01	g NOP	35 01	g NOP
35 00	g LST X	35 01	g NOP	35 01	g NOP
01	1	35 01	g NOP	35 01	g NOP
61	+	35 01	g NOP	35 01	g NOP

R ₁	-x ²	R ₄		R ₇	
R ₂	Used	R ₅		R ₈	
R ₃	Used	R ₆		R ₉	Used

FRESNEL INTEGRALS

CODE	KEYS	CODE	KEYS	CODE	KEYS
23	LBL	13	C	35 01	g NOP
11	A	35 00	g LST X	35 01	g NOP
13	C	34 01	RCL 1	35 01	g NOP
01	1	71	x	35 01	g NOP
33 03	STO 3	33 01	STO 1	35 01	g NOP
34 01	RCL 1	03	3	35 01	g NOP
23	LBL	33 03	STO 3	35 01	g NOP
01	1	81	÷	35 01	g NOP
34 02	RCL 2	22	GTO	35 01	g NOP
34 03	RCL 3	01	1	35 01	g NOP
04	4	23	LBL	35 01	g NOP
61	+	13	C	35 01	g NOP
33 03	STO 3	33 01	STO 1	35 01	g NOP
01	1	35	g	35 01	g NOP
51	-	06	ABS	35 01	g NOP
02	2	03	3	35 01	g NOP
81	÷	83	·	35 01	g NOP
33 04	STO 4	06	6	35 01	g NOP
01	1	35 22	g x ≤ y	35 01	g NOP
51	-	00	0	35 01	g NOP
34 04	RCL 4	81	÷	35 01	g NOP
71	x	34 01	RCL 1	35 01	g NOP
81	÷	41	↑	35 01	g NOP
34 01	RCL 1	71	x	35 01	g NOP
71	x	35	g	35 01	g NOP
33 01	STO 1	02	π	35 01	g NOP
34 03	RCL 3	02	2	35 01	g NOP
81	÷	81	÷	35 01	g NOP
61	+	71	x	35 01	g NOP
35 21	g x ≠ y	41	↑	35 01	g NOP
22	GTO	71	x	35 01	g NOP
01	1	42	CHS	35 01	g NOP
24	RTN	33 02	STO 2		
23	LBL	24	RTN		
12	B	35 01	g NOP		

R ₁	Used	R ₄	Used	R ₇
R ₂	$-(\pi x^2/2)^2$	R ₅		R ₈
R ₃	Used	R ₆		R ₉

COMPLETE ELLIPTIC INTEGRALS

CODE	KEYS
23	LBL
11	A
33 03	STO 3
35 07	$g x \rightleftharpoons y$
33 02	STO 2
61	+
33 01	STO 1
43	EEX
09	9
09	9
33 04	STO 4
01	1
33 05	STO 5
35 09	$g R \uparrow$
41	$\uparrow$
71	x
35 24	$g x > y$
35 09	$g R \uparrow$
24	RTN
35 21	$g x \neq y$
22	GTO
01	1
44	CLX
71	x
34 03	RCL 3
35 24	$g x > y$
35 09	$g R \uparrow$
24	RTN
35 09	$g R \uparrow$
42	CHS
35 08	$g R \downarrow$
35 07	$g x \rightleftharpoons y$
35 24	$g x > y$
35 09	$g R \uparrow$
24	RTN

CODE	KEYS
34 02	RCL 2
24	RTN
23	LBL
01	1
51	—
31	f
09	$\sqrt{x}$
33 04	STO 4
23	LBL
02	2
34 02	RCL 2
34 04	RCL 4
71	x
34 03	RCL 3
61	+
02	2
71	x
33 03	STO 3
34 05	RCL 5
33 06	STO 6
34 04	RCL 4
61	+
33 05	STO 5
81	$\div$
34 01	RCL 1
33 02	STO 2
61	+
33 01	STO 1
34 04	RCL 4
34 06	RCL 6
01	1
41	$\uparrow$
43	EEX
42	CHS
09	9

CODE	KEYS
51	—
71	x
34 06	RCL 6
34 04	RCL 4
71	x
31	f
09	$\sqrt{x}$
02	2
71	x
33 04	STO 4
35 08	$g R \downarrow$
35 24	$g x > y$
22	GTO
02	2
35	g
02	π
04	4
81	$\div$
34 01	RCL 1
71	x
34 05	RCL 5
81	$\div$
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1	a_{i+1}	R_4	$10^{99}, v_i$	R_7
R_2	a_i	R_5	u_i	R_8
R_3	b_i	R_6	u_{i-1}	R_9 Used



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