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compute your
problems
at
your desk...



with
LOCI-2



Wang Laboratories, Inc.

LOCI-2

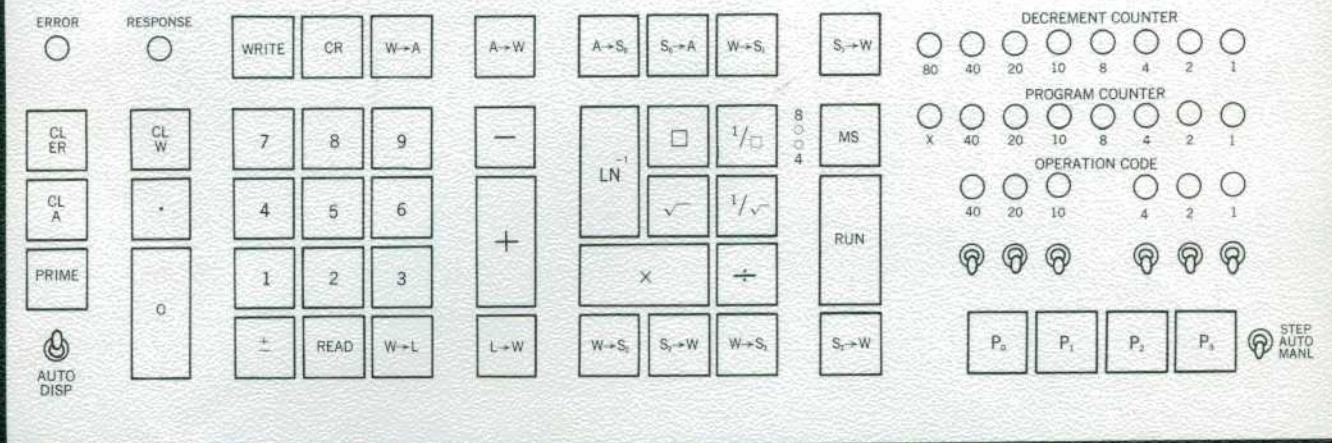
LOCI-2 (LOGarithmic Computing Instrument) is the most powerful desk-top computer designed for scientific computations. With its keyboard at your fingertips, you can expand your horizons, multiply your problem solving capability, and penetrate directly and instantaneously to the answers.

Because of its revolutionary logarithmic approach to data manipulation, LOCI-2 provides an inherent, absolutely unique flexibility and simplicity of operation. For example, it can compute $\ln(x)$ or e^x in only two keystrokes.

LOCI-2 can be readily programmed for a broad variety of complex routines, by means of pre-scored, easily-punched cards. Thus, with the appropriate card inserted in the reader, you can instantly compute and display $\sin(x)$ or $\cos(x)$ with a single keystroke. An extensive library of programs (statistical, general mathematical, etc.) is furnished free of charge to LOCI-2 purchasers.

And best of all, LOCI-2 is always at your command. You simply drop in your program card, enter your variables, press the **RUN** key, and read your results immediately.

KEYBOARD



List of operations.

The number to the left of each command is its code in octal. To obtain the corresponding code for punching on a program card, break the octal digits into the sum of 40, 20, 10, 4, 2, and 1. For example, the code for $W \rightarrow S_1$ is 52, and is punched as follows:

40 20 10 4 2 1

00	Not assigned	20	0	40	$W \rightarrow PC$	60	P_0 (Set PC to 00)
01	Clear error	21	1	41	$W \rightarrow XPC$	61	P_1 (" " " 03)
02	Clear W	22	2	42	$W \rightarrow DC$	62	P_2 (" " " 06)
03	Clear A	23	3	43	$DC \rightarrow W$	63	P_3 (" " " 09)
04	$\sqrt{ }$	24	4	44	$W \rightarrow A$	64	Store PC, DC then $W \rightarrow PC$
05	$1/\sqrt{ }$	25	5	45	$A \rightarrow W$	65	Recall PC, DC
06	\square	26	6	46	$W \rightarrow L$	66	Decrement DC
07	$1/\square$	27	7	47	$L \rightarrow W$	67	Test error
10	Step MSC	30	8	50	$A \rightarrow S_0$	70	Test DC = 0
11	Write	31	9	51	$S_0 \rightarrow A$	71	Test A = 0
12	\times	32	Run	52	$W \rightarrow S_1$	72	Reserved
13	$+$	33	\pm	53	$S_1 \rightarrow W$	73	Test W for — sign
14	$\ln-1$	34	Input MX	54	$(W \rightarrow S_2)$	74	Test L for — exponent
15	$-$	35	Output MX	55	$(S_2 \rightarrow W)$	75	Carriage return
16	\cdot	36	Prime	56	$(W \rightarrow S_3)$	76	Read
17	\div	37	Stop	57	$(S_3 \rightarrow W)$	77	Not assigned

*Commands 10, 11, 34, 35, 75, and 76 are available only when special options are purchased.

USING A PROGRAM

A number of standard programs are supplied with each LOCI-2. These programs are extremely simple to operate. Consider the examples below.

Example.

To find $\sin(42^\circ)$. Put the SIN-COS program in the reader, then key the sequence $4 \ 2 \ P_0$. The result, .66913 06067 will appear in the display. Likewise, to find $\cos(28^\circ)$, key $2 \ 8 \ P_1$ giving the result .88294 75960.

Example.

To find $\sqrt{2} \sin(42^\circ) \cos(28^\circ)$, using the SIN-COS program. Key the sequence $4 \ 2 \ P_0$. When $\sin(42^\circ)$ appears, $W \rightarrow S_1$ to store it. Then key $2 \ 8 \ P_1$. Now when $\cos(28^\circ)$ appears, press $\sqrt{ } \ S_1 \rightarrow W \ \sqrt{ } \ 2 \ \sqrt{ } \ \text{ and } \ \text{LN}^{-1}$. The answer is 1.0870 20942. This example illustrates how keyboard and program operations may be mixed. Note that only 12 keystrokes are required altogether.

Example.

To find a linear equation $y = bx + c$ that will fit with least error, a set of observed values. Let the table below be the observations:

x	1	10	5	-1	-4	-20
y	3.8	30.8	15.8	-2.2	-11.2	-59.2

To find the proper value for b, put the first card of program S106 in the reader. Press the following keys: $\text{PRM} \ P_1 \ W \rightarrow S_1 \ W \rightarrow S_2$ $W \rightarrow S_1 \ A \rightarrow S_1 \ 1 \ \text{RUN} \ 3 \ \cdot \ 8 \ \text{RUN} \ 1 \ 0 \ \text{RUN}$ $3 \ 0 \ \cdot \ 8 \ \text{RUN} \ 5 \ \text{RUN} \ 1 \ 5 \ \cdot \ 8 \ \text{RUN} \ 1 \ \pm$ $\text{RUN} \ 2 \ \cdot \ 2 \ \pm \ \text{RUN} \ 4 \ \pm \ 1 \ 1 \ \cdot \ 2 \ \pm \ \text{RUN}$ $2 \ 0 \ \pm \ 5 \ 9 \ \cdot \ 2 \ \pm \ \text{RUN}$. When the last set of points has been entered, push P_0 to get the result b which in this case is 3.0000 00015. To find c, simply put in the second card of program S106 and touch P_0 . The result is 0.8000 0024.

Note that we have in fact entered perfect data for the equation

$$y = 3x + .8.$$

This is an example of the labour saving achievable with the LOCI. It is only necessary to enter each variable and push the RUN key, repeating until all points have been entered. Many sources of error are eliminated.

KEYBOARD OPERATIONS

Operating the LOCI is simplicity itself. The ten-key digital input section is arranged in the standard pattern. A number being entered from the keyboard is held in the work, or W-register which is shown on the digital display. Addition and subtraction are performed as in any adding machine or calculator — the result of adding or subtracting is stored in the accumulator, or the A-register.

Example 1. Assume that the number 3.5 is in A. To subtract 3.14 from it, simply key the sequence $3 \ \cdot \ 1 \ 4 \ -$. The result, .36 will be found in the A-register. If the AUTO DISP switch is "on," the result will be automatically moved into W to be displayed. If the switch is off, 3.14 remains in W even after the operation. Then, to see the result, merely push the $A \rightarrow W$ key.

The novel features which give the LOCI its remarkable power are associated with the L-register. This register is used to accumulate products. More precisely, it stores the sum of logarithms. The following keys all involve the use of the L-register: $X \ + \ \sqrt{ } \ 1/\sqrt{ } \ \square \ 1/\square \ \text{LN}^{-1} \ W \rightarrow L \ L \rightarrow W$. Thus, pressing the X key causes the logarithm of the number in W (abbreviated as $\text{LN}(W)$) to be generated and added to the L-register. Likewise, pressing the $1/\sqrt{ }$ key causes $\frac{1}{2}\text{LN}(W)$ to be subtracted from the L-register. The anti-log, or LN^{-1} operation generates the anti-log of the number in L and stores the result in W to be displayed or to be used for an accumulator operation.

Example 2. To multiply the L-register contents by $(.5)^2$, simply press the following keys: $\cdot \ 5 \ \square$. This sequence adds $2\text{LN}(W)$ to L. Suppose L was zero, corresponding to $\text{LN}(1)$. Then pressing the LN^{-1} key after the above will display the number .25 in the W-register.

The $W \rightarrow L$ and $L \rightarrow W$ keys are for the purpose of transferring the contents of W into L, and vice versa. These keys may be used to generate $\text{EXP}(X)$ and $\text{LN}(X)$.

Example 3. The expression $e^{-2.1}$ may be found in only three steps:

- 1) $2 \ \cdot \ 1 \ \pm$ (This last key changes the sign of W)
- 2) $W \rightarrow L$
- 3) LN^{-1} (This displays the result, .12245 64285, in W).

Example 4. The value of $\text{LN}(3)$ can be similarly computed:

- 1) 3
- 2) X
- 3) $L \rightarrow W$ (The result, 01.098 61228 will appear in W).

EXAMPLES OF KEYBOARD OPERATIONS

Square Root

$$\sqrt{3} = 1.7320 \ 50806$$

$3 \ \sqrt{ } \ \text{LN}^{-1}$

Arithmetic Expression:

$$\frac{(4.5 / \sqrt{1.211} - 1.234 \sqrt{4.32})}{1.31 (2.68 - .245)} = .15895 \ 71547$$

$4 \ \cdot \ 5 \ X \ 1 \ \cdot \ 2 \ 1 \ 1 \ 1/\sqrt{ } \ \text{LN}^{-1} \ W \rightarrow A$
 $1 \ \cdot \ 2 \ 3 \ 4 \ X \ 4 \ \cdot \ 3 \ 2 \ \sqrt{ } \ \text{LN}^{-1} \ -$
 $A \rightarrow W \ \sqrt{ } \ 2 \ \cdot \ 6 \ 8 \ W \rightarrow A \ \cdot \ 2 \ 4 \ 5 \ -$
 $A \rightarrow W \ 1/\square \ 1 \ \cdot \ 3 \ 1 \ + \ \text{LN}^{-1}$

Root Mean Square:

$$\sqrt{\frac{1}{3} (1.1^2 + .81^2 + 1.015^2)} = .98256 \ 89119$$

$1 \ \cdot \ 1 \ \square \ \text{LN}^{-1} \ W \rightarrow A \ \cdot \ 8 \ 1 \ \square \ \text{LN}^{-1} \ +$
 $1 \ \cdot \ 0 \ 1 \ 5 \ \square \ \text{LN}^{-1} \ + \ A \rightarrow W \ \sqrt{ } \ 3 \ 1/\sqrt{ } \ \text{LN}^{-1}$

X^y:

$$2806 (1.004)^{1.1} = 3091.8 \ 39006$$

$1 \ \cdot \ 0 \ 0 \ 4 \ X \ L \rightarrow W \ X \ 2 \ 4 \ \cdot \ 3 \ X$
 $\text{LN}^{-1} \ W \rightarrow L \ 2 \ 8 \ 0 \ 6 \ X \ \text{LN}^{-1}$

PROGRAMMED OPERATION

The LOCI-2 can easily be programmed. A program consists of a sequence of coded operations stored on one or two tab cards. The codes may be recorded upon the card by pushing an unbent paper clip through the scored punch positions — no keypunch equipment is needed. A unique code is assigned to each key command. There are additional codes for commands not represented by keys. Some of these are described below.

STORAGE

The LOCI-2 may be equipped with two or four storage registers. The LOCI-2a has 16 storage registers. Storage registers S_0 , S_4 , S_8 , and S_{12} are associated with the A-register. Thus, pushing the $A \rightarrow S_0$ key puts the contents of A into S_0 . Conversely, the $S_0 \rightarrow A$ key transfers S_0 into A. The other registers $S_1 - S_2$, $S_6 - S_7$, $S_9 - S_{11}$, and $S_{13} - S_{15}$ are similarly associated with W.

CARD READER, PROGRAM COUNTER

The LOCI-2 card reader holds one program card. Up to two readers may be connected to the unit. Under control of the program counter, or PC, the coded operations or "keystrokes," are sequentially performed. The PC is a counter which selects the next operation to be performed. It is advanced by one each time an operation is selected. The consecutive sequence of the program may be altered by transferring two digits of the W-register into the PC. The simplest method for doing this is by the $W \rightarrow PC$ operation. Upon the selection of this command, the two highest digits of W and the sign are transferred into the PC. In the case where two readers are used, the sign is used to distinguish between the two readers.

DECREMENT COUNTER

The LOCI-2 is equipped with another two-digit counter called the decrement counter or DC. The DC is useful in constructing a program which runs through a particular sequence of operations for a pre-determined number of iterations, or to simply count the number of times a particular sequence is performed. The counter is loaded by a $W \rightarrow DC$ code, which shifts the high order two digits of W into DC. The converse operation is the $DC \rightarrow W$.

The value in DC is decreased by one when a decrement or DEC operation is selected. For example, assume that the DC contains the number 11. Then three repeated DEC commands will change the DC successively to 10, 09, and 08. Another code associated with the DC is the decrement counter test or DCT. Selection of this command advances the PC by three counts if the DC is zero. Note that exactly three operations are needed to put a two-digit number into W and then to transfer it into PC.

SPECIAL COMMANDS

Two extremely useful commands are the **STORE** and **RESTORE**. The **STORE** saves the PC and DC in a pair of special storage registers and also transfers two digits of W into PC. The **RESTORE** simply restores the last saved values of PC and DC. Finally the LOCI-2 has still other commands, for testing the conditions of the W, A, and L-registers.

INPUT/OUTPUT COMMANDS

The LOCI-2 can also be provided with a column printer or a page printer with paper tape reader and punch. For these options, a **WRITE** will print the W-register, while a **READ** will cause an operation code to be taken from the tape reader. These same codes can be used to address other on-line equipment.

DETAILED EXAMPLES OF PROGRAMS

1. The program below computes $(N!)$. To activate the program, first key N into the W-register. With the control switch in the AUTO position, touch the P_o key. This will start the PC to automatically sequence through the program, beginning at step 00. There is a loop between steps 01 and 07 to accumulate the product in L and to keep track of the number of iterations through the loop.

Step No.	Command	Code	Remarks
00	$W \rightarrow DC$	42	Load N into DC to set up loop
01	$DC \rightarrow W$	43 ←	Accumulate log of product
02	X	12	$N \times (N - 1) \times (N - 2) \dots 2 \times 1$
03	Decrement	66	$DC \neq 0$ Subtract 1 from DC
04	DC test	70	Test if DC = 0, if so, product is complete
05	0	20	$DC \neq 0$, therefore
06	1	21	reset PC
07	$W \rightarrow PC$	40	to step 01
08	LN^{-1}	14 ←	DC = 0, take anti-log for result
09	Stop	37	

2. This program computes $\text{SINH}(X)$ and $\text{COSH}(X)$. To use the program, key in the variable X. Then press P_o to obtain $\text{COSH}(X)$ or P_d to obtain $\text{SINH}(X)$.

Step No.	Command	Code	Remarks
00	$W \rightarrow L$	46	Compute e^x
01	LN^{-1}	14	
02	$W \rightarrow A$	44	
03	+	17	Compute e^{-x}
04	LN^{-1}	14	
05	+	13	$e^x + e^{-x}$
06	1	21	Skip to
07	5	25	Step 15
08	$W \rightarrow PC$	40	
09	$W \rightarrow L$	46	Compute e^x
10	LN^{-1}	14	
11	$W \rightarrow A$	44	
12	+	17	Compute e^{-x}
13	LN^{-1}	14	
14	-	15	$e^x - e^{-x}$
15	$A \rightarrow W$ ←	45	
16	X	12	
17	2	22	
18	÷	17	$(e^x \pm e^{-x})/2$
19	LN^{-1}	14	
20	Stop	37	

If you have an application in mind, do call us for additional information and for a demonstration.

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TYPICAL APPLICATIONS

Due to its unique features, the LOCI is the only desk-top computer capable of performing many types of complex computations. Consider some of the examples below.

Vehicle Performance

$$1) \quad W_a = \frac{.08487 (P_1 + 14.5)}{T^{\frac{1}{3}}}$$

$$h_f = \left[\frac{.1851 (P_0 + 14.5)}{W_a} \right]^{\frac{1.2519}{3}}$$

Quality Control (Failure rate coefficient)

$$2) \quad \beta = \frac{1 \ln \ln \left(\frac{1}{1 - P} \right) - 1 \ln \ln \left(\frac{1}{1 - P_1} \right)}{1 \ln T_2 - 1 \ln T_1}$$

Runway Visual Range

$$3) \quad U^2 - e^{KU} = 0, \text{ solve for } U. \left(\text{Reduced from } E = \frac{IT^{V/R}}{V^2}, \text{ solve for } V \right)$$

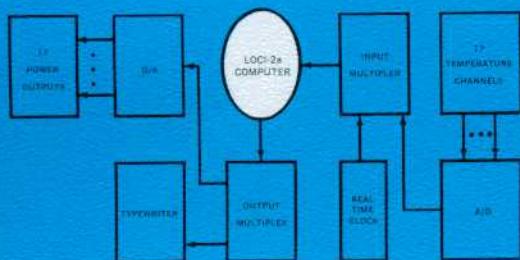
Gear Center Calculation

(Solve for X and Y, given A, B, G, H.)

$$4) \quad \begin{aligned} E &= \sqrt{A^2 + B^2} \\ P &= \frac{G^2 + E^2 - H^2}{2E} \\ Q &= \sqrt{G^2 - P^2} \\ X &= \frac{PA - QB}{E} \\ Y &= \frac{PB + QA}{E} \end{aligned}$$

Thermocouple Calibration

$$5) \quad R_t = \alpha R_0 \left[t \left(1 - \frac{\delta}{100} \right) \left(\frac{t}{100} - 1 \right) \right] + R_0$$



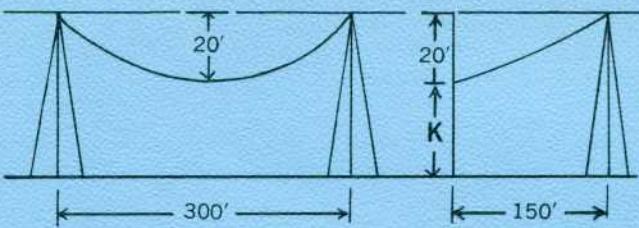
The LOCI is ideal for many types of on-line applications. Consider this temperature control system:

- 17 channels of temperature input (A/D), independently or sequentially addressable.
- 17 sets of reference temperatures and parameters.
- 1 LOCI-2a to compute the power required to stabilize temperatures about the references, as well as to accumulate statistics.
- 17 channels of output to variable power supplies (D/A).
- 1 data-logging typewriter.

PROGRAM LIBRARY

No.	Program
S100	SIN - COS
S101	ARCTAN
S102	$a^x, \sqrt[x]{a}, \log_a x$
S103	Bessel Functions
S104	SINH, COSH, SINH ⁻¹ , COSH ⁻¹
S105	Variance (σ^2)
S106	Linear least square fit $Y = bX + c$
S107	Exponential least square fit $Z = Ae^{at} + B$
S108	$N!, \ln, I(x+1)$ by Stirling's formula
S109	Erf (x)
S110	Resonant Frequency
S111	Triangulation
S112	Traverse
S113	$ax^2 + bx + c = 0$
S114	$x^3 + ax^2 + a_1x + a_0 = 0$
S115	$xe^x + k = 0$
S116	$U^2 - e^{KU} = 0$
S117	$x^4 + a_3x^3 + a_2x^2 + a_1x + a_0 = 0$
A102	Catenary Analysis
A103	Stress Analysis - Flat Circular Disk

CATENARY ANALYSIS



Use program A102, to solve

$$k \left(\cosh \frac{A}{k} - 1 \right) - B = 0,$$

for $A = 150\text{ft.}$, $B = 20\text{ft.}$

Enter 150,

Enter 20,

Enter first guess

for k ,

Answer: $k = 565.80\ 024\text{ ft.}$

$$\text{Cable length} = K \sinh \left(\frac{150}{565.8} \right)$$

$$= 151.76327\ \text{ft.}$$

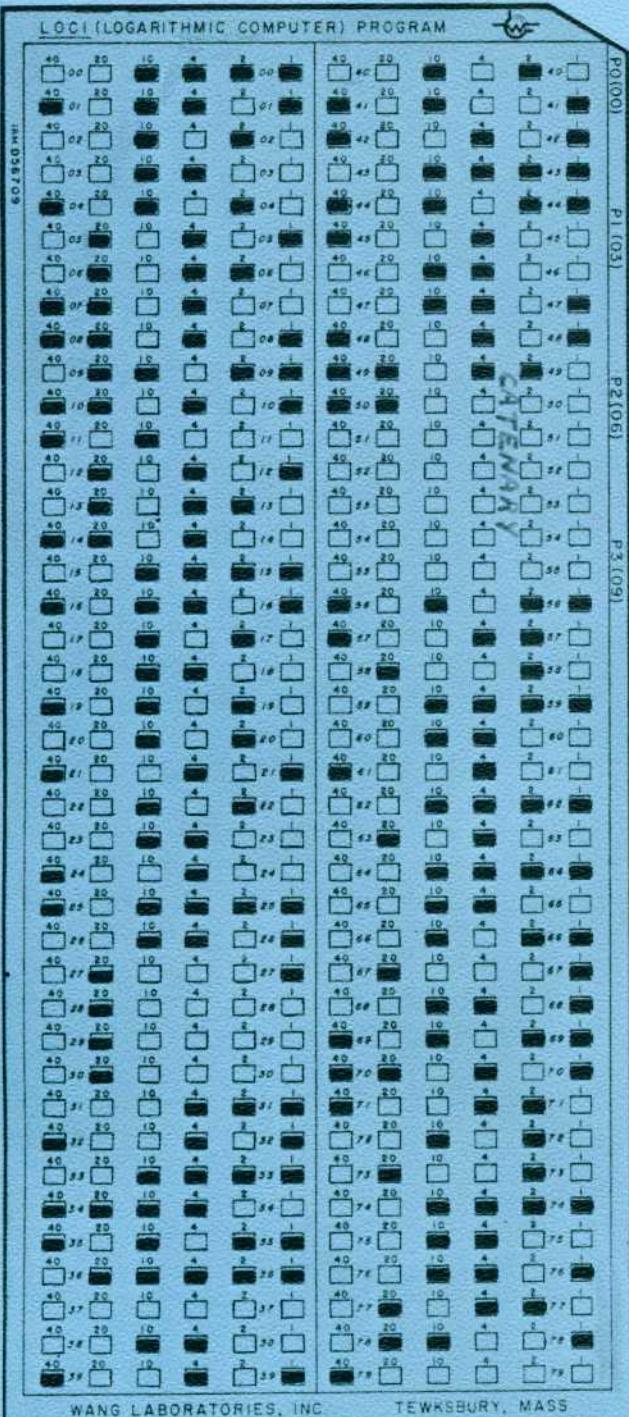
TYPICAL LOCI-2 MODELS

(L)Ogarithmic Computing Instrument)

- LOCI-2s (Keyboard, display, A-, W-, and L-registers)
- LOCI-2 (LOCI-2s, 2 storage registers, 1 card reader — 80 program steps)
- LOCI-2a (LOCI-2s, 16 storage registers, 1 card reader — 80 program steps)
- LOCI-2ab (LOCI-2s, 16 storage registers, 2 card readers — 160 program steps)
- LOCI-2abc (LOCI-2ab, a page printer with paper-tape input and output)
- LOCI-2ad (LOCI-2a, external input/output interface for on-line applications)

SPECIFICATIONS

LOCI-2 & LOCI-2s	Size: 17" w x 16" d x 11 1/4" h Weight: Approximately 45 lbs. Power: 60 watts, 110v., 60 cycle
Card Reader	Size: 8 1/2" w x 4" d x 4" h Weight: Approximately 5 lbs.



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