PERSONAL COMPUTER

FX-890P / Z-1 / Z-1GR OWNER'S MANUAL

This manual has been written by a non-Japanese speaking CASIO fan to help other non-Japanese speaking CASIO fans to make the best out of their FX-890P, Z-1GR, Z-1GRa or Z-1GR pocket computer. It is based on the Japanese Z-1 users' manual, the FX-880 & PB2000C English manuals, and all kind of other information gathered on the web. Even if most of the content is based on material with a CASIO copyright, the company CASIO cannot be held responsible for any inaccuracy within this document.
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Thanks to Ledudu.com, Daniel Pratlong, Marcus von Cube, and all the other guys whose information posted on the web helped me with this project.

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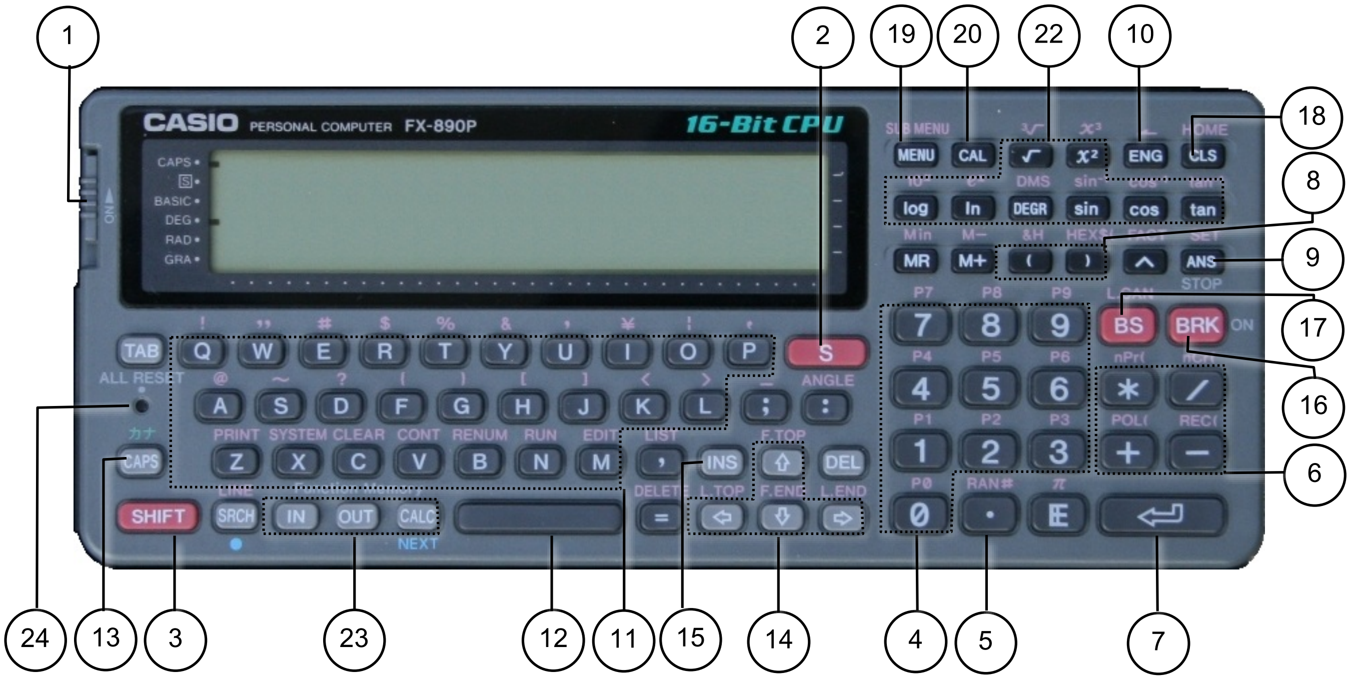

(1) **Power Switch**

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(24) **ALL RESET Button**

1.2 Operational Functions

① **Power Switch**
Slide up to switch power ON and down to switch power OFF.

② **Shift Key** (S)
Used to enter BASIC commands and symbols noted above the keys of the keyboard. Each press of this key causes the symbol “[S]” to switch on and off on the display. Throughout this manual, this key is represented by Shift in order to distinguish it from the alphabetic S key.

③ **Volatile Shift Key** (SHIFT)
Same function as the Shift key but needs to be held when pressing the various keys, like on table top computers.

④ **Numeric Keys** (0 - 9)
Enter the numeric values noted on each key.

⑤ **Decimal Key** (.)
Enters a decimal point.

⑥ **Arithmetic Operator Keys** (+ , - , * , /)
Enter the arithmetic operators noted on the keys.
+ : Addition
- : Substraction
* : Multiplication
/ : Division

⑦ **Execute Key** (↵)
Finalizes entry of a calculation and produces the result. The function of this key is equivalent to an “=” key on a standard calculator.
This key is also used to enter lines of a program and for actual execution of programs.

⑧ **Parentheses Keys** ((,))
Enter parentheses in such parenthetical calculations as: 5 x (10+20).

⑨ **Answer Key** (ANS)
Recalls the result of the most recently performed manual or program calculation. Pressing this key during program execution causes the execution to be suspended until the ↵ key is pressed (STOP displayed).

⑩ **Engineering Key** (ENG , ←)
Converts a calculation result to an exponential display.

⑪ **Alphabet Keys**
Enter the alphabetic characters noted on each key.

⑫ **Space Key** (SPC)
Enters a space

⑬ **CAPS Key** (CAPS)

Switches the alphabet keys between upper case and lower case characters. The upper case mode is indicated by the “CAPS” symbol on the display.

⑭ **Cursor Keys** (← , → , ↑ , ↓)

Move the cursor on the screen. Each press moves the cursor in the direction noted on the keys pressed, while holding down the keys causes continuous, high speed movement. Each cursor key also takes on a different function when pressed in combination with the [Shift] key.

KEY	FUNCTION	[Shift] +
←	Cursor left	Moves to beginning of logical line (L.TOP)
→	Cursor right	Moves to end of logical line (L.END)
↑	Cursor up	Moves to File top in editor mode (F.TOP)
↓	Cursor down	Moves to File end in editor mode (F.END)

⑮ **Insert / Delete Keys** (INS , DEL)

INS inserts a space at the current cursor position by shifting everything from the cursor position right one space to the right. Its function is different when editing C programs though.

DEL deletes the character at the current cursor position and automatically fills in the space by shifting everything to the right of the cursor one space to the left.

Holding down either of these keys causes continuous high-speed operation of the respective function.

⑯ **Break Key** (BRK)

Terminates manual operations, program execution, printer output, and LIST output. Also reactivates the power supply when it has been interrupted by the Auto Power OFF function.

⑰ **Backspace / Clear Line Key** (BS / L.CAN)

Deletes the character located immediately to the left of the cursor and automatically fills in the space created by shifting everything from the cursor position right one space to the left.

In combination with the Shift key, clears the content of the line where the cursor is located, and brings the cursor to the left of the screen.

⑱ **Clear Screen / Home Key** (CLS / HOME)

Clears the content of the screen and locates the cursor at the upper left corner of the screen.

In combination with the Shift key, locates the cursor at the upper left corner of the screen.

⑲ **Menu / Sub Menu Key** (MENU / SUB MENU)
Used in combination with numeric keys to specify operational modes.
MENU 1 …. Serial Port communication mode
MENU 2 …. BASIC mode (program writing/editing)
MENU 3 …. C mode (program writing/editing)
MENU 4 …. CASL mode (program writing/editing)
MENU 5 …. ASSEMBLER mode (program writing/editing)
MENU 6 …. FX Statistics mode
MENU 7 …. Default configuration selection menu allowing to chose the default configuration at switch ON (mode, default program file, display of the Carriage Return characters ↲) and the current angle unit and printer mode.

In combination with the Shift key, allows within a specific mode to show the Sub Menu of the mode.

⑳ **Calculator Key** (CAL)
Switch to the CAL calculator mode.

㉑ **Program Area Keys** (Shift P0 – P9)
Executes the BASIC program in the corresponding program area in the CAL mode. Specifies a program area for writing or editing in the BASIC mode.

㉒ **Function Keys** (log , ln , sin , etc.)
Allow one-touch entry of often-used functions.

- Direct input functions
  $^2\sqrt{}$, x^2 , log , ln , DEGR , sin , cos , tan , ^
- Shift functions
  $^3\sqrt{}$, x^3, 10^x, e^x, DMS , $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, &H, HEX$, FACT

㉓ **Formula Storage Keys** (IN , OUT , CALC)
Used when working with the formula storage fuction. See PART 4 FORMULA STORAGE FUNCTION for details.

㉔ **ALL RESET Button** (**O** ALL RESET)
Clears all memory contents end enters the CAL mode. All important data should be saved elsewhere before pressing this button. If pressing this button does not clear memory contents, first press the P button and then press ALL RESET button again.

㉕ **P Button** (**O** P) (rear panel)
Hardware reset button to halt misoperation caused by static electricity. Though execution is interrupted, memory contents are retained. The ALL RESET button should be used when the misoperation damages memory contents. Note that power switches OFF and then ON again when the P button is pressed.

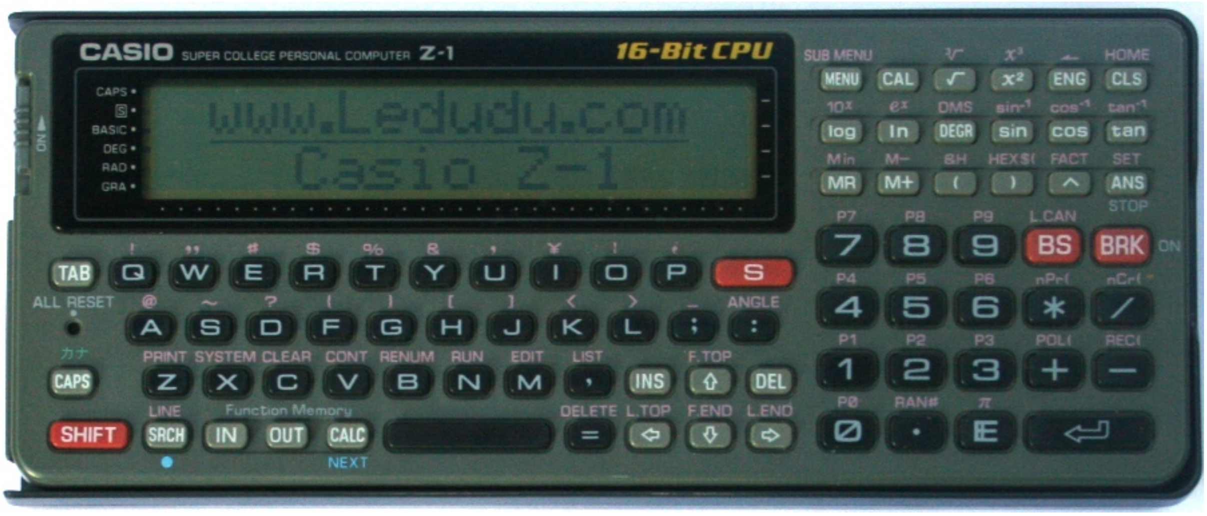
1.3 Symbol Display

The symbols noted on the display illustrated below appear to show the current status of a calculation

CAPS . $\boxed{\text{S}}$. BASIC . DEG . RAD . GRA .	

CAPS: Upper case alphabetic characters (lower cases when not displayed)
$\boxed{\text{S}}$: Shift mode (commands/functions marked above the keys can be input
BASIC: BASIC mode (BASIC program input, editing, execution)
DEG: Angle unit – degrees
RAD: Angle unit – radians
GRA: Angle unit – grads

1.4 Keyboard



A look at the keyboard of the unit reveals characters and symbols located above the keys. These are accessed using the CAPS and Shift keys.

1.4.1 Keytop Functions

Normal Mode

In this mode, each key inputs the characters, symbols, or commands noted on the keys themselves. (this status is automatically set when power is switched ON and immediately following a RESET procedure.)

EXAMPLE:

Operation		Display
A	→	A
E	→	E

Lower Case Mode

Pressing the CAPS key shifts the alphabetic keys (only) to lower case characters, indicated by the CAPS symbol disappearing from the display. Pressing the CAPS key once locks the keyboard into the lower case mode, while pressing again returns to upper case.

EXAMPLE:

Operation		Display
CAPS A	→	a
B	→	b
D	→	d

1.4.2 Functions Noted Above the Keys

The BASIC one-key commands, and the symbols and commands noted above the keys are entered when the corresponding keys are pressed following the Shift key. Note, however, that pressing the numeric keys (0 - 9) after Shift in the CAL mode executes the BASIC program in the corresponding program area.

EXAMPLE:

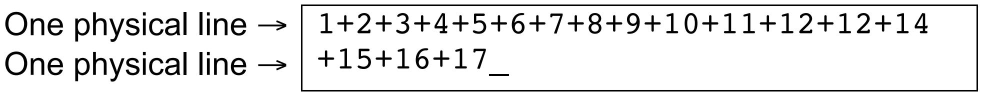
Operation		Display
Shift Z	→	PRINT
Shift *	→	NPR(

1.5 Screen

The screen is a 32-column x 2-line liquid crystal display. Characters are formed by a 5 x 7 dot matrix.

1.5.1 Physical Lines and Logical Lines

The maximum display capacity of one line is 32 columns, but internally the unit is capable of handling lines up to 255 characters long. The display capacity line (32 characters) is referred to as the physical line, while the internal capacity line is called a logical line. A logical line is a continuous line of characters in which any column on the extreme right of the screen is not a null.



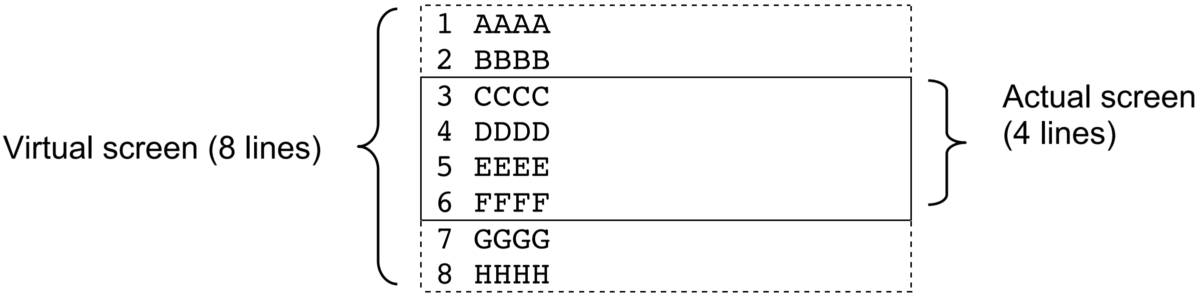
```
1+2+3+4+5+6+7+8+9+10+11+12+12+14
+15+16+17_
```

One logical line, from the first character to the last

Pressing Shift ← moves the cursor to the beginning of the logical line, while Shift → moves the cursor to the end of the logical line. These operations are useful in determining the extent of logical lines.

1.5.2 Virtual Screen

The screen can display four lines at one time, and as the 5th line is input, the first line scrolls off the top of the screen. Lines that scroll off of the screen can, however, be brought back into view using the cursor (↑ / ↓) keys, because the unit is able to store up to eight lines internally. These eight lines make up the virtual screen, while the four lines actually displayed are called the actual screen.

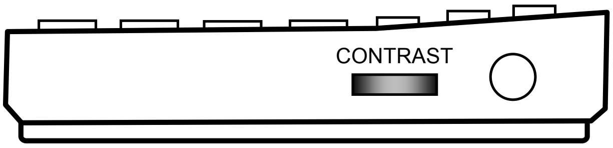


```
1 AAAA
2 BBBB
3 CCCC
4 DDDD
5 EEEE
6 FFFF
7 GGGG
8 HHHH
```

1.5.3 Screen Editor

Any program lines or data included on the virtual screen can be edited. First the portion of the program or data is brought onto the actual screen, and then the cursor is located at the position to be edited

1.5.4 Display Contrast



The display may appear dark or dim depending upon the strength of the batteries or the viewing angle. The contrast of the display can be adjusted to the desired level by rotating the control dial down darkens the display, while rotating it up lightens the display.
A weak display when contrast is set to high level indicates weakened batteries, and batteries should be replaced as soon as possible.

1.6 Display Characters

The relationship between characters and character codes is illustrated in the following table.

Character Code Table

High-order digit →

Low-order digit ↓

		0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
	HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	0			SPC	0	@	P	`	p	Ä	0	SPC	-	タ	ミ	≥	×
1	1		DEL		1	A	Q	a	q	∫	1	°	ア	チ	ム	≤	円
2	2	LINE TOP	INS	“	2	B	R	b	r	√	2	｢	イ	ツ	メ	±	年
3	3			#	3	C	S	c	s	´	3	｣	ウ	テ	モ	↑	月
4	4	SHIFT RELEASE			4	D	T	d	t	∑	4	`	エ	ト	ヤ	←	日
5	5	LINE CANCEL			5	E	U	e	u	Ω	5	.	オ	ナ	ユ	↓	千
6	6	LINE END		&	6	F	V	f	v	▨	6	ヲ	カ	ニ	ヨ	→	万
7	7	BEL		’	7	G	W	g	w	■	7	ァ	キ	ヌ	ラ	π	£
8	8	BS		(	8	H	X	h	x	α	8	ィ	ク	ネ	リ	♠	¢
9	9	CAPS L-U		)	9	I	Y	i	y	β	9	ゥ	ケ	ノ	ル	♥	±
10	A	LF		*	:	J	Z	j	z	γ	+	ェ	コ	ハ	レ	♦	〒
11	B	HOME		+	;	K	[	k	{	ε	-	ォ	サ	ヒ	ロ	♣	o
12	C	CLS	➡	,	<	L	¥	l	|	θ	n	ャ	シ	フ	ワ	□	
13	D	CR	⬅	-	=	M	]	m	}	μ	x	ュ	ス	ヘ	ン	○	
14	E	SHIFT SET	⬆	.	>		^	n	~	σ	-1	ョ	セ	ホ	¨	∆	
15	F	CAPS U-L	⬇	/	?		_	o		ϕ	÷	ッ	ソ	マ	。	\	

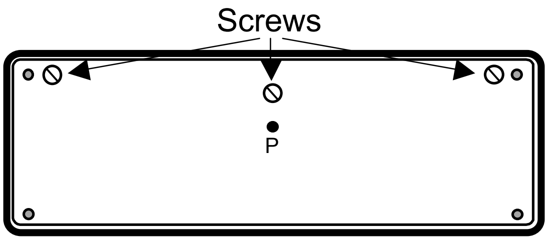
Characters which cannot be displayed using keyboard input can be displayed using the CHR$ function.

1.7 Power Supply

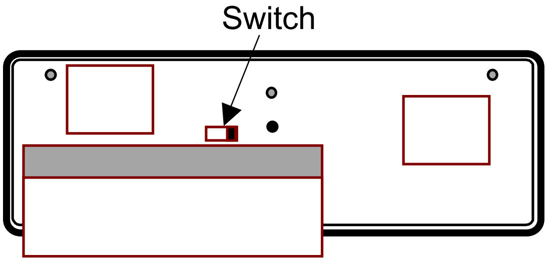
This unit is equipped with a main power supply (four AA Alkaline batteries) and a backup power supply (one CR2032 lithium battery). Batteries should be replaced whenever the display remains dim, even after contrast adjustment. Batteries should also be replaced once every two years regardless of how much the unit has been used.

Battery Replacement

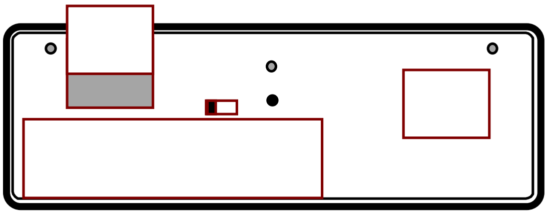
1) Switch the power of the unit OFF and remove the rear panel of the unit after removing the three screws holding it in place.



2) To replace the four batteries of the main power supply, position the internal switch to the right, slide the cover of the battery compartment and replace the four AA batteries.
Put back the internal switch in its central position



3) To replace the memory backup battery, position the internal switch to the left, slide the cover of the battery compartment and replace the CR2032 battery.
Put back the internal switch in its central position



4) Replace the rear panel on the unit and three screws to hold it in place.

1.8 Auto Power Off

The power of the unit is automatically switched OFF approximately 6 minutes after the last key operation (except during program execution), or the last input for an INPUT statement or PRINT statement. Power can be resumed by either switching the power switch OFF and then ON again, or by pressing the BRK key.
Program and data contents are retained even when power is switched OFF, but settings such as the number of digits or the mode (i.e. BASIC mode) are cancelled.

1.9 SYSTEM* Self Test Function

The unit has a powerful built-in self-test function you can address by entering the following command:

S Y S T E M * ↵

```
[0]ROM   [1]LCD    [2]KEY   [3]LB
[4]RAM   [5]RAMW   [6]RAMR [7]DISP
[8]3Pin Connector[9]DISPLOOP
[+]I/O
```

Note: This hardware test will **erase all programs and data** stored in the unit.

Selecting one of the options of the self-test menu will allow following tests

0. Test of the Read Only Memory, computing check sum and XOR check
1. Test of the symbol displays, outside pixels, uneven pixels, even pixels, all pixels together. Go from one test to another with the ↵ key.
2. Test of each key, starting with MENU and finishing with ➡ . The computer will ask to depress each key, notifying a successful result with the beeper.
3. Low Battery test. This allows testing the main battery and backup (SUB) battery status. Press BRK key to go back to the SYSTEM* menu.
4. Test of the Random Access Memory. This test will return the amount of RAM in the unit (main and optional extension pack) and test it by writing and reading it, returning “CHECK OK” when successful. Press any key to go back to SYSTEM* menu.
5. Writing test of the RAM. This is the first phase of the [4]RAM test.
6. Reading test of the RAM. This is the second phase of the [4]RAM test, and it will work properly only if executed just after the writing test. Use the BRK key to exit the test in case of an error.
7. Rest of the display and the beeper. Press the BRK key to go back to SYSTEM* menu.
8. Test of the 3-pin connector.
9. Test of the display using a loop printing the character set. Exit the loop with the BRK key.

+ Test of the Input / output port.

Exit the SYSTEM* menu by pressing the CAL key.

2 Fundamental Operation

This section covers the various modes available with the computer using a series of simple examples. These procedures should be mastered before attempting more complex operations.

2.1 CAL Mode

The CAL mode is in effect each time the power of the unit is switched ON. Arithmetic calculations, function calculations, formula storage calculations, program execution can be performed in this mode.

EXAMPLE:
2.5+3.5-2=

OPERATION:
2 . 5 + 3 . 5 - 2 ↵

```
3.5+3.5—2
 4
```

The touch ↵ is used instead of the = key, operation is identical to that used in a standard calculator.
The CAL mode can be entered from another mode by pressing the CAL key.

2.2 Formula Storage Function

The formula storage function makes it possible to store often-used formulas in memory for calculation when values are assigned to variables. This function is applied in the CAL mode using the IN , OUT , and CALC keys.

EXAMPLE:
Determining the selling price of a product by applying a profit rate based on the purchase price and selling price.

SELLING PRICE = PURCHASE PRICE / (1 – PROFIT%)

KEY INPUT
CAL
S E L L = P U R C H A S E / (1 - P R O F I T) IN

Ensure that input of the formula is correct by pressing the OUT key.

OPERATION:
OUT

```
SELL=PURCHASE/(1—PROFIT)
SELL=PURCHASE/(1—PROFIT)_
```

Now, calculate the selling prices of the following:

PURCHASE PRICE	PROFIT
$1000	30%
$960	25%

CALC

```
PURCHASE?_
```

1000 ↵

```
PURCHASE?1000
PROFIT?_
```

0 . 3 ↵

```
PURCHASE?1000
PROFIT?0.3
SELL= 1428.571429
```

CALC

```
PURCHASE?_
```

960 ↵

```
PURCHASE?960
PROFIT?_
```

. 25 ↵

```
PURCHASE?960
PROFIT?.25
SELL= 1280
```

As can be seen in this example, once a formula is input, it can be used repeatedly by simply assigning values for the variables. See PART 4 FORMULA STORAGE FUNCTION for details.

* The BRK key can be used to terminate this function.

2.3 BASIC Mode

The BASIC mode is used for the creation, execution and editing of BASIC programs. The BASIC mode can be entered from another mode by pressing MENU 2.

EXAMPLE:

Create and execute a program that calculates the sum of two values A and B.

PROGRAM INPUT

MENU 2

```
P 0 1 2 3 4 5 6 7 8 9    51146B
Ready P0
```

Shift P0

10 A = 5 ↵

20 B = 6 ↵

30 P R I N T A + B ↵

40 E N D ↵

PROGRAM EXECUTION

R U N ↵

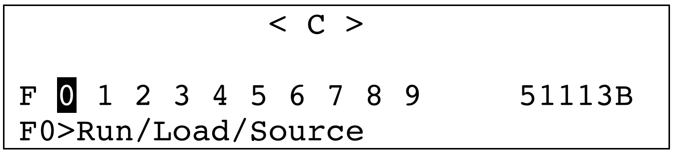
```
RUN
 11
Ready P0
```

2.4 C Mode

The C mode is used for the creation, execution and editing of C programs. The C mode can be entered from another mode by pressing MENU 3.

EXAMPLE:
Create and execute a program that prints HELLO.

PROGRAM INPUT
MENU 3

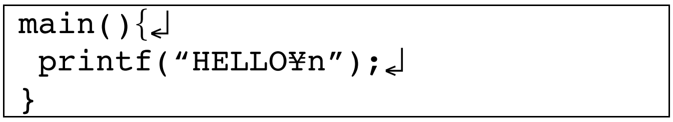


```
                 < C >

F 0 1 2 3 4 5 6 7 8 9      51113B
F0>Run/Load/Source
```

You can use the ⬅ ➡ cursor keys to select the program area 0 - 9
Press R (Run) to run the C program
Press L (Load) to load the C program for the interpreter
Press S (Source) to edit the C source code.

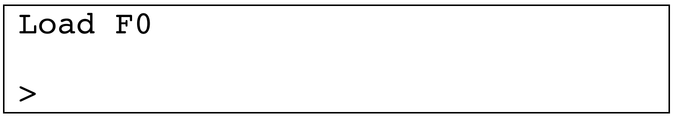
S

M A I N ( ) Shift { ↵
SPC P R I N T F (“ CAPS H E L L O Shift ¥ CAPS N ”)
; ↵
Shift } ↵



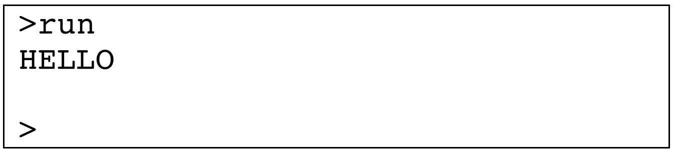
```
main(){↵
 printf(“HELLO¥n”);↵
}
```

Shift SUB MENU L



```
Load F0

>
```

R U N ↵



```
>run
HELLO

>
```

2.5 CASL Mode

The CASL mode is used for the creation, execution and editing of the assembler language dedicated to the virtual machine COMET widely used in Japan to teach computer science. The CASL mode can be entered from another mode by pressing MENU 4.

2.6 Assembler Mode

3 Calculation Function

This section covers fundamental arithmetic calculations and function calculations, which are performed manually.

3.1 Manual Calculation Preparations

Switch the power of the unit ON

```
  CAPS .■ | _
     S .  |
 BASIC .  |
   DEG .■ |
   RAD .  |
   GRA .  |
```

The display illustrated above appears whenever the power is switched ON. It indicates the CAL mode in which manual calculations can be performed. Currently specified angle units, however, is retained even when the power is switched OFF.

3.2 Manual Calculation Input and Correction

Perform the following fundamental calculations to become familiar with this mode.

EXAMPLE:

123 + 456 = 579

123 [+] 456 (Formula input)

```
123+456_
```

[↵] (Obtains result)

```
123+456
 579
```

As can be seen here, the [↵] key is pressed in place of [=] . The [*] key is used for multiplication and [/] is used for division.

The following procedure can be used to correct entered data.

EXAMPLE:

33 x 5 + 16 = 181

For the sake of example, the value 33 here will be mistakenly entered as 34.

34 [*] 5 [+] 16

```
34*5+16_
```

Press [⬅] six times to move cursor back to position of 4. This can also be accomplished by [Shift] L.TOP [➡]

[⬅] [⬅] [⬅] [⬅] [⬅] [⬅]

```
34*5+16
```

[3] (Replaces 4 with 3)

```
33*5+16
```

[↵]

```
33*5+16
 181
```

EXAMPLE:
33 x 5 + 16 = 181

For the sake of the example, the above calculation will be performed with the value 33 mistakenly entered as 34.

34 * 5 + 16 ↵

```
34*5+16
 186
```

↑ ← ← ← (Move cursor to position for correction.)

```
34*5+16
 186
```

3

```
33*5+16
 186
```

↵ (Re-execute calculation.)

```
33*5+16
 181
```

Correction of entries can use following keys:
The INS key is used to insert spaces at the current cursor location for input of characters or symbols.
The Shift DEL key is used to delete characters at the current cursor location.

```
ABCDEFGH
```

Shift DEL

```
ABCEFGH
```

The BS key can also be used to delete characters, but its operation is slightly different from the Shift DEL .

```
ABCDEFGH
```

BS

```
ABDEFGH
```

Practice the following examples to become familiar with the fundamental calculation procedure.

EXAMPLE 1:
9 + 7.8 ÷ 6 – 3.5 x 2 = 3.3

OPERATION:
9 + 7.8 / 6 - 3.5 * 2 ↵

```
9+7.8/6-3.5*2
 3.3
```

EXAMPLE 2:
56 x (-12) ÷ (-2.5) = 268.8

OPERATION
56 * - 12 / - 2.5 ↵

```
56*-12/-2.5
 268.8
```

Negative values are entered by pressing the - key before entering the value.

EXAMPLE 3:
$(4.5 \times 10^{75}) \times (-2.3 \times 10^{-78}) = -0.01035$

OPERATION:
4.5 $\boxed{\text{IE}}$ 75 $\boxed{*}$ $\boxed{-}$ 2.3 $\boxed{\text{IE}}$ $\boxed{-}$ 78 $\boxed{\hookleftarrow}$

```
4.5E75*-2.3E-78
-0.01035
```

Exponents are entered by pressing the $\boxed{\text{IE}}$ key (or the alphabetic $\boxed{\text{E}}$ key) before entering the value.

EXAMPLE 4:
(23 + 456) x 567 = 271593

OPERATION:
23 $\boxed{+}$ 456 $\boxed{\hookleftarrow}$
$\boxed{*}$ 567 $\boxed{\hookleftarrow}$

```
23+456
 479*567
 271593
```

The last result obtained can be entered at any point in a subsequent calculation by pressing the $\boxed{\text{ANS}}$ key.

EXAMPLE 5:
81.3 / (5.6 + 8.9) = 5.6
↑ This process performed first

OPERATION:
5.6 $\boxed{+}$ 8.9 $\boxed{\hookleftarrow}$
81.2 $\boxed{/}$ $\boxed{\text{ANS}}$ $\boxed{\hookleftarrow}$

```
5.6+8.9
 14.5
81.2/ 14.5
 5.6
```

3.3 Priority Sequence

Arithmetic, relational and logical operations are performed in the following priority sequence:

1. (,)
2. Functions
3. Power
4. Signs (+, -)
5. *, /, ¥, MOD
6. +, -
7. Relational operators
8. NOT
9. AND
10. OR, XOR

3.1 Scientific Calculations

The scientific functions can be used either with BASIC programs or for manual calculations. For the sake of the explanation, all the examples here will cover only manual calculations.

3.1.1 Trigonometric and Inverse Trigonometric Functions

SIN (Sine), COS (Cosine), TAN (Tangent),
ARCSIN (Arc Sine), ARCCOS (Arc Cosine), ARCTAN (Arc Tangent).

These functions return a trigonometric function value for a given angle, or an angle value of a given trigonometric function value. The ANGLE command should be used to specify the unit for the angle value when these functions are used. Angle unit specification is only required once for all subsequent trigonometric / inverse trigonometric functions. Angle units can be specified using either the MODE command or the ANGLE command.

• DEG (Degrees)	ANGLE0	MODE4
• RAD (Radians)	ANGLE1	MODE5
• GRAD (Grads)	ANGLE2	MODE6

It is as well possible to use the MENU 7.

The relationship among these three specifications is:
90 Degrees = π/2 Radians = 100 Grads

The current angle unit is retained when the power of the unit is switched OFF, and the angle unit becomes ANGLE0 (DEG) when ALL RESET button is pressed.

The value for π can be directly entered into a formula using “PI” (3.141592654).

EXAMPLE 1:
sin (30°) = 0.5

OPERATION:
Shift ANGLE 0 ↵
sin 30 ↵

```
ANGLE 0
SIN30
 0.5
```

EXAMPLE 2:
cos (π/3) = 0.5

OPERATION:
Shift ANGLE 1 ↵
cos (π / 3) ↵

```
ANGLE 1
COS(PI/3)
 0.5
```

4 Formula Storage Function

The formula Storage function is very useful when performing repeat calculations. Three different keys are used when working with the formula Storage function.

IN key……. Stores presently displayed formula.
OUT key…… Displays formula stored in memory.
CALC key…. Assigns values to variables in formula, and displays formula calculation result.

Sample Application

EXAMPLE:
Obtain the value for each of the value assigned to x when y = 3.43 cosx. (Calculate in three decimal places.)

x	8°	15°	22°	27°	31°
y					

OPERATION:
First, specify the angle unit and number of decimal places
MENU 7 ➡ , select the DEG unit using the (⬆ / ⬇) cursor keys. Exit the angle units selection menu pressing the CAL key.
Shift SET F 3 ↵ (Obtain in 3 decimal places by rounding off the 4th decimal place.)

Next, input a formula and press IN key to store it.
Y = 3 . 43 * COS X IN

Press the OUT key to confirm that the formula has been stored.
CLS OUT

```
Y=3.43*COSX_
```

Then, start calculating by pressing the CALC key.
CALC

```
X?_
```

8 ↵

```
X?8
Y= 3.397
```

↵

```
X?8
Y= 3.397
X?_
```

15 ↵

```
X?8
Y= 3.397
X?15
Y=3.313
```

↵

```
Y= 3.397
X?15
Y=3.313
X?_
```

22 ↵

```
X?15
Y=3.313
X?22
Y= 3.180
```

↵

```
Y=3.313
X?22
Y= 3.180
X?_
```

27 ↵

```
X?22
Y= 3.180
X?27
Y= 3.056
```

↵

```
Y= 3.180
X?27
Y= 3.056
X?_
```

31 ↵

```
X?27
Y= 3.056
X?31
Y= 2.940
```

BRK

```
Y= 3.056
X?31
Y= 2.940
_
```

The CALC key can be used in place of the ↵ key to perform repeat calculations. The BRK key can be used to terminate this function to automatically return to the CAL mode.

4.1 Utilization for Preparing Tables

Multiple formulas can be written by separating with colons (:). Tables such as that shown below can be easily prepared by using this method.

EXAMPLE:
Complete the following table. (Calculate in 3 decimal places by rounding off.)

X	Y	P=X*Y	Q=X/Y
4.27	1.17		
8.17	6.48		
6.07	9.47		
2.71	4.36		

OPERATION:

SHIFT SET F 3 ↵ Specification of number of decimal places

P = X * Y : Q = X / Y IN Storing the formula

CALC

```
X?_
```

4 . 27 ↵

```
X?4.27
Y?_
```

1 . 17 ↵

```
X?4.27
Y?1.17
P= 4.996
```

↵

```
X?4.27
Y?1.17
P= 4.996
Q= 3.650
```

Continue to input the values of X and Y in this manner, and the values of P and Q will be calculated in successive order and the table will be completed as shown below.

X	Y	P=X*Y	Q=X/Y
4.27	1.17	4.996	3.650
8.17	6.48	52.942	1.261
6.07	9.47	57.483	0,641
2.71	4.36	11.816	0.622

Variable names consist of up to 15 upper case or lower case alphabetic characters. This means that variable names can be created which actually describe their contents. Remarks can also be affixed following variable names by enclosing the remarks within square brackets [ ]. Any character except for commas can be used within the remarks brackets.

EXAMPLE:

Complete the following table. (Calculate in two decimal places by rounding off.)

Radius r (m)	Height h (m)	Volume of a cylinder ($V_0=\pi r^2 h$) (m^3)	Volume of a cone ($V_1={}^1/_3\ V_0$) (m^3)
1.205 2.174 3.357	2.227 3.451 7.463		

OPEARTION:

Shift SET F 2 ↵

C Y L I N D E R Shift [M 3 Shift] = Shift π * R A D I U S Shift [M Shift] ^ 2 * H E I G H T Shift [M Shift] : C O N E Shift [M 3 Shift] = C Y L I N D E R / 3 IN

CALC

```
RADIUS[M]?_
```

1 . 205 ↵

```
RADIUS[M]?1.205
HEIGHT[M]?_
```

2 . 227 ↵

```
RADIUS[M]?1.205
HEIGHT[M]?2.227
CYLINDER[M3]= 10.16
```

↵

```
RADIUS[M]?1.205
HEIGHT[M]?2.227
CYLINDER[M3]= 10.16
CONE[M3]= 3.39
```

↵

```
HEIGHT[M]?2.227
CYLINDER[M3]= 10.16
CONE[M3]= 3.39
RADIUS[M]?_
```

2 . 174 ↵

```
CYLINDER[M3]= 10.16
CONE[M3]= 3.39
RADIUS[M]?2.174
HEIGHT[M]?_
```

And so on…

If the radius (r) and height (h) are input in this manner, volume (V_0) of the cylinder and volume (V_1) of the cone will be calculated successively and the table will be completed as shown below.

Radius r (m)	Height h (m)	Volume of a cylinder ($V_0=\pi r^2h$) (m^3)	Volume of a cone ($V_1={}^1/_3 V_0$) (m^3)
1.205	2.227	10.16	3.39
2.174	3.451	51.24	17.08
3.357	7.463	262.22	88.07

IMPORTANT

1. Up to 255 characters can be stored using the IN key. Storing new formula clears the currently stored formula.
2. Memory contents are retained even when power is switched OFF, either manually or by the auto power OFF function.
3. The CALC key can only be used to execute numeric expressions stored using the IN key.
4. An error is generated when an entry stored by the IN key is not a numeric expression.
5. The same limitations that apply to BASIC variables apply to formula storage function variables (see page 38).
6. Calculations are terminated under the following conditions:
   - Pressing the BRK key.
   - When an error is generated.

5 BASIC Programming

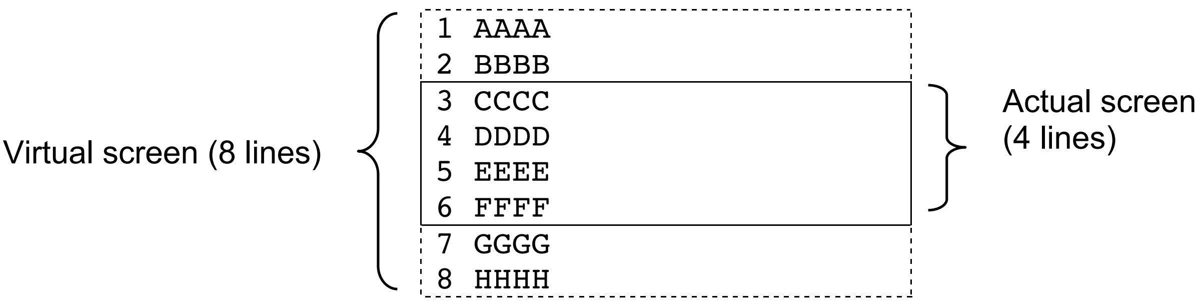
Standard BASIC is employed as the programming language for this unit, and this section covers application of the BASIC language.

5.1 Features of BASIC

1. BASIC is much easier to use than other programming languages such as FORTRAN, making it suitable even for novices.
2. Writing programs is also easier because program creation, editing and execution are all performed by interacting with the computer itself.

The following functions are also available:

1. High-precision calculations are made possible by display of numeric values with 10-digit mantissas and 2-digit exponents (13-digit mantissa and 2-digit exponents for internal operations)
2. A wide selection of built-in functions makes operation easier.
   Standard mathematical functions
   SIN COS TAN ASN ACS ATN LOG LN EXP SQR ABS SGN INT FIX FRAC PI ROUND RAN# DEG
   Powerful string handling functions
   CHR$ STR$ MID$ LEFT$ RIGHT$ HEX$ DMS$ ASC VAL LEN
   High-level mathematical functions
   POL REC NCR NPR HYPSIN HYPCOS HYPTAN HYPASN HYPACS HYPATN CUR
3. 10 independent program areas
   up to ten programs can be stored independently in memory at the same time (P0 – 9).
4. Extended variable names
   Variable names up to 15 characters long can be used, making it possible to use names that make contents easy to understand.
5. Powerful debugging function
   A TRON command displays the number of the program line currently being executed, making it possible to easily trace execution and locate mistakes in programming.
6. Powerful screen editor
   Programs can be easily modified and corrected on the screen.
7. Virtual screen function
   Thought the actual physical display of the unit has a 32-column x 4-line capacity, the virtual screen is 32 columns x 8 lines. The virtual screen can be easily scrolled using the cursor keys.



5.2 BASIC Program Configuration

5.2.1 BASIC Program Format

The following is a typical BASIC program, which calculates the volume of a cylinder.

EXAMPLE:

```
10 REM CYLINDER
20 R=15
30 INPUT “H=”;H
40 V=PI*R^2*H
50 PRINT “V=”;V
60 END
```

As can be seen, the BASIC program is actually a collection of lines (six lines in the above program). A line can be broken down into a line number and a statement.

```
20   R=15
Line Statement
number
```

Computers execute programs in the order of their line numbers. In the sample program listed above, the execution sequence is 10, 20, 30, 40, 50, 60. Program lines can be input into the computer in any sequence, and the computer automatically arranges the program within its memory in order from the smallest line number to the highest. Lines can be numbered using any value from 1 to 65535.

```
20 R=15                          10 REM CYLINDER
40 V=PI*R^2*H                    20 R=15
60 END                           30 INPUT “H=”;H
10 REM CYLINDER        ➡         40 V=PI*R^2*H
30 INPUT “H=”;H                  50 PRINT “V=”;V
50 PRINT “V=”;V                  60 END
   Input sequence                   Memory contents
```

Following the line number is a statement or statements which actually tell the computer which operation to perform. The following returns to the sample program to explain each statement in detail

`10 REM CYLINDER`	REM stands for “remark”. Nothing in this line is executed.
`20 R=15`	Assigns the constant 15 (radius) to variable R.
`30 INPUT “H=”;H`	Displays H= to prompt a value input for height.
`40 V=PI*R^2*H`	Calculates volume (V) of cylinder.
`50 PRINT “V=”;V`	Prints result of line 40
`60 END`	Ends program.

As can be seen, a mere six lines of programming handles quite a bit of data. Multiple BASIC program lines can also be linked into a single line using colons.

EXAMPLE:

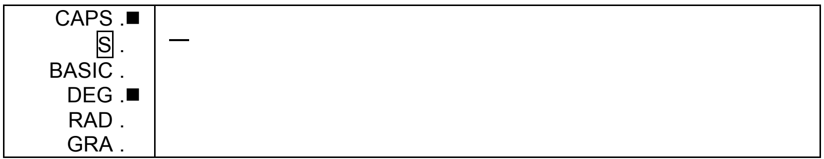
```
100 R==15:A=7:B=8
```

Such a program line is known as “multi-statement”.

5.3 BASIC Program Input

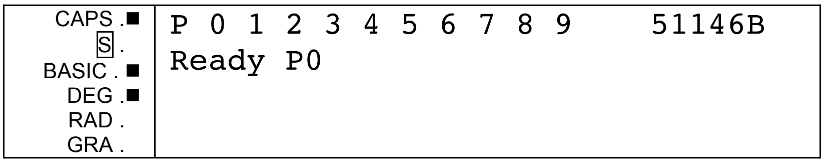
5.3.1 Preparation

First, switch the power of the computer ON. At this time, the display should appear as illustrated below.



```
CAPS .■  _
   S .
BASIC .
  DEG .■
  RAD .
  GRA .
```

This is the CAL mode, so the operation MENU 2 should first be performed to allow input of BASIC programs. The display should now appear as illustrated below.



```
  CAPS .■  P 0 1 2 3 4 5 6 7 8 9    51146B
     S .   Ready P0
BASIC . ■
   DEG .■
   RAD .
   GRA .
```

Note the BASIC indicator on the left of the screen indicates the BASIC mode. This is the mode used for BASIC program input. The other indicators on tne display in the BASIC mode have the following meanings.

P : Program area
0 – 9 : Program area numbers. The numbers of program areas which alreasy contain programs are replaces by asteriks.
51146B : Capacity (number of bytes) remaining in area for writing programs and data (free area). This number depends on the type of unit (FX-890P, Z1), the presence of the optional RP-33 memory module, and will decrease as storage space is used.
Ready P0 : Current program area = area 0. The current program area can be switched by pressing Shift followed by the desired program area.

Previously stored programs can be deleted using one of two different procedures.
NEW : Deletes program stored in the current program area only.
NEW ALL : Clears all BASIC programs stored in memory.

5.3.2 Program input

The following input procedure inputs the sample program for calculation of the volume of a cylinder.

```
10 R E M SPC C Y L I N D E R ↵
20 R = 15 ↵
30 I N P U T Shift “ H = Shift “ ; H ↵
40 V = P I * R ^ 2 * H ↵
50 P R I N T Shift “ V = Shift “ ; V ↵
60 E N D ↵
```

Note that the ↵ key is pressed at the end of each line. A program line is not entered into memory unless the ↵ key is pressed.

ONE KEY INPUT

The one-key BASIC commands help to make program input even easier.

EXAMPLE:
Line 50 input
50 Shift PRINT Shift “ V = Shift “ ; V ↵

5.3.3 Program Editing

The procedure used for making corrections or changes to a program depends upon what step of program input the changes are to be made.

1. Changes in a line before ↵ key is pressed
2. Changes in a line after ↵ key is pressed
3. Changes within a program already input
4. Changes within a program following the EDIT command

Changes in a line before ↵ key is pressed

EXAMPLE:
`20 E=15` mistakenly input for `20 R=15`

```
10 REM CYLINDER
20 E=15_
```

⇦ ⇦ ⇦ ⇦ (Move cursor to E)

```
10 REM CYLINDER
20 E=15
```

R (Input correct character)

```
10 REM CYLINDER
20 R=15
```

↵ (Editing complete)

```
10 REM CYLINDER
20 R=15
_
```

Note that once the desired changes are made, the ↵ key must be pressed to store the entered line into memory.

Changes in a line after ↵ key is pressed

EXAMPLE:
`40 V=P1*R^2*H` mistakenly input for `40 V=PI*R^2*H`

```
40 V=P1*R^2*H
_
```

⇧ ⇨ ⇨ ⇨ ⇨ ⇨ ⇨ (Move cursor to 1)

```
40 V=P1*R^2*H
```

I (Input correct character)

```
40 V=PI*R^2*H
```

↵ (Editing complete)

```
40 V=PI*R^2*H
_
```

Again, the ↵ key must be pressed to store the corrected line into memory after changes are made.

Changes within a program already input

The LIST command displays the program stored in the current program area form beginning to end.
Shift LIST ↵

```
10 REM CYLINDER
20 R=15
30 INPUT "H=";H
40 V=PI*R^2*H
```

...

```
40 V=PI*R^2*H
50 PRINT "V=";V
60 END
Ready P0_
```

The last line of the program is displayed when the LIST operation is complete.
⬆ ⬆ ⬆ ⬆ ⬆ ⬆

```
10 REM CYLINDER
20 R=15
30 INPUT "H=";H
40 V=PI*R^2*H
```

The 8-line virtual screen of the computer now makes it possible to use the cursor keys to scroll to preceding lines not shown on the display.
When a program greater than eight lines is stored in memory, the LIST operation should be performed by specifying the line numbers to be displayed.

EXAMPLE:
Displaying from line 110 to line 160 on the virtual screen.
Shift LIST 110 - 160 ↵

Note: The BRK key can be used to terminate the LIST operation. The Shift STOP key suspends the operation, and listing can be resumed by pressing ↵ .

Changes within a program following the EDIT command

The EDIT command makes it easier to edit or review programs already stored in memory.
Shift EDIT ↵

```
 CAPS .■ | 10 REM CYLINDER
     S . | 20 R=15
BASIC . ■| 30 INPUT "H=";H
  DEG .■ | 40 V=PI+R^2*H
  RAD .  |
  GRA .  |
```

From the display, ⬇ (or ↵) advances to the following line, while ⬆ (or Shift ↵) returns to the previous line.

⬇ ⬇ (displays line 30 to 60)

```
30 INPUT “H=”;H
40 V=PI+R^2*H
50 PRINT “V=”;V
60 END
```

Here, a correction will be made in line 40.

⬇ (Displays line 40 to 60, line 40 at the upper line of the display)

➡ (Enables program editing)

```
40 V=PI+R^2*H
```

➡ ➡ ➡ ➡ ➡ ➡ ➡ * ↵ (Moves cursor and makes correction)

```
40 V=PI*R^2*H
50 PRINT “V=”;V
60 END
```

BRK (BRK key exits EDIT mode)

```
Ready P0
```

5.4 BASIC Program Execution

5.4.1 Program Execution

Once a BASIC program is stored in memory, it can be executed using one of the two following procedures.

Using Shift (program area) in CAL mode

EXAMPLE: Shift P9
Executes the program in program area 9.

Entering RUN command in BASIC mode

EXAMPLE: Shift RUN ↵
Executes the program in the current program area.

Execute the program input in the previous section to determine the volume of a cylinder with a height ao 10 (radius is fixed at 15).

Shift RUN ↵

```
RUN
H=?_
```

10 ↵

```
H=?10
V= 7068.583471
Ready P0

_
```

5.4.2 Errors

At times, the results produced by a program are not what is expected. Such irregular executions can be broadly divided under two major classifications.

1. Executions that produce errors
2. Irregular execution that do not produce errors (mostly logic errors)

Execution that produce errors

Simple programming errors. This is the most common type of program error and is generally caused by mistakes in program syntax. Such errors result in the following message being displayed:

```
SN error P0-10
```

This message indicates that a syntax error has been detected in line 10 of the program stored in program area 0. The indicated program line should be chacked and corrected to allow proper execution.

Program logic errors. This type of error is generally caused by such illegal operations as division by zero or LOG(0). Such errors result in the following message being displayed:

```
MA error P0-10
```

As before, this message indicates that a mathematical error has been detected in line 10 of the program stored in program area 0. In this case, however, program lines related to the indicated program line as well as indicated program line itself should be examined and corrected. When an error message is displayed, the following operations can be used in BASIC mode to display the line in which the error was detected.

Shift LIST 10 ↵
Shift EDIT 10 ↵
Shift LIST . ↵
Shift EDIT . ↵

The periods contained in **LIST .** and **EDIT .** instruct the computer to automatically display the last program line executed

Irregular execution that do not produce errors

Such errors are also caused by a flaw in the program, and must be corrected by executing the LIST or EDIT command to examine the program to detect the problem. The TRON command can also be used to help trace the execution of the program. Entering T R O N ↵ puts trace mode ON. Now executing a BASIC program displays the program area and line number as execution is performed, and halts execution until ↵ is pressed. This allows confirmation of each program line, making it possible to quickly identify problem lines. Executing T R O F F ↵ cancels the trace mode.

5.5 Commands

Though there are a variety of commands available in BASIC for use in programs, the nine fundamental commands listed below are the most widely used.

The following program reads data items located within the program itself, with a number of data items being read being determined by input from an operator. The operator may input any value, but note that values greater than 5 are handled as 5 (because there are only 5 data items in line 180). The program then displays the sum of the data read from line 180, followed by the square root and cube root of the sum. Program execution is terminated when the operator enters a zero.

`10 S=0`	Clear current total assigned to S
`20 RESTORE`	Specifies read operation should begin with 1st data item
`30 INPUT N`	Input the number of data items to be read
`40 IF N>5 THEN N=5`	Input of values greater than 5 should be treated as 5
`50 IF N=0 THEN GOTO 130`	Jump to line 130 when input is zero
`60 FOR I=1 TO N`	This section is repeated the number of times specified by operator input in line 30
`70 READ X`	
`80 S=S+X`	
`90 NEXT I`	
`100 GOSUB 140`	Branch to subroutine starting from line 140
`110 PRINT S;Y;Z`	Displays contents of variables S,Y,Z
`120 GOTO 10`	Jump to line 10
`130 END`	Program end
`140 REM SQUARE/CUBE ROOT`	Remarks
`150 Y=SQR S`	Square root calculation
`160 Z=CUR S`	Cube root calculation
`170 RETURN`	Return to statement following the GOSUB
`180 DATA 9,7,20,28,36`	Data read by READ statement in line 70

5.5.1 REM

The REM command (line 140) is actually short for the word “remarks”. The computer disregards anything following a REM command, and so it is used for such purposes as labels in order to make the program list itself easier to follow. Note that a single quotation mark (Shift ‘) can be used in place of the letters “REM”.

5.5.2 INPUT

The INPUT command (line 30) is used to allow input from the computer’s keyboard during program execution. The data input are assigned to a variable immediately following the INPUT command. In the above example, input numeric data are assigned to the variable N. Note that a string variable must be used foe a string input.

EXAMPLE:

`10 INPUT A$` (string input)

5.5.3 PRINT

The PRINT command (line 110) is used to display data on the computer’s display. In this example, this command is used to display the results of the sum, square root and cube root calculations.

5.5.4 END

The END command (line 130) brings execution of the program to an end, and can be included anywhere within the program.

5.5.5 IF – THEN

The IF/THEN command (lines 40 and 50) is used for comparisons of certain conditions, basing the next operation upon whether the comparison turns out to be true of false. Line 40 checks whether or not value assigned to N is greater than 5,

and assigns a value of 5 to N when the original value is greater. When a value of 5 or less is originally assigned to N, execution proceeds to the next line, with N retaining its original value.
Line 50 checks whether or not value assigned to N is zero. In the case of zero, program execution jumps to nine 130, while execution proceeds to next line (line 60) when N is any other value besides zero.

Note: Line 50 can also be abbreviated as follows:

```
50 IF N=0 THEN 130
```

5.5.6 GOTO

The GOTO command (lines 50 and 120) performs a jump to a specified line number or program area. The GOTO statement in line 120 is an unconditional jump, in that execution always returns to line 10 of the program whenever line 120 is executed. The GOTO statement in line 50, on the other hand, is a conditional jump, because the condition of the IF-THEN statement must be met before the jump to line 130 is made.

Note: Program area jumps are specified as GOTO #2 (to jump to program area 2).

5.5.7 FOR/NEXT

The FOR/NEXT combination (line 60 and 90) forms a loop. All of the statements within the loop are repeated the number of times specified by a value following the word “TO” in the FOR statement.
In the example being discussed here, the loop is repeated N number of times, with the value N being entered by the operator in line 30.

5.5.8 READ/DATA/RESTORE

These statements (lines 50, 180, 20) are used when the amount of data to be handled is too large to require keyboard input with every execution. In this case, data are included within the program itself. The READ command assigns data to variables, the DATA statement holds the data to be read, and the RESTORE command is used to specify from which point the read operation is to be performed.
In the program example here, the READ command reads the number of data items specified by the input variable N. Though the DATA statement holds only five data items, the RESTORE command in line 20 always returns the next read position to the first data item, the READ statement never runs out of data to read.

5.5.9 GOSUB/RETURN

The GOSUB/RETURN commands (line 100 and 170) are used for branching to and from subroutines. Subroutines (lines 140 to 170) are actually mini programs within the main program, and usually represent routines that are performed repeatedly at different locations within a program. This means that GOSUB/RETURN makes it possible to write the repeated operation once, as a subroutine, instead of writing each time it is needed within the main program.

Execution of the RETURN statement at the end of a subroutine returns execution of the program back to the statement following the GOSUB command. In this sample program, execution returns to line 110 after the RETURN command in line 170 is executed.

Note: GOSUB routines can also be used to branch to other program areas, as in GOSUB #3 (branches to program area 3). Note, however, that a return must be made back to original program area using the RETURN command before an END command is executed.

5.5.10 Labels

You have the possibility to assign label names to program lines. This feature allows an easier understanding of the program structure, especially GOTO and GOSUB statements.

We will modify the program of chapter 5.5 using labels:

```
10 *Start:S=0                Clear current total assigned to S
20 RESTORE                   Specifies read op. should begin with 1st data item
30 INPUT N                   Input the number of data items to be read
40 IF N>5 THEN N=5           Input of values greater than 5 is treated as 5
50 IF N=0 THEN GOTO *Finish  Jump to program end when input is zero
60 FOR I=1 TO N              This section is repeated the number of times
70 READ X                    specified by operator input in line 30
80 S=S+X
90 NEXT I
100 GOSUB *Root              Branch to subroutine labeled Root
110 PRINT S;Y;Z              Displays contents of variables S,Y,Z
120 GOTO *Start              Jump to program begin
130 *Finish:END              Program end
140 *Root:REM SQR/CUBE ROOT  Remarks
150 Y=SQR S                  Square root calculation
160 Z=CUR S                  Cube root calculation
170 RETURN                   Return to statement following the GOSUB
180 DATA 9,7,20,28,36        Data read by READ statement in line 70
```

Label names follow the same rules as variable names, except that they are not limited to 15 characters.

5.6 Operators

The following are the operators used for calculations, which involves variables.

Operators	Arithmetic operators	Signs Addition Subtraction Multiplication Division Power Integer division Integer remainder of integer division	+,- + - * / ^ ¥ MOD
	Relational operators	Equal to Does not equal Less than Grater than Less than or equal to Grater than or equal to	= <>, >< < > =>, <= =>, >=
	Logical operators	Negation Logical product Logical sum Exclusive OR	NOT AND OR XOR
	String operator	Concatenation	+

Relational operators

Relational operations can be performed only when the operators are both strings or both numeric values.

With strings, character codes are compared one-by-one from the beginning of the strings. This is to say that the first position of string A is compared to the first position of string B, the second position of string A with the second position of string B, etc. The result of the comparison is based upon the character codes of the first difference between the strings detected, regardless of the length of the strings being compared.

EXAMPLES:

STRING A	STRING B	RESULT
ABC	ABC	A=B
ABC	ABCDE	A<B
ABC	XYZ	A<B (character code for A less than that for X)
XYZ	ABCDE	A>B (character code for X greater than that for A)

A result of -1 is returned when the result of a relational operation is true (condition met), while 0 is returned when the return is false (conditions not met)

EXAMPLE:

```
10 PRINT 10>3              -1 returned because 10>3 is true
20 PRINT 7>1               0 returned because 7<1 is false
30 PRINT “ABC”=3XYZ”       0 returned because ABC=XYZ is false
40 END
```

Logical Operators

The operands of logical operations are truncated to integers and the operation is performed bit-by-bit to obtain the result.

X	Y	X AND Y	X OR Y	X XOR Y	NOT X	NOT Y
0	0	0	0	0	1	1
0	1	0	1	1	1	0
1	0	0	1	1	0	1
1	1	1	1	0	0	0

String Operators

Strings may be concatenated using a + sign. The result of the operation (including intermediate results) may not exceed 255 characters.

EXAMPLE:

```
A$=”AD”+”1990”
```

The above example results in the string “AD1990” being assigned to variable A$.

Order of Operations

Arithmetic, relational and logical operations are performed in the following order of precedence:

1. (,)
2. Scientific function
3. Power
4. Sign (+, -)
5. *, /, ¥, MOD
6. Addition and subtraction
7. Relational operators
8. NOT
9. AND
10. OR, XOR

Operations are performed from left to right when the order of precedence is identical.

5.7 Constants and Variables

5.7.1 Constants

The following shows the constants included in the sample program of page 33:

PROGRAM	CONSTANTS
`20 R=15`	15
`30 INPUT “H=”;H`	“H=”
`40 V=PI*R^2*H`	2
`50 PRINT “V=”;V`	“V=”

Of these, 15 and 2 are numeric constants, while “H=” and “V=” are string constants.

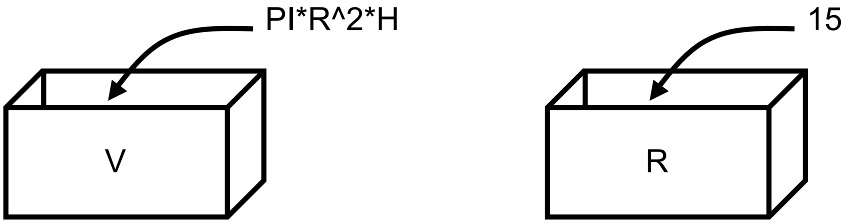
5.7.2 Variables

Numeric Variables

The following shows the numeric variables included in the sample program on page 33:

PROGRAM	NUMERIC VARIABLES
`20 R=15`	R
`30 INPUT “H=”;H`	H
`40 V=PI*R^2*H`	V

Numeric variables are so named because their contents are handled as numbers. Numeric variable names can be up to 15 characters long, and are used within programs to store calculation results or constants in memory. In the sample program, the value 15 is stored in H, while V, which is the result of the calculation, holds the value that represents the volume of the cylinder. As can be seen, assignment to a variable is performed using the “=” symbol. This differs from an equal sign in that it declares that what is to the right should be assigned to what is to the left. Actually, a variable can be thought as a kind of box as illustrated below.



String Variables

Another type of variable is known as a string variable, which is used to store character string data. String variable names are indicated by “$” following the name.

EXAMPLE:

`10 A$=”AD”`	Assigns “AD” to string variable A$
`20 INPUT “YEAR=”;B$`	Assigns keyboard input to variable B$
`30 C$=A$+B$`	Assigns combination of A$ and B$ to C$
`40 PRINT C$`	Displays contents of C$
`50 END`	

In the above program example, entering a year such as 1990 in line 20 results in a display of AD1990 in line 40.

Note: Strings cannot be assigned to numeric variables such as A, and numeric values cannot be assigned to string variables such as A$.

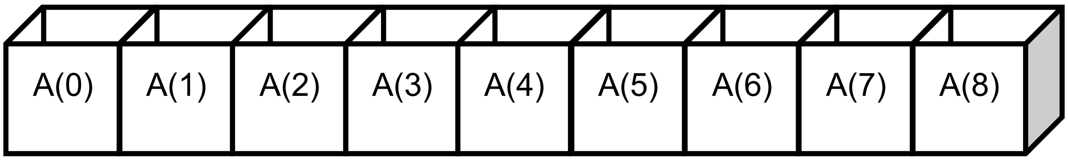
Array Variables

Both numeric variables and string variables can store only one data item per variable. Because of this, large amounts of data are better-handled using array variables (usually referred to as simply “arrays”). Before an array variable can be used within a program, a DIM statement must appear at the beginning of the program to “declare” to the computer that an array variable is to be employed.

EXAMPLE:
Declare array variable A for storage of 9 numeric data items.

```
10 DIM A (8)
```

Note: a declared value of 8 makes possible to store 9 data items.



EXAMPLE:
Recall value stored in element 4 of array A

```
Y=A(4)
```

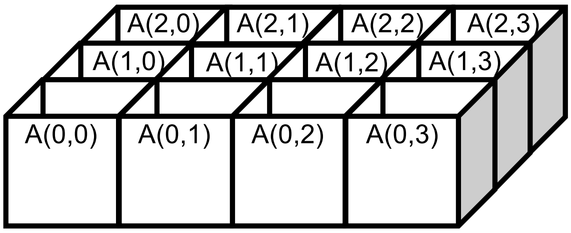
Or

```
X=4:Y=A(X)
```

The value that specifies an element in an array (4 above) is called a subscript.

Until now, the only arrays covered have been those formed by a single line of elements or “boxes”. These are known as “one-dimensional” arrays. Arrays may also contain more than one dimension with elements connected vertically and horizontally into two-dimensional and three-dimensional arrays.

EXAMPLE:
DIM A (2,3)



The declaration in this example sets up an array of three lines and four columns, making it capable of storing 12 different values.

As with simple variables, arrays can also be declared to hold strings by using the “$” symbol following the array variable name.

5.7.3 Summary

Variable types

The three following types of variable are available for use with this unit.

1. Numeric variables (up to 12-digit mantissa)		A, a, NUMBER, POINTS
2. String variables (up to 255 characters)		A$, STRING$
3. Array variables	Numeric array	A(10), XX(3,3,3)
	String array	A$(10), ARRAY$(2,2)

Variable names

Variable names can consist of upper, lower case or numeric characters, but a numeric character cannot be used in the first position of the variable name (i.e. 1AE, 3BC$ are illegal).
Reserved words (see page 75) cannot be used as the leading characters of a variable name (i.e. RUNON, LIST1$ are illegal).
The maximum length of a variable name is 15-character.

Arrays

1. Arrays are declared by DIM statements.
2. Elements described by subscripts, which are integer greater than 0. Fractions are disregarded.
3. The number of dimensions is limited by stack capacity.
4. The maximum value of subscripts is limited by memory capacity.

5.8 BASIC Command Reference

5.8.1 Format elements

The method for entering statements is explained below.

- Words in bold type are command or functions, and they must be entered as shown.
- Braces indicate that one of the parameters enclosed must be specified.
- Commas contained in braces must be written in the position shown.
- Brackets indicate that the parameters enclosed may be omitted. Brackets themselves are not entered.
- An asterisk indicates that the term preceding it may appear more than once.
- Numeric expressions – Constants, expressions and numeric variables (e.g. 10, 10+25, A, unit cost*quantity).
- String expressions – String constants, string variables and string expressions (e.g. “ABC”, A$, A$+B$).
- Expressions – General term for numeric and string expressions
- Arguments – Elements used by commands and functions
- Ⓟ Can only be executed in a program.
- Ⓜ Can only be executed manually.
- Ⓐ Can be executed both manually and in a program.
- Ⓕ Function instruction that can be executed both manually and in a program.

EXAMPLE: MID$ function

MID$	(string array	,	position	[,	number of characters	])
	String expression		Numeric expression		Numeric expression	

The term “string expression” under “string array” describes that array. Likewise, “numeric expression” under “position” and “number of characters are descriptors. Also, since the comma and number of characters are enclosed in brackets, they may be omitted.

5.8.2 Manual Commands

PASS Ⓐ

PURPOSE: Specifies or cancels a password
FORMAT:
PASS $\underbrace{\text{“password”}}_{\text{String expression}}$
EXAMPLE: PASS”TEXT”
PARAMETERS:

1. Registering a single password makes it the password for all BASIC program areas (P0-P9) and for C language and Assembler program areas (F0-F9).
2. The password must be a string of 1-8 characters.
3. All characters after the first 8 are ignored when 9 or more characters are entered.

EXPLANATION:

1. The password is used to protect programs.
2. The password can be registered in the CAL mode, BASIC mode, C mode.
3. Executing this command registers a password when no password previously exists.
4. Executing PASS statement using a previously registered password cancels the password. Specifying a password that is different from that registered results in a “PR error”.
5. The following operations and commands cannot be executed when a password is registered:
   - Program write
   - LIST, LIST ALL, LIST#, NEW, NEW ALL, NEW#, EDIT

NEW [ALL] Ⓜ

PURPOSE: Deletes a program.
FORMAT:
NEW [ALL]
EXAMPLE: NEW
EXPLANATION:

1. Deletes the program in the currently specified program area when ALL is omitted. Variables are not cleared.
2. “Ready Pn” is displayed on the screen after the program is deleted, and the computer stands for command input.
3. This command cannot be executed for program files that are password protected.
4. Attempting to use this command in the CAL mode results in a “FC error”.
5. Specifying NEW ALL clears the programs in all program areas and all variables.
6. This command cannot be included within a program.

CLEAR Ⓐ

PURPOSE: Clears all variables and determines the memory mapping in accordance with the parameters entered.

FORMAT:

CLEAR [[strings area size] [, assembler area size , variables area size]]

CLEAR	[[strings area size] [,	assembler area size ,	variables area size]]
	Numeric expression	Numeric expression	Numeric expression

EXAMPLE: CLEAR
CLEAR 400
CLEAR 4096,512,6144

PARAMETERS:

1. Strings area size: Determines the area used for strings. The initial setting when ALL RESET is executed is 4096. The current value can be obtained through FRE 3.
2. Assembler area size: Determines the area used for assembler programs. The initial setting when ALL RESET is executed is 0. The current value can be obtained through FRE 6.
3. Variables area size: It has to be bigger than the sum of strings and assembler area sizes to avoid a “BS Error”. The current value can be obtained through FRE 2.

EXPLANATION:

1. Clear all variables
2. Strings, assembler or variables areas cannot be set during program execution.
3. If assembler area size and variable area size are omitted, these values will remain unchanged.
4. If strings area size is omitted, the CLEAR statement will clear all variables without changing memory mapping.

SEE: FRE, SYSTEM

FRE Ⓕ

PURPOSE: Returns memory area size in accordance with argument.

FORMAT:

FRE	argument
	Numeric expression

EXAMPLE: PRINT FRE 1

PARAMETERS: the argument can have the value 1-6:

1. Overall free memory (in Bytes)
2. Overall variables area size (in Bytes). FRE 2 = FRE 3 + FRE 4
3. String variables area size (in Bytes)
4. Numeric variables + assembler area size (in Bytes). FRE 4 > FRE 6
5. Free memory for string variables (in Bytes). FRE 5 <= FRE 3
6. Assembler area size (in Bytes)

SYSTEM Ⓜ

PURPOSE: Shows main system status.
FORMAT: SYSTEM
EXAMPLE: SYSTEM

```
PRINT OFF   TRACE OFF
CLEAR  4096,512,6144
FREE 83703 V:4096
_
```

EXPLANATION: Data returned by the SYSTEM statement are:

1. PRINT mode (ON/OFF)
2. TRACE mode (ON/OFF)
3. CLEAR followed by 3 numbers. These are the parameters of the last CLEAR statement entered.
   - First number is the memory area size in Bytes. This is what returns FRE 3.
   - Second number is the assembler area size in Bytes. This is what returns FRE 6
   - Third is overall variables area size. This is what returns FRE 2
4. FREE followed by two numbers
   - Total free area in Bytes. This is what returns FRE 1
   - Variables free area in Bytes. This value is inferior or equal to memory area size. This is what returns FRE 5.

SEE: FRE, CLEAR

SYSTEMP Ⓜ

PURPOSE: Shows memory status of BASIC program areas P0-P9.
FORMAT: SYSTEMP
EXAMPLE: SYSTEMP

```
P0[     0] P1[     0] P2[     0]
P3[     0] P4[     0] P5[     0]
P6[     0] P7[     0] P8[     0]
P9[     0]
```

EXPLANATION: The number following each Pn is the amount of Bytes the program area is using. Value 0 shows that program area is empty.

SYSTEMF Ⓜ

PURPOSE: Shows memory status of file areas F0-F9.
FORMAT: SYSTEMF
EXAMPLE: SYSTEMF

```
F0[     0] F1[     0] F2[     0]
F3[     0] F4[     0] F5[     0]
F6[     0] F7[     0] F8[     0]
F9[     0]
```

EXPLANATION: The number following each Fn is the amount of Bytes the file area is using (BASIC file, C or assembler program). Value 0 shows that file area is empty.

LIST [ALL] Ⓜ

PURPOSE: Displays all or part of the currently specified program.

FORMAT:

```
        ⎧   [start line number]   [ -  [end line number] ]   ⎫
        ⎪      Line number                Line number         ⎪
LIST   ⎨            [.]                                       ⎬
        ⎪          [ALL]                                       ⎪
        ⎩          *Label                                      ⎭
                Label name
```

EXAMPLE: LIST
LIST 100
LIST 100-300
LIST -400
LIST*Root

PARAMETERS:

1. Start line number: integer in the range of 1≤ line number ≤ 65535 (first line number when omitted)
2. End line number: integer in the range of 1≤ line number ≤ 65535 (end line number when omitted)
3. Label: Name of a label in the program.

EXPLANATION:

1. Displays the currently specified program in the range specified by the line numbers.
2. A minus sign must be used as a delimiter between line numbers.
3. The following five examples illustrate specification of the display range.
   a) LIST ↵ (All lines from beginning of program)
   b) LIST 30 ↵ (Line 30)
   c) LIST 50-100 ↵ (Lines 50 through 100)
   d) LIST 200- ↵ (From line 200 through end of program)
   e) LIST -80 ↵ (From beginning of program through line 80)
4. Using a period in place of the line number displays the most recently handled (i.e. written, edited, executed). If a program is halted during execution by an error, executing "LIST ."displays the line in which the error was generated.
5. When the specified start line number does not exist, the first line number above that specified is taken as the start line number
6. When the specified end line number does not exist, the greatest line number not exceeding that specified is taken as the end line number
7. The start line number must be smaller than the end line number.
8. Pressing the BRK key can halt LIST command execution.
9. Press the Shift STOP key to momentarily halt LIST command execution. To restart execution, press the ↵ key or one of the alphanumeric keys
10. Specifying ALL displays all programs in sequence from area P0 to P9.
11. Specifying a label name after an asterisk will list

SEE: EDIT

EDIT Ⓜ

PURPOSE: Enters the BASIC edit mode.
FORMAT:

$$\text{EDIT}\ \left\{\begin{array}{c}\underline{\text{[start line number]}}\\ \text{Line number or period}\\ \text{[.]}\\ \underline{\text{*Label}}\\ \text{Label name}\end{array}\right\}$$

EXAMPLE: EDIT 100
PARAMETERS:

1. Start line number: integer in the range of 1 ≤ line number ≤ 65535 (first line number when omitted)
2. Label: Name of a label in the program.

EXPLANATION:

1. Enters the BASIC edit mode and displays the program at the specified line number, or at the specified label. The cursor is displayed and editing becomes possible with either the ⬅ or ➡ key is pressed.
2. Using a period in place of the line number displays the most recently handled (i.e. written, edited, executed). If a program is halted during execution by an error, executing “EDIT .”displays the line in which the error was generated
3. When the specified start line does not exist, the first line number above that specified is taken as the start line number.
4. It is possible to change the line number in EDIT mode by using either ⬇ or ⬆ key.
5. This mode is cancelled by pressing the BRK key.

SEE: LIST

VARLIST Ⓐ

PURPOSE: Displays variable names and array names.
EXAMPLE: VARLIST
EXPLANATION:

1. Displays all currently existing variable names and array names
2. Press the Shift STOP key to momentarily halt VARLIST command execution. To restart execution, press the ↵ key or one of the alphanumeric keys

RUN Ⓜ

PURPOSE: Executes a program.

FORMAT:

```
        ⎧  [start line number]   ⎫
        ⎪ Line number or period  ⎪
RUN    ⎨                        ⎬
        ⎪        *Label          ⎪
        ⎩      Label name        ⎭
```

EXAMPLE: RUN
RUN 100
RUN*Root

PARAMETERS:

1. Start line number: Interger in the rage of 1 ≤ line number ≤ 65535
2. Label: Name of a label in the program.. Entering an unknown label will generate an “UL error”.

EXPLANATION:

1. Execution starts from the beginning of the program when the line number or label name is omitted.
2. When the specified start line does not exist, the first line number above that specified is taken as the start line number.
3. Variable and array values are not cleared.
4. This command cannot be used within a program.
5. This command cannot be used in the CAL mode.

TRON Ⓐ

PURPOSE: Specifies the trace mode.

EXAMPLE: TRON

EXPLANATION:

1. Switches the trace mode ON.
2. All subsequent program execution is accompanied by a display of the area name and line number. The first two lines are displayed, and execution is suspended.
3. The program stays in the TRON mode until TROFF statement is executed or the power is switched OFF

SEE: TROFF

TROFF Ⓐ

PURPOSE: Cancels the trace mode.

EXAMPLE: TROFF

EXPLANATION: Cancels the trace mode (entered using the TRON statement).

SEE: TRON

5.8.3 Fundamental Commands

END Ⓟ

PURPOSE: Terminates program execution.
EXPLANATION:

1. Terminates program execution, and the computer stands for command input
2. Closes all files that are open
3. Variables and arrays are not cleared.
4. Any number of END statements can be used in a single program. Program execution is terminated and open files are closed automatically at the end of a program even if an END statement is not included.

STOP Ⓟ

PURPOSE: Temporarily halts program execution.
EXAMPLE: STOP
EXPLANATION:

1. Temporarily halts program execution. Program area and line number of the STOP statement are displayed. Execution can be resumed by entering the CONT command or pressing Shift CONT ↵.
2. Open files, variable values and array values are retained as they are at the point when execution is halted.

WAIT Ⓟ

PURPOSE: Pauses program execution for a certain time.
FORMAT:
WAIT $\underbrace{\text{argument}}_{\text{Numeric expression}}$
EXAMPLE: WAIT 100
EXPLANATION: The argument is the number of 10th of a second the program will pause before resuming its execution. This instruction is useful to slow down screen outputs that would be too fast to read.

GOTO Ⓟ

PURPOSE: Branches unconditionally to a specified branch destination.

FORMAT:

$$\textbf{GOTO} \left\{ \begin{array}{c} \underline{\text{branch destination line number}} \\ \scriptstyle\text{Line number} \\ \underline{\text{\# program area number}} \\ \scriptstyle\text{Single character; 0-9} \\ \underline{\text{*Label}} \\ \scriptstyle\text{Label name} \end{array} \right\}$$

EXAMPLE:

```
GOTO 1000
GOTO #7
GOTO *Finish
```

PARAMETERS:

1. Branch destination line number: integer in the range of 1≤ line number ≤65535
2. Program area number: single character, 0-9
3. Label: Name of a label in the program.

EXPLANATION:

1. Specifying a line number causes program execution to jump to that line number in the current program area.
2. Specifying a program area number causes program execution to jump to the first line number of the specified program area.
3. Specifying a label name causes program execution to jump to that label in the current program area.
4. An “UL error” is generated when the specified line number or label name does not exist.

GOSUB Ⓟ

PURPOSE: Jumps to a specified subroutine.

FORMAT:

```
        ⎧  branch destination line number  ⎫
        ⎪             Line number          ⎪
GOSUB  ⎨      # program area number       ⎬
        ⎪     Single character; 0-9        ⎪
        ⎩              *Label              ⎭
                     Label name
```

EXAMPLE: GOSUB 100
GOSUB #6
GOSUB *Root

PARAMETERS:

1. Branch destination line number: integer in the range of 1≤ line number ≤65535
2. Program area number: single character, 0-9
3. Label: Name of a label in the program.

EXPLANATION:

1. Program execution branches to the subroutine that starts at the specified line number or label. Execution is returned from the subroutine by the RETURN statement.
2. Subroutines can be nested up to 96 levels. Exceeding this value results in an “OM error”
3. An “UL error” is generated when the specified line number or label name does not exist.
4. CLEAR command cannot be used within a subroutine.

SEE: RETURN

RETURN Ⓟ

PURPOSE: Returns execution from a subroutine to the main program.

FORMAT: RETURN

EXAMPLE: RETURN

EXPLANATION:

1. Returns program execution to the statement immediately following the statement that originally called a subroutine.
2. A “GS error” is generated when the RETURN statement is executed without first executing a GOSUB statement.

SEE: GOSUB, ON GOSUB

ON GOTO Ⓟ

PURPOSE: Jumps to a specified branch destination in accordance with a specified branching condition.

FORMAT:

$$\textbf{ON}\ \underset{\text{Numeric expression}}{\underline{\text{Condition}}}\ \textbf{GOTO}\ [\left\{\begin{array}{c}\underset{\text{Line number}}{\underline{\text{branch destination line number}}}\\ \underset{\text{Single character; 0-9}}{\underline{\text{\# program area number}}}\\ \underset{\text{Label name}}{\underline{\text{*Label}}}\end{array}\right\}]$$

$$[\ ,\ [\left\{\begin{array}{c}\underset{\text{Line number}}{\underline{\text{branch destination line number}}}\\ \underset{\text{Single character; 0-9}}{\underline{\text{\# program area number}}}\\ \underset{\text{Label name}}{\underline{\text{*Label}}}\end{array}\right\}]\ ]^{*}$$

EXAMPLE: ON A GOTO 100, 200, 300

PARAMETERS:

1. Branch condition: Numeric expression truncated to an integer
2. Branch destination line number: integer in the range of 1≤ line number ≤65535
3. Program area number: single character, 0-9
4. Label: Name of a label in the program.

EXPLANATION:

1. The GOTO statement is executed in accordance with the value of the expression used for the branch condition. For example, execution jumps to the first branch destination when the value is 1, to the second destination when the value is 2 etc.
2. Program execution does not branch and execution proceeds to the next statement when the value of the condition is less than 1, or if a branch destination corresponding to the value does not exist.
3. Up to 99 branch destinations may be specified.

SAMPLE PROGRAM:

```
10 INPUT “1 OR 23;A
20 ON A GOTO 40,50
30 END
40 PRINT ”ONE”:END
50 PRINT “TWO”
```

Execution jumps to line 40 if 1 ↵ is entered or to line 50 if 2 ↵ is entered.

SEE: ON GOSUB

ON GOSUB Ⓟ

PURPOSE: Jumps to a specified subroutine in accordance with a specified branching condition.

FORMAT:

$$\textbf{ON}\ \underset{\text{Numeric expression}}{\underline{\text{Condition}}}\ \textbf{GOSUB}\ [\left\{\begin{array}{c}\underset{\text{Line number}}{\underline{\text{branch destination line number}}}\\ \underset{\text{Single character; 0-9}}{\underline{\text{\# program area number}}}\\ \underset{\text{Label name}}{\underline{\text{*Label}}}\end{array}\right\}]$$

$$[\ ,\ [\left\{\begin{array}{c}\underset{\text{Line number}}{\underline{\text{branch destination line number}}}\\ \underset{\text{Single character; 0-9}}{\underline{\text{\# program area number}}}\\ \underset{\text{Label name}}{\underline{\text{*Label}}}\end{array}\right\}]\ ]^{*}$$

EXAMPLE: ON A GOSUB 1000, 1100, 1200

PARAMETERS:

1. Branch condition: Numeric expression truncated to an integer
2. Branch destination line number: integer in the range of 1≤ line number ≤65535
3. Program area number: single character, 0-9
4. Label: Name of a label in the program.

EXPLANATION:

1. The GOSUB statement is executed in accordance with the value of the expression used for the branch condition. For example, execution jumps to the first branch destination when the value is 1, to the second destination when the value is 2 etc.
2. Program execution does not branch and execution proceeds to the next statement when the value of the condition is less than 1, or if a branch destination corresponding to the value does not exist.
3. Up to 99 branch destinations may be specified.

SEE: RETURN

IF-THEN-ELSE / IF-GOTO-ELSE Ⓟ

PURPOSE: Executes the THEN statement or GOTO statement when the specified condition is met. The ELSE statement is executed when the specified condition is not met.

FORMAT:

$$\textbf{IF}\ \underset{\text{Numeric expression}}{\underline{\text{condition}}}\ \left\{\begin{array}{ll}\textbf{THEN} & \text{statement} \\ & [\ :\ \text{statement} \\ \textbf{GOTO} & \text{branch destination}\end{array}\right\} \left[\ \textbf{ELSE}\ \left\{\begin{array}{c}\text{statement} \\ [\ :\ \text{statement} \\ \text{branch destination}\end{array}\right\}\right]$$

$$\text{With branch destination:} \left\{\begin{array}{c}\underset{\text{Line number}}{\underline{\text{branch destination line number}}} \\ \underset{\text{Single character; 0-9}}{\underline{\text{\# program area number}}} \\ \underset{\text{Label name}}{\underline{\text{*Label}}}\end{array}\right\}\ ]\ ]^{*}$$

EXAMPLE: IF A=0 THEN 300 ELSE 400
IF K$="Y" THEN PRINT X ELSE PRINT Y

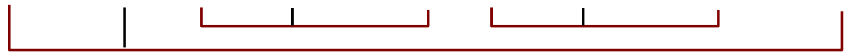
PARAMETERS:

1. Branch condition: Numeric expression truncated to an integer
2. Branch destination line number: integer in the range of 1≤ line number ≤65535
3. Program area number: single character, 0-9
4. Label: Name of a label in the program.

EXPLANATION:

1. The statement following the THEN clause is executed, or execution jumps to the destination specified by the GOTO statement when the branch condition is met.
2. If the branch condition is not met, the statement following the ELSE statement is executed, or the program jumps to the specified branch destination. Execution proceeds to the next program line when the ELSE statement is omitted.
3. The format "IF A THEN –" results in the condition being met when value of the expression (A) is not 0 (absolute value of A > 10^{-99}). The condition is not met when the value of the expression is 0.
4. IF statements can be nested (an IF statement may contain other IF statements). In this case, the THEN – ELSE statements are related by their proximity. The GOTO – ELSE combinations have the same relationships.

```
IF – THEN IF THEN – ELSE IF – THEN ELSE – ELSE –
```



SAMPLE PROGRAM:

```
10 INPUT "1 TO 9";A
20 IF (0<A)AND(A<10) THEN PRINT "GOOD!" ELSE 10
```

"GOOD!" is displayed for input values from 1 to 9. Re-input is requested for other values.

FOR-NEXT Ⓟ

PURPOSE: Executes the program lines between the FOR statement and NEXT statement and increments the control variable, starting with the initial value. Execution is terminated when value of the control variable exceeds the specified final value.

FORMAT:

FOR control variable **=** initial value **TO** final value
Numeric variable name Numeric expression Numeric expression

[STEP increment]
Numeric expression

|

NEXT [control variable] [, control variable] *
Numeric variable name Numeric variable name

EXAMPLE: FOR I=1 TO 10 STEP 0.1
|
NEXT I

PARAMETERS:

1. Control variable: numeric variable name. Array variables cannot be used.
2. Initial value: Numeric expression
3. Final value: Numeric expression
4. Increment: Numeric expression (default value = 1).

EXPLANATION:

1. None of the statements beyween FOR and NEXT are executed and the program proceeds to the next executable statement after NEXT when the initial value is greater than the final value.
2. Each FOR requires a corresponding NEXT.
3. FOR – NEXT loops can be nested (a FOR – NEXT loop can be placed inside another FOR – NEXT loop). Nested loops must be structured as shown below with NEXT appearing in inverse sequence of the FOR (e.g. FOR A, FOR B, FOR C – NEXT C, NEXT B, NEXT A).

```
10 FOR I=1 TO 12 STEP 3
20 FOR J=1 TO 4 STEP 0.5
30 PRINT I,J
40 NEXT J
50 NEXT I
60 END
```

4. FOR – NEXT loops can be nested up to 29 levels.
5. The control variable may be omitted from NEXT. However, use of the control variable in the NEXT statement is recommended when using nested loop, to make the code easier to understand.
6. NEXT statements can be chained by including them under one NEXT statement, separated by commas.

```
10 FOR I=1 TO 12 STEP 3
20 FOR J=1 TO 4 STEP 0.5
30 PRINT I,J
40 NEXT J,I
50 END
```

7. The control variable retains the value that exceeds the final value (and terminates the loop) when loop execution is complete.
   With the loop FOR I=3 to 10 STEP 3 for example, the value of control variable I is 12 when execution of the loop is complete.
8. Jumping out of a FOR – NEXT loop is also possible. In that case, the current control variable value is retained in memory, and the loop can be resumed by returning with a GOTO statement.

REM (‘) Ⓟ

PURPOSE: Allow remarks or comments to be included within a program. This command in not executed.

FORMAT:

{ **REM** / ‘ } comments
String expression

EXPLANATION:

1. Including an apostrophe or REM statement following the line number indicates that the following text is comments and should be ignored in program execution.
2. The apostrophe may be included at the end of any executable statement to indicate that the following text is comments. The REM statement can only be used at the beginning of a line.
3. Any command following a REM statement is treated as comment and is not executed.

SAMPLE PROGRAM:

```
10 REM This is a comment
20 ‘This is as well a comment
30 LET A=1: REM I can comment within a line
40 LET N=1 ‘The apostrophe does not require :
```

LET Ⓐ

PURPOSE: Assigns the value of an expression on the right side of an equation to the variable on the left side.

FORMAT:

[LET] numeric variable name = Numeric expression
[LET] string variable name = String expression

EXPLANATION:

1. Assigns the value of an expression on the right side of an equation to the variable on the left side
2. Numeric expressions can only be assigned to numeric variables, and string expressions can only be assigned to string variables. A “TM error” is generated when an attempt is made to assign a string expression to a numeric variable, and vice versa.
3. LET may be omitted.

SAMPLE PROGRAM:

```
10 LET A=10
20 B=20 ‘LET statement is omitted
30 PRINT A;B
```

DATA Ⓟ

PURPOSE: Holds data for Reading by the READ statement.

FORMAT:

$$\textbf{DATA}\quad \underbrace{\text{[data]}}_{\text{Constant}}\ \text{[,}\ \underbrace{\text{[data]}}_{\text{Constant}}\ \text{] *}$$

EXAMPLE:

```
DATA 10,5,8,3
DATA CAT,DOG,LION
```

PARAMETERS:

1. Data: String constants or numeric constants
2. String constants: Quotation marks are not required unless the string contains a comma that is part of the data. A null data string (length 0) is assumed when data is omitted from this statement.

EXPLANATION:

5.8.4 Mathematical Functions

ABS Ⓕ

PURPOSE: Returns the absolute value of the argument.
FORMAT:
ABS (argument)
Numeric expression
The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: ABS (-1.1)
PARAMETERS: argument : numeric expression
SEE: SGN

ACS Ⓕ

PURPOSE: Returns the angle value for which cosine (angle value) = argument.
FORMAT:
ACS (argument)
Numeric expression
The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: ACS (0.1)
PARAMETERS: argument must be within the [-1 , +1] range
EXPLANATION:

1. The unit of the returned value is specified using the ANGLE function.
2. The returned value is in the [0, 180°] or [0 , π Radians] range.

SEE: ANGLE, COS

ANGLE Ⓐ

PURPOSE: Specifies the angle unit.
FORMAT:
ANGLE angle specification
Numeric expression
EXAMPLE: ANGLE 0
PARAMETERS: angle specification: Numeric expression truncated to an integer in the range of 0 ≤ angle specification ≤ 3
EXPLANATION:

1. The angle units for the trigonometric functions can be specified using the values 0,1 and 2.
   0: DEG (Degrees)
   1: RAD (Radians)
   2: GRAD (Grads)
2. The relationships between the angle units are as follows:
   90° = π/2 Radians = 100 Grads
3. ANGLE 0 is set whenever ALL RESET is executed.
4. The angle unit can also be specified using the MODE command.

SEE: MODE, SIN, COS, TAN

ASN Ⓕ

PURPOSE: Returns the angle value for which sine (angle value) = argument.
FORMAT:
ASN (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: ASN (0.1)
PARAMETERS: argument must be within the [-1 , +1] range
EXPLANATION:

1. The unit of the returned value is specified using the ANGLE function.
2. The returned value is in the [0 , 180°] or [0 , π Radians] range.

SEE: ANGLE, COS

ATN Ⓕ

PURPOSE: Returns the angle value for which tangent (angle value) = argument.
FORMAT: double atan(x) double x;
ATN (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

PARAMETERS: argument must be within the [-1x10^{100} , +1x10^{100}] range.
EXPLANATION:

1. The unit of the returned value is specified using the ANGLE function.
2. The returned value is in the [-90° , 90°] or [-π/2 , π/2 Radians] range.

SEE: ANGLE, TAN

COS Ⓕ

PURPOSE: Returns the value of the cosine of the argument.
FORMAT:
COS (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: COS (30)
PARAMETERS: argument: numeric expression (angle).
-1440° < argument < 1440°
-8π Radians < argument < 8π Radians
-1600 Grads < argument < 1600 Grads
EXPLANATION:

1. The unit of the argument is specified using the ANGLE function.
2. The returned value is in the [-1 , 1] range.

SEE: ANGLE, ACS, SIN, TAN

CUR Ⓕ

PURPOSE: Returns the cubic root of the argument.
FORMAT:
CUR $\underset{\text{Numeric expression}}{\underline{\text{(argument)}}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: Y = CUR (X)
PARAMETERS: argument: numeric expression.
SEE: SQR

EXP Ⓕ

PURPOSE: Returns the value of $e^{\text{(argument)}}$.
FORMAT:
EXP $\underset{\text{Numeric expression}}{\underline{\text{(argument)}}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: EXP (1)
PARAMETERS: argument must be within the [-230.2585092 , +230.2585092] range.
EXPLANATION:

1. The value of e is 2.7182818284590452353602874713526...
2. The returned value is in the]0 , 10^{100}[range.

SEE: LN

FACT Ⓕ

PURPOSE: Returns factorial of argument.
FORMAT:
FACT $\underset{\text{Numeric expression}}{\underline{\text{(argument)}}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: A = FACT(10)
PARAMETERS: argument must be an integer in the [0 , 69] range.
EXPLANATION:

1. Returns factorial of the argument: FACT (n) = n! = 1 x 2 x 3 x . . . x n
2. A fractional value as the argument generates an error.

SEE: NPR

FIX Ⓕ

PURPOSE: Returns the integer part of the argument.
FORMAT:
FIX $\underbrace{\text{(argument)}}_{\text{Numeric expression}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: FIX (-1.5)
PARAMETERS: argument : numeric expression
SEE: INT, FRAC

FRAC Ⓕ

PURPOSE: Returns the fractional part of the argument.
FORMAT:
FRAC $\underbrace{\text{(argument)}}_{\text{Numeric expression}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: FRAC (3.14)
PARAMETERS: argument : numeric expression
EXPLANATION:

1. Returns the fractional art of the argument.
2. The sign (±) of the value is the same as that for the argument.

SEE: INT, FIX

HYPACS Ⓕ

PURPOSE: Returns the value for which hyperbolic cosine (value) = argument.
FORMAT:
HYPACS $\underbrace{\text{(argument)}}_{\text{Numeric expression}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: HYPACS (150)
PARAMETERS: argument must be within the [1 , $5x10^{99}$[range
EXPLANATION:

1. The mathematical formula for reverse hyperbolic cosine is :
   $\text{acosh}(x) = \ln (x + \sqrt{x^2 - 1})$ where ln is the natural logarithm .
2. The returned value is in the [-230.2585092 , +230.2585092] range.

SEE: HYPCOS, LN

HYPASN Ⓕ

PURPOSE: Returns the value for which hyperbolic sine (value) = parameter.
FORMAT:
HYPASN (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: HYPASN (-150)
PARAMETERS: argument must be within the]-5x10^{99} , 5x10^{99}[range
EXPLANATION:

1. The mathematical formula for reverse hyperbolic sine is :
   asinh(x) = ln (x + $\sqrt{x^2 + 1}$) where ln is the natural logarithm .
2. The returned value is in the [-230.2585092 , +230.2585092] range.

SEE: HYPSIN, LN

HYPATN Ⓕ

PURPOSE: Returns the value for which hyperbolic tangent (value) = argument.
FORMAT:
HYPATN (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: HYPATN (-0.3)
PARAMETERS: argument must be within the]-1 , +1[range
EXPLANATION:

1. The mathematical formula for reverse hyperbolic tangent is :
   atanh(x) = (ln (1+x) – ln (1-x)) / 2 where ln is the natural logarithm .
2. The returned value is in the]-10^{100} , +10^{100}[range.

SEE: HYPTAN, LN

HYPCOS Ⓕ

PURPOSE: Returns the value of the hyperbolic cosine of the argument.
FORMAT:
HYPCOS (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: HYPCOS (30)
PARAMETERS: argument must be within the [-230.2585092 , +230.2585092] range.
EXPLANATION:

1. The mathematical formula for hyperbolic cosine is :
   cosh(x) = (e^x + e^{-x}) / 2 where e is 2.71828182845904523536028747135266...
2. The returned value is in the [-1 , 5x10^{99}[range.

SEE: HYPACS, LN

HYPSIN Ⓕ

PURPOSE: Returns the value of the hyperbolic sine of the argument.

FORMAT:

HYPSIN (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: HYPSIN (1.5)

PARAMETERS: argument must be within the [-230.2585092 , +230.2585092] range.

EXPLANATION:

1. The mathematical formula for hyperbolic sine is :
   sinh(x) = (e^x - e^{-x}) / 2 where e is 2.7182818284590452353602874713526...
2. The returned value is in the]-5x10^{99} , 5x10^{99}[range.

SEE: HYPASN, LN

HYPTAN Ⓕ

PURPOSE: Returns the value of the hyperbolic tangent of the argument.

FORMAT:

HYPTAN (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: HYPTAN (2.5)

PARAMETERS: argument must be within the]-1x10^{100} , 10^{100}[range.

EXPLANATION:

1. The mathematical formula for hyperbolic tangent is :
   tanh(x) = (e^x - e^{-x}) / (e^x + e^{-x}) where e is 2.71828182845904523536028747...
2. The returned value is in the]-1 , 1[range.

SEE: HYPATN, LN

INT Ⓕ

PURPOSE: Returns the largest integer that does not exceed the value of the argument.

FORMAT:

INT (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: INT (-1.3)

PARAMETERS: argument : numeric expression

EXPLANATION:

1. Returns the largest integer, which does not exceed the value of the argument.
2. INT(x) is equivalent to FIX(x) when x is positive, and FIX(x)-1 when x is negative.

SEE: FIX, FRAC

LOG Ⓕ

PURPOSE: Returns the common logarithm of the argument.
FORMAT:
LOG (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: LOG (7922)
PARAMETERS: argument must be within the]10^{-100} , 10^{100}[range.
EXPLANATION:

1. The returned value is in the]-100 , +100[range.

SEE: LN

LN Ⓕ

PURPOSE: Returns the natural logarithm of the parameter
FORMAT:
LN (argument)
Numeric expression

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.
EXAMPLE: LN (1965)
PARAMETERS: argument must be within the]10^{-100} , 10^{100}[range.
EXPLANATION:

1. The returned value is in the [-230.2585092 , +230.2585092] range.
2. LN is the inverse function of EXP:
   For any positive argument, EXP(LN(argument)) # argument.

SEE: EXP

NCR Ⓕ

PURPOSE: Returns the combination nCr for the values of n and r.
FORMAT:
NCR (n value , r value)
Numeric expression Numeric expression

EXAMPLE: X = NCR(70,35)
PARAMETERS: n value and r value should follow: $0 \leq r \leq n < 10^{10}$
EXPLANATION:

1. Returns the permutation: nCr = n! / (r! (n-r)!)
2. A fractional value as either n or r generates an error.

SEE: FACT, NPR

NPR Ⓕ

PURPOSE: Returns the permutation nPr for the values of n and r.
FORMAT:

NPR	(n value	,	r value)
	Numeric expression		Numeric expression

EXAMPLE: X = NPR(69,20)
PARAMETERS: n value and r value should follow: $0 \le r \le n < 10^{10}$
EXPLANATION:

1. Returns the permutation: nPr = n! / (n-r)!
2. A fractional value as either n or r generates an error.

SEE: FACT, NCR

PI Ⓕ

PURPOSE: Returns the value of π.
FORMAT: PI
EXPLANATION:

1. Returns the value of π.
2. The value of π used for internal calculations is 3.1415926536.
3. The displayed value is rounded off to 10 digits, so the value of π is displayed as 3.141592654.

POL Ⓕ

PURPOSE: Converts rectangular coordinates (x, y) to polar coordinates (r, θ).
FORMAT:

POL	(x-coordinate	,	y-coordinate)
	Numeric expression		Numeric expression

EXAMPLE: POL(3,2)
PARAMETERS: x- and y-coordinates: numeric expressions not both zero.
EXPLANATION:

1. Converts rectangular coordinates (x, y) to polar coordinates (r, Θ). The following relational expressions are used at this time:
   $r = \sqrt{x^2 + y^2}$ $\cos\theta = x / \sqrt{x^2 + y^2}$ $\sin\theta = y / \sqrt{x^2 + y^2}$
2. The value of r is automatically assigned to variable X, wile θ is automatically assigned to variable Y
3. The value of θ is the]-180°, 180°] or]-π Radians, π Radians] range.

SEE: REC

RAN# Ⓕ

PURPOSE: Returns a random value in the range of 0 to 1.

FORMAT:

RAN# $\underbrace{\text{(argument)}}_{\text{Numeric expression}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: RAN# * 10

PARAMETERS: argument : numeric expression

EXPLANATION:

1. Returns a random value in the]-1, 1[range.
2. Random numbers are generated from the same table when X=1.
3. The last random number generated is repeated when X=0.
4. Random numbers are generated from the random table when X=-1.
5. Random number generation begins with the same value each time a program is executed. This means that the same series of numbers is generated unless the argument of RAN# is omitted or is equal to -1.

EXAMPLE: RAN# * 10

REC Ⓕ

PURPOSE: Converts polar coordinates (r, θ) to rectangular coordinates (x, y).

FORMAT:

REC $\underbrace{\text{(distance r}}_{\text{Numeric expression}}$, $\underbrace{\text{angle } \theta \text{)}}_{\text{Numeric expression}}$

EXAMPLE: REC(10,15)

PARAMETERS: x- and y-coordinates: numeric expressions not both zero.

1. Distance r: numeric expression in the [0, 10^{100}[range.
2. Angle θ in the]-1440°, 1440°[or]-8π Radians, 8π Radians[range.

EXPLANATION:

1. Converts polar coordinates (r, θ) to rectangular coordinates (x, y). The following relational expressions are used at this time:
   $x = r\cos\theta$ $y = r\sin\theta$
2. The value of x is automatically assigned to variable X, wile y is automatically assigned to variable Y

SEE: POL

ROUND Ⓕ

PURPOSE: Rounds the argument at the specified digit.
FORMAT:
ROUND $\underbrace{\text{(argument}}_{\text{Numeric expression}}$, $\underbrace{\text{digit)}}_{\text{Numeric expression}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: ROUND (A, -3)
PARAMETERS:

1. argument : numeric expression
2. digit: numeric expression truncated to an integer in the]-100, 100[range.

EXPLANATION:
Rounds the argument (to the nearest whole number) at the specified digit.
SEE: FIX, INT

SGN Ⓕ

PURPOSE: Returns a value, which corresponds, to the sign of the argument.
FORMAT:
SGN $\underbrace{\text{(argument)}}_{\text{Numeric expression}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: SGN (A)
PARAMETERS: argument : numeric expression
EXPLANATION: Returns a value of -1 when the argument is negative, 0 when the argument equals 0, and 1 when the argument is positive.
SEE: ABS

SIN Ⓕ

PURPOSE: Returns the value of the sine of the argument.
FORMAT:
SIN $\underbrace{\text{(argument)}}_{\text{Numeric expression}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: SIN (PI/3)
PARAMETERS: argument: numeric expression (angle).
-1440° < argument < 1440°
-8π Radians < argument < 8π Radians
-1600 Grads < argument < 1600 Grads

EXPLANATION:

1. The unit of the argument is specified using the ANGLE function.
2. The returned value is in the [-1, 1] range.

SEE: ANGLE, ASN, COS, TAN

SQR Ⓕ

PURPOSE: Returns the square root of the argument.

FORMAT:

SQR $\underbrace{\text{(argument)}}_{\text{Numeric expression}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: SQR (4)

PARAMETERS: argument must be positive.

SEE: CUR

TAN Ⓕ

PURPOSE: Returns the value of the tangent of the argument.

FORMAT:

TAN $\underbrace{\text{(argument)}}_{\text{Numeric expression}}$

The parenthesis enclosing the argument can be omitted when the argument is a numeric value or variable.

EXAMPLE: TAN (PI/3)

PARAMETERS: argument: numeric expression (angle).
-1440° < argument < 1440°
-8π Radians < argument < 8π Radians
-1600 Grads < argument < 1600 Grads

EXPLANATION:

1. The unit of the argument is specified using the ANGLE function.
2. argument must be different from 90° or 270° (π/2 or 3π/2 Radians).
3. The returned value is in the]-1x10^{100}, 10^{100}[range.

SEE: ANGLE, ATN, COS, SIN

5.8.5 String Functions

ASC Ⓕ

PURPOSE: Returns the character code corresponding to the character in the first (leftmost) position of a string.

FORMAT:

ASC $\underset{\text{String expression}}{\underline{\text{ (string) }}}$

EXAMPLE: ASC (“A”)

PARAMETERS: String : string expression

EXPLANATION:

1. Returns the character code corresponding to a character. The character code for the first (leftmost) character only is returned for a string of two or more characters long.
2. A value of 0 is returned for a null string.

SEE: CHR$, Character code table page 12.

DEG Ⓕ

PURPOSE: Converts a sexagesimal value to a decimal value.

FORMAT:

DEG $\underset{\text{Numeric expression}}{\underline{\text{ (degrees }}}$ [, $\underset{\text{Numeric expression}}{\underline{\text{ minutes }}}$ [, $\underset{\text{Numeric expression}}{\underline{\text{ seconds]]) }}}$

EXAMPLE: DEG (1, 30, 10)

PARAMETERS:

1. Degrees: numeric expression in the $]-10^{100} , 10^{100}[$ range.
2. Minutes: numeric expression in the $]-10^{100} , 10^{100}[$ range.
3. Seconds: numeric expression in the $]-10^{100} , 10^{100}[$ range.

EXPLANATION: Converts the degrees, minutes and seconds of sexagesimal values to decimal values as follows:

DEG(degrees, minutes, seconds) = degrees + minutes/60 + seconds/3600

SEE: DMS$

DMS$ Ⓕ

PURPOSE: Converts a decimal value to a sexagesimal string.

FORMAT:

DMS$ $\underset{\text{Numeric expression}}{\underline{\text{ (argument) }}}$

EXAMPLE: DMS$ (1.52)

PARAMETERS: Argument: numeric expression in the $]-10^{100} , 10^{100}[$ range.

EXPLANATION:

1. Converts decimal values to sexagesimal strings.
2. Minutes and seconds are not displayed when the argument is in the range of numeric expressions ≥ 10^6. In this case, the absolute value of the argument is converted to a string as it is.

SEE: DEG

&H Ⓐ

PURPOSE: Converts the 1 through 4-digit hexadecimal value following &H to a decimal value.

FORMAT:

&H argument
Hexadecimal value

EXAMPLE: A = &HAF

PARAMETERS: Hexadecimal value in the [0, FFFF] range.

EXPLANATION:

1. The hexadecimal value is expressed using values 0 to 9, plus characters A to F.
2. In the manual mode, &H is entered followed by the hexadecimal value. Pressing ↵ produces the decimal equivalent.
   Example: Shift &H 1 B 7 F ↵ → 7039
3. The following shows a typical example within a program. Since a numeric variable cannot be used following &H, the hexadecimal value is appended to &H as a string, and then converted to a decimal value using the VAL function.

SAMPLE PROGRAM:

```
10 REM &H SAMPLE
20 INPUT “&H”;A$
30 H=VAL(“&H”+A$)
40 PRINT “&H”;A$;”=”;H
50 GOTO 10
```

SEE: HEX$

HEX$ Ⓕ

PURPOSE: Converts the argument (numeric value or numeric expression value) to a string.

FORMAT:

HEX$ (argument)
Numeric expression

EXAMPLE: HEX$ (15)

PARAMETERS: Argument: numeric expression truncated to an integer in the]-32769, 65536[range. Values more than 32767 are converted by subtracting 65536.

EXPLANATION:

Returns a 4-digit hexadecimal string for a decimal value specified in the argument.

SEE: &H

LEFT$ Ⓕ

PURPOSE: Returns a substring of a specified length counting from the left of a string.

FORMAT:

LEFT$ $\underbrace{\text{(string}}_{\text{String expression}}$, $\underbrace{\text{number of characters)}}_{\text{Numeric expression}}$

EXAMPLE: LEFT$ ("ABCDEF", 3)

PARAMETERS:

1. String: string expression
2. Number of characters: numeric expression truncated to an integer in the [0 , 256[range.

EXPLANATION:

1. Returns the substring of a specified length from the left of a string.
2. The entire string is returned when the specified number of characters is greater than the number of characters of the string.

SEE: MID$, RIGHT$

LEN Ⓕ

PURPOSE: Returns a value that represents the number of characters contained in a string.

FORMAT:

LEN $\underbrace{\text{(string)}}_{\text{String expression}}$

EXAMPLE: LEN (A$)

PARAMETERS: String : string expression

EXPLANATION:

Returns a value that represents the number of characters contained in a string, including characters that don't appear on the display (character codes from &H0 - &H1F) and spaces.

MID$ Ⓕ

PURPOSE: Returns a substring of a specified length from a specified position within a string.

FORMAT:

MID$	(string	,	position	[,	number of characters])
	String expression		Numeric expression		Numeric expression

EXAMPLE: MID$ (A$, 5, 3)

PARAMETERS:

1. String: string expression
2. Position: numeric expression truncated to an integer in the [0 , 256[range.
3. Number of characters: numeric expression truncated to an integer in the [0 , 256[range. The default option is from the specified position to the end of the string when this parameter is omitted.

EXPLANATION:

1. Returns the substring of a specified length from a specified position within a string. A substring from the specified position to the end of the string when the length of the substring is not specified.
2. A substring of length 0 (null) is returned when the specified position exceeds the length of the string.
3. A substring from the specified position to the end of the string is returned when the specified number of characters is greater than the number of characters from the specified position to the end of the string.

SEE: RIGHT$, LEFT$

RIGHT$ Ⓕ

PURPOSE: Returns a substring of a specified length counting from the right of a string.

FORMAT:

RIGHT$	(string	,	number of characters)
	String expression		Numeric expression

EXAMPLE: RIGHT$ (“ABCDEF”, 3)

PARAMETERS:

1. String: string expression
2. Number of characters: numeric expression truncated to an integer in the [0 , 256[range.

EXPLANATION:

1. Returns the substring of a specified length from the right of a string.
2. The entire string is returned when the specified number of characters is greater than the number of characters of the string.

SEE: MID$, LEFT$

STR$ Ⓕ

PURPOSE: Converts the argument (numeric value or numeric expression value) to a string.

FORMAT:

STR$ $\underbrace{\text{(argument)}}_{\text{Numeric expression}}$

EXAMPLE: STR$ (123), STR$ (255+3)

PARAMETERS: Argument: numeric expression

EXPLANATION:

1. Converts decimal values specified in the argument to strings.
2. Converted positive values include a leading space and converted negative values are preceded by a minus sign

SEE: VAL

VAL Ⓕ

PURPOSE: Converts a numeric character string to a numeric value.

FORMAT:

VAL $\underbrace{\text{(string)}}_{\text{String expression}}$

EXAMPLE: A=VAL (“345”)

PARAMETERS: string : string expression

EXPLANATION:

1. Converts a numeric character string to a numeric value.
2. Numeric characters are converted up to the point in the string that a non-numeric character is encountered. All subsequent characters are disregarded from the non-numeric character onwards. (i.e. VAL(“123A456”) = 123).
3. The value of this function becomes 0 when the length of the string is 0 or when the leading character is non-numeric.

SEE: STR$, VALF

VALF Ⓕ

PURPOSE: Performs calculation of numeric expression expressed as string, and returns the result.

FORMAT:

VALF $\underbrace{\text{(string)}}_{\text{String expression}}$

EXAMPLE: VALF (X$)

PARAMETERS: String : string expression

EXPLANATION:

1. Performs calculation of numeric expressions, which are expressed as strings, and returns their results.
2. An error is generated when an intermediate of final result of calculation exceeds 10^{100}.
3. VALF cannot be used within a VALF argument.

5.8.6 Graphical Functions

DRAW Ⓕ

PURPOSE: Draws a line segment between two graphic coordinates.
FORMAT:

DRAW	[	(x1	, y1)	]	- (x2	, y2)
		Numeric expression	Numeric expression		Numeric expression	Numeric expression

EXAMPLE: DRAW (0,0)-(50,50)
DRAW-(100,50)

PARAMETERS:

1. (x1, y1) are the coordinates of the first graphic coordinate. When omitted, the computer will use the last graphic coordinate used in the program.
2. (x2, y2) are the coordinates of the second graphic coordinate.
3. x1 and x2 should be in the [0 , 191] range.
4. y1 and y2 should be in the [0 , 63] range, knowing [0 , 31] only is within the actual screen, [32 , 63] being in the virtual screen that can be made visible using the ⬆ ⬇ cursor keys.

SEE: DRAWC

DRAWC Ⓕ

PURPOSE: Erases a line segment between two graphic coordinates.
FORMAT:

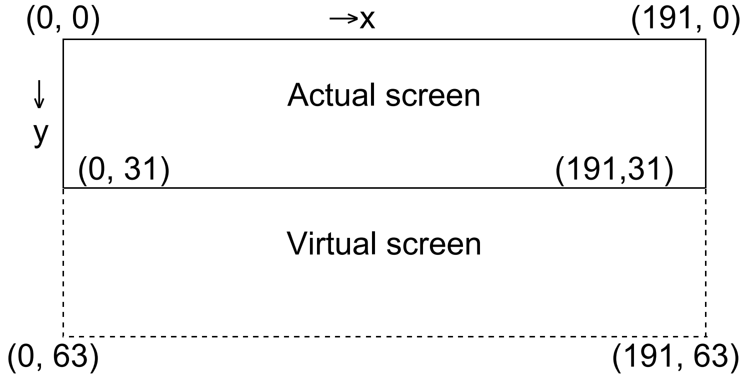
DRAWC	[	(x1	, y1)	]	- (x2	, y2)
		Numeric expression	Numeric expression		Numeric expression	Numeric expression

EXAMPLE: DRAWC (0,0)-(50,50)
DRAWC-(100,50)

PARAMETERS:

1. (x1, y1) are the coordinates of the first graphic coordinate. When omitted, the computer will use the last graphic coordinate used in the program.
2. (x2, y2) are the coordinates of the second graphic coordinate.
3. x1 and x2 should be in the [0 , 191] range.
4. y1 and y2 should be in the [0 , 63] range, knowing [0 , 31] only is within the actual screen, [32 , 63] being in the virtual screen that can be made visible using the ⬆ ⬇ cursor keys.

SEE: DRAWC



POINT Ⓕ

PURPOSE: Returns the status of a pixel

FORMAT:

POINT (x , y)

Numeric expression Numeric expression

EXAMPLE: POINT(50,50)

PARAMETERS: (x, y) is a graphic coordinate.

1. x should be in the [0 , 191] range.
2. y should be in the [0 , 63] range.

EXPLANATION: Value returned is 1 if the pixel is active (black), 0 if the pixel is inactive.

5.1 BASIC Commands Index

6 C Programming

6.1 The Basics of C

6.1.1 C and the other programming languages

Early history of C

C is a programming language that incorporates such concepts as module programming and structural syntax along the lines of ALGOL. Another well-known offshoot of ALGOL is PASCAL, and forebears of C are the CPL and BCPL languages. Both CPL and ECPL were early innovations by Britain's Cambridge University in an attempt to make ALGOL 60 easier to use. This concept crossed over to the United States, Resulting in such languages as B and Mesa.
B language was developed as the notation of the UNIX operating system, and the development of an improved UNIX notation produced today's C language.

Why C?

Until a number of years ago, the main programming languages for mainframe computing devices were COBOL FORTRAN and PL/1, while microcomputers were programmed using assembler or BASIC. Recently, however, there is a definite movement toward the use of C for programming a variety of computers. But what has made the C the language of choice for programming?
One reason is that C was developed for thr UNIX operating system. UNIX on the other served as basis for the widely popular MS-DOS, which means that the UNIX notation system is applied in a wide variety of software in use today.
Another reason is the wide appeal of C due to its distinctive features noted below.

Features of C

1. Wide applicability
C can be used in a wide range of programming applications, from numeric calculations to machine control.

2. Simple program portability
Since C is a high level programming language, programs can be used on a wide variety of computing devices.

3. Compact programs
The abundant operators and control structures that are built into C greatly simplify complex processing. Compared with other languages, the rules that govern C are relatively simple making program creation quick and easy.

4. Control structures based on structured programming
Structured programming allows easily mastered programs that are similar to human thought patterns. This means that conditional branching and repeat loop controls are all included.

5. A host of operators
C includes arithmetic operators, logical operators, relational operators, incremental / decremental operators, bit logical operators, and bit shift operators.

6. Pointer control
Unlike the memory addresses used in FORTRAN, COBOL and BASIC, C employs a pointer to indicate memory locations.

7. Efficient use of memory
Memory and data management functions, as well as programs are very compact, for more efficient memory utilization.
Thanks to this, C gives you the high level programming capabilities of FORTRAN and Pascal, with all of the detailed processing of machine language.

6.1.2 Learning about C with your pocket computer

There once was a time that C could be seen running on large computers. A time when it was only within the realm of programmers and system engineers. Since C notation resembles that of machine language, it often appeared too difficult or confusing for the casual user.

All of that changed with the introduction of the Casio PB-2000C pocket computer and its successors. It is now possible for everyone to enjoy the many benefits of programming in C. The full portability of the pocket computer format means that the computer can go with you everywhere, so you can program and compute whenever and wherever you want.

Since C interacts with many of the computer’s functions, it would be difficult to obtain a solid grasp of its workings by simply reading this manual. We highly recommend that you get as much hands on experience as possible with your pocket computer, creating and running your own programs. This is the best way to learn about the power and versatility of C.

The Casio pocket computer makes actually a very good teacher. Should you make a mistake when inputting a program, error messages will appear on the display to guide you back to the correct path. With each error you will be moving one more step closer to the mastery of C. A trace function is also provided to give you valuable insights of programs as they are executed.

6.1.3 Meet the Casio C interpreter

With most computers, C acts as a **compiler language**. A **compiler** translates the program written in C into a **machine language**, which can directly be understood by the computer. The program that the computer actually executes in the machine language program.

Since the compiler must perform the three steps of **compiling**, **linking** and **execution** for each program, they cannot be executed immediately after you enter them. The two steps of compiling and linking require some time to perform.

The Casio pocket computers, on the other hand, feature a C interpreter. The interpreter translates programs as you enter them, making it much easier to operate than a compiler. Once you enter a program, all you have to do is enter the RUN command to execute the program. Everyone who has ever worked with the BASIC programming language will find this is a very familiar process.

The few differences between the Casio interpreted C language and an ANSI standard compiled C will be highlighted in this manual

6.2 C Program Input

6.2.1 About the C Interpreter and Editor

The unit provides you with both a C interpreter and editor. The interpreter is used to execute programs. The editor is used for program creation and editing. Before getting into the actual operations of the unit, perhaps it might be a good idea to first look at these two functions in a little more detail.

About the C interpreter

There are two ways to process a C program: using a compiler or using an interpreter. With the compiler, the program is first translated into machine language before it is executed. This means that each time you write a program, all of the following processes must be performed:

Program input → compiling → linking → execution.

With an interpreter, the program is entered and executed in the same environment, for easier operation. The Casio unit features a C interpreter. After you enter the program, all you have to do is enter the RUN command to execute it.

Throughout the rest of this manual, the C interpreter will be referred simply as an “interpreter”.

About the C editor

An editor can be used to write everything from a few lines to an entire program. Unlike the interpreter in which simple writing cannot be performed easily, the editor lets you easily modify and correct programs.

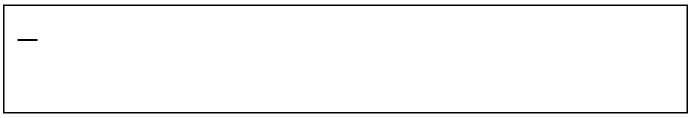
The C editor is for writing and modifying C programs. You should note, however, that you cannot execute programs while in the C editor. You can only execute from the interpreter.

Throughout the rest of this manual, the C editor will be referred simply as an “editor”.

6.2.2 Activating the C mode

Besides the C mode, the unit also features calculator, formula, BASIC, CASL and ASSEMBLER modes. Here, we will see how to select the C mode.

1. Switch the power of the unit ON.

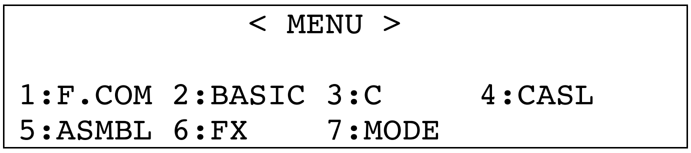


```
_
```

The display indicates that the computer is in the CAL mode. This is the initial mode when you switch the computer ON.

2. Press the MENU key.

MENU



```
            < MENU >

1:F.COM 2:BASIC 3:C     4:CASL
5:ASMBL 6:FX    7:MODE
```

3. Pressing the key 3 will lead to the C sub-menu allowing writing, compiling, running and editing programs in C language.

3

```
< C >

F 0 1 2 3 4 5 6 7 8 9     51113B
F1>Run/Load/Source
```

You can use the ← → cursor keys to select the program area 0 - 9

The S key allows to start writing the source code with the editor.

S

```
█


```

Note that the C language is case sensitive. Key words have to be written in lower case characters only. Make sure the CAPS symbol is switched OFF before entering a keyword.

M A I N ( ) Shift { ↵

```
main(){↲
█

                        <     2>
```

SPC P R I N T F (“ CAPS H E L L O Shift ¥ CAPS N ”) ; ↵

```
main(){↲
 printf(“HELLO¥n”);↲
█
                        <     3>
```

Shift } ↵

```
 printf(“HELLO¥n”);↲
}↲
█
                        <     4>
```

This gives the following C program:

```
main(){
 printf(“HELLO¥n”);
}
```

6.2.3 Using the Editor

The editor of the computer is used for creating and editing programs, as we saw with our HELLO program. This section takes you further along the path of using the editor effectively to create and edit useful C programs.

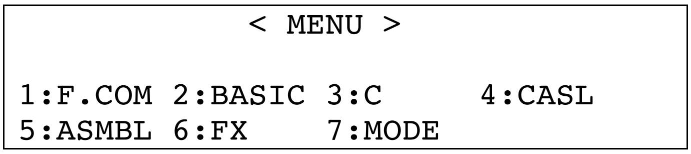
Entering the editor

You can enter the editor either from the MENU mode (by pressing 3 for the C mode, and the S for the editor), or from the interpreter (by entering the EDIT command).

To create a new program from the MENU mode

1. Press the MENU key to enter in the main menu.

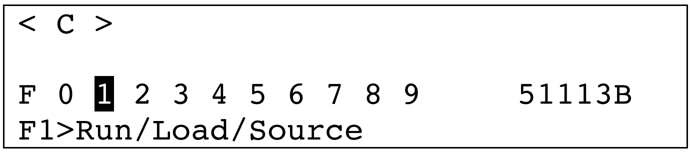
MENU



```
               < MENU >

1:F.COM 2:BASIC 3:C     4:CASL
5:ASMBL 6:FX    7:MODE
```

2. Press the key 3 to enter in the C mode

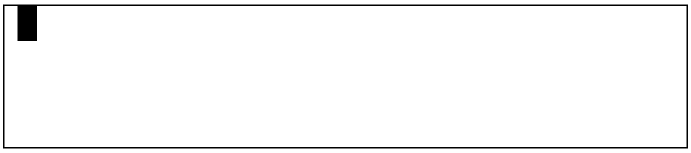
3



```
< C >

F 0 1 2 3 4 5 6 7 8 9     51113B
F1>Run/Load/Source
```

Use the ⬅ ➡ cursor keys to select an empty program area among areas 0 - 9
Enter the editor typing the S key.

S



You can start writing the new program.

To enter an existing program from the interpreter

After executing a program, you may want to edit it to make modifications. Just enter the EDIT command followed by ↵.

Moving the cursor

You can control cursor movement using the cursor keys in the editor as follows:

⬆ Cursor moves up
⬇ Cursor moves down
⬅ Cursor moves left
➡ Cursor moves right

Moving the cursor to the beginning of a line

Use the following operation to move the cursor to the beginning (left end) of the current line while in the editor:

Shift L.TOP

Moving the cursor to the end of a line

Use the following operation to move the cursor to the end (right end) of the current line while in the editor:

Shift L.END

Scrolling the screen

Press the ⬆ cursor key while the cursor is at the top line of the display to scroll the display downward.
Press the ⬇ cursor key while the cursor is at the bottom line of the display to scroll the display upward.

Editing a C program

Once in the editor, there are two modes for editing: the INSERT mode and the OVERWRITE mode. Switch between these two modes by pressing the INS key.

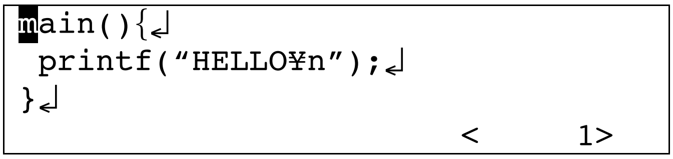
The INSERT mode is automatically specified when you enter the editor. The insert mode is indicated by a cursor thet looks like "█". While the computer is in the INSERT mode, any characters that you enter from the keyboard are inserted between any characters already on the display.

You can specify the OVERWRITE mode by pressing the INS key. The OVERWRITE mode is indicated by a cursor that looks like "_". While the computer is in the OVERWRITE mode, any character that you enter from the keyboard replace any characters already at the current cursor position.

Search function

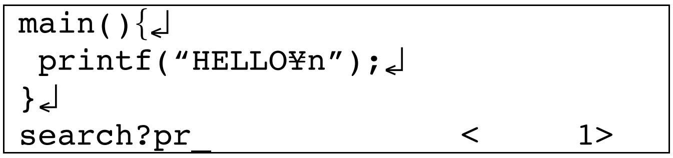
The editor search function lets you search through programs for specific character strings. We will demonstrate the search function using the following display.

EDIT ↵



```
main(){↲
 printf("HELLO¥n");↲
}↲
                        <     1>
```

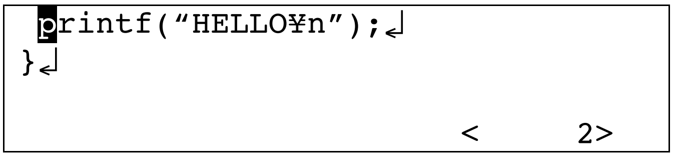
SRCH P R



```
main(){↲
 printf("HELLO¥n");↲
}↲
search?pr_              <     1>
```

↵

The specified character string is located and displayed, with the cursor located at the first letter of the string.



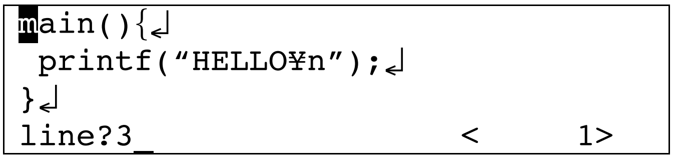
```
 printf("HELLO¥n");↲
}↲

                        <     2>
```

The number in the lower right of the display indicates the program line number.
You can search for the next occurrence of the string without entering it again with the Shift NEXT function (written for once under the CALC key).

Jumping to a specific line

The editor allows you to jump directly to a certain line using the Shift LINE function and entering the line number:

Shift LINE 3



```
main(){↲
 printf("HELLO¥n");↲
}↲
line?3_                 <     1>
```

↵

```
}↲


                         <      3>
```

Note that the line number displayed at the lower right is the one requested.
Now, let’s execute our program.

6.1 C Program Execution

6.1.1 To execute a program

You can exit the editor by pressing the SUB MENU key, which will go back to the C mode menu.
Shift SUB MENU

```
< C >

F 0 * 2 3 4 5 6 7 8 9     51113B
F1>Run/Load/Source
```

Note that the program area 1 you just used for the short program is now shown as occupied with a “*”.
You need to load the program into the interpreter, using the L key.
L

```
Load F1

>_
```

Enter run and press ↵ to actually execute the program
R U N ↵.

```
>run
HELLO

>_
```

Success! Your computer has said HELLO to you.

6.1.1 Using Command line Operation

As you are using the interpreter, the screen always shows a “>_” prompt. In this mode, you can enter four different commands followed by the ↵ key. Note that these commands are not case sensitive.
RUN – executes the currently loaded program
EDIT – transfers to the editor
TRON – enters the TRACE mode
TROFF – exits the TRACE mode

6.1.2 Using the Trace Function

The **trace function** of the interpreter executes programs statement-by-statement to let you see on the display the exact flow of all of the commands. This function comes in very handy when debugging programs or when you wish to see the operation of the control structure. When the trace function is activated, the computer is in the TRACE mode.

To illustrate operation of the TRACE mode, we will add a sub() procedure at the top of our HELLO program, and call it in the main().
Here is how the modified program will look like:

```
sub(){
 printf(“WORLD¥n”);
}
main(){
 printf(“HELLO¥n”);
 sub();
}
```

Loading and running this program will generate following output:

```
HELLO
WORLD

>_
```

With the TRACE function, it is possible to follow step by step the execution:

T R O N ↵

```

>tron

>_
```

R U N ↵

```
>run

(F1-5) printf(“HELLO¥n”);
Break?_
```

The display shows that execution is halted at line 5 of the program F1. The question mark in the bottom line of the display indicates that the computer is asking if it should execute line 5. Press ↵ to execute line 5.

↵

```
HELLO

(F1-6) sub();
Break?_
```

The display shows the result of the execution of line 5, and stands by for you to press ↵ and execute line 6.

↵

```
Break?

(F1-2) printf(“WORLD¥n”);
Break?_
```

The execution of line 6 led the program to line 2, which is in the function sub().

↵

```
Break?
WORLD

>_
```

To interrupt execution of the TRACE mode
Lets run again the program in TRACE mode:
R U N ↵

```
>run

(F1-5) printf("HELLO¥n");
Break?_
```

1. You can press T or ↵ to execute the line and carry on the TRACE mode.
2. You can press BRK to exit the program, but stay in TRACE mode. This is useful if you want to re-run the program because you missed something.

To exit the TRACE mode
There are four different methods that you can use to exit the TRACE mode.
1. Enter the TROFF command and press ↵. "TROFF" stands for **trace off**.
2. Exit the interpreter while entering the editor or the MENU mode. This automatically exits the TRACE mode.
3. Switch the power of the computer OFF. This automatically exits the TRACE mode.
4. Press N during TRACE mode execution when prompted "Break?_" to exit the TRACE mode and finish executing the program.

Variable Test Function
During TRACE mode execution of a program, you can press D when prompted "Break?_".
T R O N ↵
R U N ↵

```
>run

(F1-5) printf("HELLO¥n");
Break?_
```

D

```

(F1-5) printf("HELLO¥n");
Break?d
var>
```

Entering the name of the variable followed by ↵ will give you the type and value of the variable at this stage of the execution of the program.
Entering only ↵ will resume the TRACE mode execution.

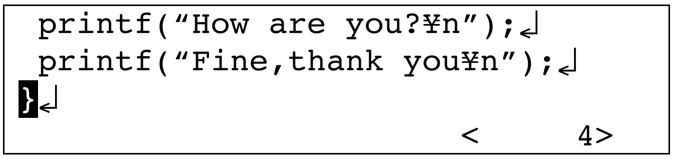
6.2 Introduction to C

This chapter tells you about the important points and rules to remember when creating C programs. Simply work with the example programs presented in this chapter to become familiar with proper procedure. This chapter puts you on the route to becoming a C programmer.

6.2.1 Outputting characters

Creating a program to output character strings
We have already some experience in chapter 6.2 with a few simple programs that output lines of characters to the display. Here, let's try understanding how it works.

Enter the following program:
M A I N ( ) Shift { ↵
SPC P R I N T F (“ CAPS H CAPS O W SPC A R E SPC
Y O U Shift ? Shift ¥ N ”) ; ↵
SPC P R I N T F (“ CAPS F CAPS I N E , T H A N K
SPC Y O U Shift ¥ N ”) ; ↵
Shift } ↵



```
 printf(“How are you?¥n”);↲
 printf(“Fine,thank you¥n”);↲
}↲
                         <     4>
```

The following shows how the program is stored in the source file:

```
main(){
 printf(“How are you?¥n”);
 printf(“Fine,thank you¥n”);
}
```

As already stated, C programs instructions are written using lower case characters. Also note the following characters in lines 1 and 4 of the program:

```
main() {
 .........
}
```

These are called the **function** that makes up the C program. The word “main” defines the function name, and the statements between the braces are actually executed. Actually, you can assign your function any name you wish, but “main” is special in that the computer will always begin execution from the function named “main”.
Lines 2 and 3 contain two printf() statements. The printf() statement is actually a function of C language that is used to output characters to the display. Such functions are called **standard functions**. The character strings included within the parenthesis following printf are what is output to the display. Note that a **character string** is defined as such by being included within double quotation marks. A character string or anything else that is included within the parentheses is called an **argument**.

The “¥n” at the end of each printf() character string is called a **newline** character, and advances the output to the left margin of the next line. Here the newline character is at the end of the string, but you can also include it within the string to tell the computer to go to the beginning of the next line.
Note that the newline character is noted “\n” in the ANSI C language. Nevertheless, the backslash character (Ascii code 92) is not available on the pocket computer. The character coded 92 is the Yen character (see chapter 1.6). Hence, every time a backslash would be required in ANSI C, we will use the Yen character instead.

Making your program easy to read
You have probably noticed by now that we have been writing and editing our C programs in a certain format. The previous program was written and entered as:

```
main(){
 printf(“How are you?¥n”);
 printf(“Fine,thank you¥n”);
}
```

We could have just as easily written and input it as:

```
main(){
 printf(“How are you?¥nFine,thank you¥n”);
}
```

Or even:

```
main(){printf(“How are you?¥nFine,thank you¥n”);}
```

The computer would execute the program identically in either case. The first format is preferred, however, because it is much easier to read. Though you may not see the need for such a format at this point, but when you start dealing with longer programs you will greatly appreciate an easier to read format.

Creating a program to output numeric values
C programs can output octal, decimal, and hexadecimal values. Here, let’s create a program that displays the vale 65 in its decimal, hexadecimal and floating-point format, using a few more new techniques.
First, enter the editor and input the following:

```
/* Output Value */
main(){
 printf(“D=%d H=%x F=%f¥n”65,65,65.0);
}
```

The first line is what we call a comment line. The computer reads everything between /* and */ as a comment, and so they are ignored. You can use comment lines inside of a program to point out certain features, or as memos for later reference.
Putting /* and */ around program statements is as well a good way to temporarily forbid the interpreter executing them without deleting them for good.

The remainder of the program is quite similar to the one that we created to output character strings to the display, but the argument for printf() looks a bit different. The commas inside of the parentheses are there to separate arguments. This means that the printf statement in this program has a total of four arguments.

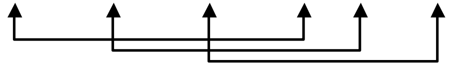
```
printf(“D=%d H=%x F=%f¥n”65,65,65.0);
              | 1st argument  |  |   | 4th argument
                              |  | 3rd argument
                              | 2nd argument
```

The arguments inside the parenthesis of printf tell the computer to print the following:
D=<65 as decimal integer> H=<65 as hexadecimal> F=<65.0 as floating point>

Note that there is a direct relationship with

- the 1st % construction and the 2nd argument
- the 2nd % construction and the 3rd argument
- the 3rd % construction and the 4th argument.

```
printf("D=%d H=%x F=%f¥n"65,65,65.0);
```



You just have to be careful to ensure that the proper % construction is matched with the proper value, or else you will get strange results. Here is a list of some other % constructions in addition to those noted above.

% construction	Output
%d	decimal integer
%x	hexadecimal integer
%f	floating point
%s	string
%c	single character

Now, let's enter the RUN command to execute our program and look at the result.

R U N ↵

```
>run
D=65 H=41 F=65.000000

>_
```

Here we can see that the decimal equivalent of 65 is 65, the hexadecimal equivalent is 41, and the floating-point equivalent is 65.000000.

Integer notation in C

In the previous program, the decimal value 65 was converted in accordance with three corresponding % constructions. In some instances, however, you might want to include the actual values as they are in printf() arguments, without conversion when they are displayed. To do this, you have to specify the value as an integer constant. With C, you can specify decimal, octal and hexadecimal values, as well as characters as integer constant. Use the following formats to specify values or characters of integer constants.

- 65 – displayed as decimal integer 65
- 0101 – displayed as octal value 101. Include 0 in the first digit of an octal value to specify it as an integer constant.
- 0x41 – displayed as hexadecimal value 41. Include 0x in the first two digits of a hexadecimal value to display it as an integer constant.
- 'A' – displayed as a single character. Include the character in single quotes.

If you go back to our last program and change the printf() arguments as noted below:

```
/* Output Value V2 */
main(){
 printf("D=%d O=%o H=%x C=%c¥n"65,0101,0x41, 'A');
}
```

The following results would be displayed:
R U N ↵

```
>run
D=65 O=101 H=41 C=A

>_
```

6.2.2 Variable types and operations

Declaring variable types

With C programs, you have to declare the type of data that will be assigned to each variable before you can use the variable. The following statement, for example, tells the computer that the variable “x” will be used for the storage of integers:
`int x;`

The following table shows the other declarations that can be made for variables.

Declaration	Meaning
char	8-bit integer
short	16-bit integer
int	16-bit integer*
long	32-bit integer
float	32-bit single precision floating point
double	64-bit double precision floating point

Besides these, you can also include the declaration “unsigned” in front of any of the integer declaration (except long) to indicate that the integer is unsigned (no positive/negative sign)

*Note: the “int” declaration is hardware dependent, despite the fact it is the default type in many cases, and the fastest for arithmetics. On the pocket computer, which uses a 16-bit microprocessor, it refers to a 16-bit integer. But on other processors, it may refer to 24-bit or 32-bit integers. For best portability, it is recommended to use the “short” declaration instead, when possible.

Assigning values to variables

To see how to declare variables and also how to assign values, let’s write a program that performs various operations using the values 49 and 12.
Enter the editor and input the following program.

```
/* Arithmetic Operations 1 */
main(){
 short a,b,c,d,e;
 a=49+12;printf(“%d  “,a);
 b=49-12;printf(“%d  “,b);
 c=49*12;printf(“%d  “,c);
 d=49/12;printf(“%d  “,d);
 e=49%12;printf(“%d¥n“,e);
}
```

The first four operations are addition, subtraction, multiplication and division. The value for “e” will be the modulus (remainder) of 49 divided by 12.
When you execute the program, the display should appear as follows:
R U N ↵

```
>run
61  37  588  4  1

>_
```

The following statement in the first line of the program declares that all five variables will be for the storage of 16-bit integers.

```
Short a,b,c,d,e;
```

As you can see, you can use a single declaration for multiple variables by separating the variables by commas.
In each of the following lines, the computer performs the calculation and assigns the result to the corresponding variable. Then, the result is displayed by including the variable as an argument in the printf() statement.

Using arrays
An array is a variable with depth. With an array, you use a single name followed by a number to indicate the variable name. For example, a[0], a[1], a[2], a[3], a[4] represent five memory areas within an array called “a[5]”. Note that the values following the name must be enclosed within brackets.
With arrays, declaration of repetitive variables becomes very simple. Let’s go back to our original program where we used variables “a” to “e” to store calculation results, and use an array” a[5]” instead.

```
/* Arithmetic Operations 2 */
main(){
 short a[5];
 a[0]=49+12;printf(“%d  “,a[0]);
 a[1]=49-12;printf(“%d  “,a[1]);
 a[2]=49*12;printf(“%d  “,a[2]);
 a[3]=49/12;printf(“%d  “,a[3]);
 a[4]=49%12;printf(“%d¥n“,a[4]);
}
```

Note that like in BASIC, an array can have multiple dimensions. The array a[3][3] would represent a total of nine values:
a[0][0] a[0][1] a[0][2]
a[1][0] a[1][1] a[1][2]
a[2][0] a[2][1] a[2][2]

6.2.3 Entering characters and values

Entering a single character from the keyboard

Here we will create a program that outputs a character and its corresponding character code in hexadecimal format. If you press the key for the letter “B”, for example, the format will be:

```
Char=B Hex=0x42
```

The standard function getchar() is used to tell the computer to get one character input from the keyboard. In most ANSI C compilers, this function is part of the standard input / output library which complements the core of C language. You need then to include this library with the following statement:

```
#include “stdio.h”
```

If you use mathematical functions, which are again not in the historical core of C language, you need to include the mathematical library:

```
#include “math.h”
```

The C interpreter of your pocket computer does not need these instructions for a compiler. Nevertheless, it is a good idea to add a comment reminding the need for the standard libraries to help portability.

The following is the program that will accomplish our task:

```
/* Diplay character codes */
/* #include <stdio.h> */
main(){
 int c;
 c=getchar();
 printf(“Char=%c  Hex=0x%x¥n“,c,c);
}
```

The getchar() function only returns the character code, and so no argument is used inside of the parenthesis. In the printf() function, %c specifies character format while %x specifies hexadecimal format.

Try inputting and executing this program.
When you enter the RUN command, the interpreter executes the program until it comes to the getchar() function. At that time, execution stops and the cursor flashes at the bottom of the display waiting for further input. At this time, you should enter a letter, number or symbol. The following shows the display that should result if you enter the letter “Q”.

R U N ↵
Q ↵

```
Q
Char=Q  Hex=0x51

>_
```

This shows that the character code for “Q” is hexadecimal 51.

Entering Values

Now, let’s try a program that calculates the sine and cosine of values that you enter from the keyboard. Since we can be expecting decimal values for input and output, we will be defining the variable as floating-point. The program to accomplish this task would appear as follows:

```
/* Compute sine & cosine */
/* #include <stdio.h> */
/* #include <math.h> */
main(){
 float x;
 printf(“Input Value(DEG)“);
 scanf(“%f”,&x);
 angle(0); /* Degrees */
 printf(“sin(%f)=%f¥n“,x,sin(x));
 printf(“cos(%f)=%f¥n“,x,cos(x));
}
```

First, we must specify the variable x as floating point.
The scanf() function is used to get the entry of a value from the keyboard. Exactly the opposite as the printf() function, the first argument of the scanf() determines the type, and the value is assigned to the second argument. In the program here, we can see that the first argument of scanf() is “%f”, to indicate floating point format. The second argument is &x which is a pointer to the variable x. A pointer indicates the address in memory of a variable. The second argument of the scanf() function must be a pointer.
The statement “angle(0);” specifies the unit of angular measurement. You can specify the unit by changing the argument of angle() as follows:

- angle(0) – degrees
- angle(1) – radians
- angle(2) – grads

The next statements are the now familiar printf().

After you input this program, enter the interpreter and execute it.
When the computer reaches the scanf() function, it displays the message “Input Value(DEG)” and waits for input of a value. Here, let’s enter 60 and press the ↵ key. This value is assigned to variable “x”, and the following appears on the display.
R U N ↵
60 ↵

```
sin(60.000000)=0.866025
cos(60.000000)=0.500000

>_
```

6.2.4 Using selection statements

Using the "if" selection statement

You can use the "if" statement to tell the computer to shift the flow of control if certain conditions are met. The "if" statement has two basic formats.

1. if (condition) statement.

Here, the statement is executed if the condition is met (true = any value other than 0), and not executed if the condition is not met (false = 0).

2. if (condition) statement 1
else statement 2

In this case, statement 1 is executed if the condition is met (true = any value other than 0), while statement 2 is executed if the condition is not met (false = 0).
The "if – else" statement may contain multiple statements for the "if" and the "else" statements. In the following example, please also note the proper format for easy reading.
Note that the statements are aligned and also note the position of the braces.

```
if (condition){
 Statement 1
 Statement 2
}
else{
 Statement 3
 Statement 4
}
```

A program to solve quadratic equations

Here, we will create a program that produces two solutions for the following quadratic equation: $ax^2 + bx + c = 0$ ($a \neq 0$)
In the above equation, it is assumed that a, b and c are real numbers.
The solution for the formula is:

$$x = \frac{- b \pm \sqrt{(b^2 - 4ac)}}{2a}$$

Also, the following is the discriminant which determines the following concerning the solutions of the above equation:

- $D = b^2 - 4ac$
- D>0 – Two different real solutions
- D=0 – Single real solution
- D<0 – Two different imaginary numbers (conjugate complex numbers)

In the program listed below, the discriminantr is used in the condition of a selection statement with one operation being performed if $D \geq 0$ and another being performed when $D<0$.

```
/* Quadratic equation */
/* #include <stdio.h> */
/* #include <math.h> */
main(){
 double a,b,c,D,q,r;
 scanf(“%lf %lf %lf“,&a,&b,&c);
 D=b*b-4.0*a*c;
 if (d>=0){
  q=(-b+sqrt(D))/a/2.0;
  r=(-b-sqrt(D))/a/2.0;
  printf(“%If, %If¥n“,q,r);
 }
 else{
  r=sqrt(-D)/a/2.0;
  q=-b/a/2.0;
  printf(“%lf+%lfi  “,q,r);
  printf(“%lf-%lfi¥n“,q,r);
 }
}
```

The variables “a”, “b” and “c” correspond to the “a”, “b”, and “c” in the quadratic equation, while the “D” variable is the “D” of the discriminant. Variables “q” and “r” are used for the two solutions. Note that all of the variables are specified as “double”, meaning that they are for double-precision floating point values.
Note that the % construction in the scanf() function is “%lf”. The “f” portion specifies a floating-point value, while the “l” stands for long, and means that the integer part of the value is longer than normal.

Relational operators

The condition “D>=0” is called a relational operator. This tells the computer to compare the value assigned to variable “D” with 0. If the value of “D” is greater than or equal to 0, a value of 1 (TRUE) is returned to indicate true. If it is less than zero, a 0 (FALSE) is returned to indicate false. The following are the other relational operators that can be used with C.

Operator	Example	Meaning
>	i>j	True (1) if i is greater than j, false (0) if not.
<	i<j	True (1) if i is less than j, false (0) if not.
>=	i>=j	True (1) if i is greater than or equal to j, false (0) if i is less than j
<=	i<=j	True (1) if i is less than or equal to j, false (0) if i is greater than j
==	i==j	True (1) if i is equal to j, false (0) if not.
!=	i!=j	True (1) if i is not equal to j, false (0) if it is.

6.2.5 Using loops

Using the “while” loop

The “while” loop makes it possible to repeat execution of statements until a specific condition is met. The format of the “while” loop is as follows:

```
while (condition)
 Statement
```

The “while” loop first executes the condition. If the condition is met (true, returning a value other than 0), the statement is executed, and execution loops back to the “while” loop to evaluate the condition again. Whenever the condition is not met (false, returning 0), execution of the “while” loop is ended.
You can have multiple statements in a while loop, but note the following format that you should use in order to make the program easier to read:

```
while (condition){
 Statement 1
 Statement 2
    .
    .
 Statement n
}
```

The closed brace should be directly under the “w” of the “while”. Keep the statements indented.

Now, let’s create a program that uses the “while” loop. The program will output the character codes for the characters “0” through “Z” as illustrated below:

```
Char(0) = Hex(0x30)
Char(1) = Hex(0x31)
…
Char(Z) = Hex(0x5A)
```

The following shows the program that produces such result.

```
/* Character codes */
/* #include <stdio.h> */
#define STR ‘0’
#define END ‘Z’
main(){
 char ch;
 ch=STR;
 while (ch<=END){
  printf(“Char(%c) = Hex(0x%x)¥n“,ch,ch);
  getchar(); /* waits for return key */
  ch++;
 }
}
```

Using the #define statement

Lines 3 and line 4 of the program contain the #define statement. The #define statement defines a name for a particular string of characters. In the above program, “#define STR ‘0’ “ tells the computer that anytime it comes across the name “STR”, it should replace it with the character “0”. Likewise, “#define END ‘Z’ “ tells the computer that the name “END” is to be replaced by the character ‘Z’.

The reason for using a #define statement is to make the program easier to read and to change later. If, in the above program, we used the character ‘0’ a number of times throughout the program and we wished to change all of them to ‘A’, it would be much easier to change the #define statement once, rather than making multiple changes.

Incrementing and decrementing

The program here establishes the initial value for trhe variable “ch” as “0”, and tells it to keep repeating the loop “while (ch<=END)”, in which END is the name that represents the character “Z”. As long as “ch” is less than or equal to “Z”, the following printf() statement is executed, and then the getchar() statement is executed.

This program does not really require input of any characters, but if we did not include a getchar() statement here, the data produced by this program would simply scroll across the display so quickly that we would not be able to use it. The getchar() statement causes the computer to stop here and wait for input, so that you can read the last line produced by the program. When you are ready to continue, simply press the ↵ key.

Once execution continues past the “ch++;” statement, 1 is added to the value of “ch”. “++” is called the increment operator. The following table shows how it is used, as well as its opposite, the decrement operator.

Operator	Example	Meaning
++	++i	Increment i by 1 and use the value.
--	--i	Decrement i by 1 and use the value.
++	i++	Use i and then increment it by 1.
--	i--	Use i and then decrement it by 1.

As you can see here, the increment and decrement operators can be used either before or after the value, with different results. For other useful operators, see page 108 of this manual.

Using the “do – while” loop

The “do – while” loop is another method that you can use for repeat execution. The format of the “do – while” loop is as follows:

```
do
 Statement
while (condition);
```

Unlike the “while” loop, the “do – while” loop executes the statement first and then checks whether or not the condition has been met or not. Note also the semicolon at the end of the “while” line cannot be omitted.
Let’s use the “do – while” to find the Greatest Common Measure for two values.

```
/* Greatest Common Measure */
/* #include <stdio.h> */
main(){
 int gcm,x,y;
 x=56;
 y=63;
 printf(“¥nGCM(%d,%d) = ”,x,y);
 do{
  gcm=x; x=y%x; y=gcm;
 }while (x!=0)
 printf(“%d¥n”,gcm);
}
```

When you execute this program, the following result should be produced:

```

GCM(56,63) = 7

>_
```

Using the “for” loop

You can also use the “for” loop for repeat execution of statements. The format of the “for” loop is as follows:

```
For (expression 1; expression 2; expression 3)
 Statement
```

Note that there are three expressions inside of the parentheses of the “for” loop.

- Expression 1 initializes the counter variable, and is executed only once, before the first pass of the loop.
- Expression 2 is the condition of the loop, so the loop continues to execute until this condition is not met.
- Expression 3 performs an operation on the counter variable before the statement in the loop is executed.

Note the following:

```
for (i=0; i<10; i++)
 printf(…)
```

This tells the computer to execute the printf() statement starting from a count of 0 which is incremented by 1 which each pass of the loop, until the count reaches 10. As with the “if” and “while” loops, multiple statements within a “for” loop are enclosed in braces.
Let’s write a program that squares all of the integer from 1 to 100.

```
/* 100 squares */
/* #include <stdio.h> */
main(){
 int i;
 for (i=1; i<=100; i++)
  printf(“%8d %8d¥n”,i,i*i);
  getchar(); /* waits ret key */
}
```

First, let’s look at the expressions contained in the parentheses following the “for” statement and see what each of them mean.

- Expression 1   i=1   Initial value of counter is 1.
- Expression 2   i<=100   Repeat as long as I is less than or equal to 100.
- Expression 3   i++   Increment I by 1 with each pass of loop (i=i+1).

In effect, this tells the computer to keep repeating the loop starting with a counter value of 1, and repeat the loop as long as the counter value is 100 or less.
In the next line, the “%8d” in the first argument tells the computer to display the decimal value flush right in an 8-character block reserved on the display. Flush left would be “%-8d”.
When you execute this program, the following result should be produced:

```
       1        1
       2        4 …
   … 100    10000
>_
```

The following shows how the same loop could be written as a “for” loop and a “while” loop. As you can see, the “for” loop is much easier to write and read.

```
For (expression 1; expression 2; expression 3)
 Statement
```

⇑
⇓

```
expression 1;
while (expression 2){
 Statement
 expression 3
}
```

Nested loops

The term nested loop means simply “loops inside of loops”. To better understand how nested loops work, let’s have a look at a very short, simple representative program.

```
/* nested loops example */
/* #include <stdio.h> */
main(){
 float a[3][3];
 int i,j;
 for (i=0; i<3; i++)
  for (j=0; j<3; j++)
   scanf(“%f”,&a[i][j]);
}
```

The program uses a pair of “for” loops to read values from the keyboard and assign them to a 3x3 2-dimensional array a[3][3]. Remember that such an array looks something like the following:

a[0][0] a[0][1] a[0][2]
a[1][0] a[1][1] a[1][2]
a[2][0] a[2][1] a[2][2]

Considering just the loop counter (i and j) values, the above program executes as follows:

First pass (i)	Second pass (i)	Third pass (i)
i=0	i=1	i=2
j=0	j=0	j=0
j=1	j=1	j=1
j=2	j=2	j=2

This means that values entered from the keyboard are read into “%f” by scanf() and assigned to array a[3][3] in sequence by “&a[i][j] as “i” and “j” change values as noted above.

Let’s expand on this program so that a second nested loop reads the values out of the array and displays them on the screen.

```
/* nested loops example 2 */
/* #include <stdio.h> */
main(){
 float a[3][3];
 int i,j;
 for (i=0; i<3; i++)
  for (j=0; j<3; j++)
   scanf(“%f”,&a[i][j]);
 for (i=0; i<3; i++) {
  for (j=0; j<3; j++)
   printf(“%8.2f”,a[i][j]);
  printf(“¥n”);
 }
}
```

We have now the value assignment nested loop we saw before, followed by a similar set of loops to read and display the values after they are stored. The only new item is the “%8.2f” which specifies that each value will be displayed in an area of at least 8 characters, with two decimal places (right flush).

R U N ↵
1 ↵ 2 ↵ 3 ↵ 4 ↵ 5 ↵ 6 ↵ 7 ↵ 8 ↵ 9 ↵

```
    1.00    2.00    3.00
    4.00    5.00    6.00
    7.00    8.00    9.00
>_
```

6.2.6 Defining functions

Function definition and program modules

Besides the standard functions, the C programming language lets you define your own routines as functions to be called by later programs. We have seen a hint of this already in the “main()” first line of our programs to define them as main functions.

Using the procedures presented here, you will ba able to break large programs down into modules and then call up each module from the main() function. This means that you will eventually build up your own library of functions that you can call up from various programs as you need them.

Creating functions

The following is the format for function definition:

```
function type declaration  function name (arguments)
argument type declaration;
{
 declaration of variables used in the function
 statements…
}
```

Function type
This part of the function declares the type of data that will be returned by the function. This line may be omitted if the value to be returned is an integer (int) or if there is no data returned. But a good programming discipline is to formally declare an “int” type or a “void” type when nothing is returned.

Function name
You cannot use reserved words as function names, and you should not use names already used for standard function names The following is a table of reserved words.

auto	default	float	register	(struct)	(volatile)
break	do	for	return	switch	while
case	double	goto	short	(typedef)	
char	else	if	signed	(union)	
const	(enum)	int	sizeof	unsigned	
continue	extern	long	static	void	

The standard functions are listed on page 113

Arguments
Arguments are used to pass values to the function when it is called. If no values are passed, the arguments can be omitted. If the arguments are omitted, the following argument type declaration is also omitted.

Argument type declaration
Declares the types of the arguments specified above.
Note that ANSI C allows declaring arguments directly inside the parenthesis. The C interpreter does not allow such a declaration.

Statements
The portion of the function between the braces is executed when the function is called. Use the same format as that which we have seen for our main() programs.

EXAMPLE 1:
For illustrative purposes, let’s modify the program that squares all integers from 1 to 100 (see page 97) by performing the squaring calculation with a function.

```
/* 100 squares 2 */
/* #include <stdio.h> */

int isquare(x) /* square of int */
int x;
{
 return (x*x);
}

main(){
 int i;
 for (i=1; i<=100; i++)
  printf(“%8d %8d¥n”,i,isquare(i));
  getchar(); /* waits ret key */
}
```

Returned value
The function isquare() that we have defined receives the argument, squares it, and then returns the squared value. The line “return(i*i)” instructs the computer to square the value of “x” and return it to the main() function.
When the main() function executes isquare(i), the value stored in the variable “I” is passed to function isquare() as argument “x”. Note that the value only is passed, and that variables x and i are different variables. There is no way for the function isquare() to modify the content of variable i.
The “return” statement within isquare() will give the value of the square to the expression isquare(i) in the main() function, and execution precedes to the printf statement for output.

EXAMPLE 2:
We will rewrite the same program using now a function that returns floating-point values.

```
/* 100 squares 3 */
/* #include <stdio.h> */

double dsquare(x) /* square */
double x;
{
 return (x*x);
}

main(){
 double d;
 for (d=1.0; d<=100.0; d+=1.0)
  printf(“(%lf)^2=%f¥n”,i,dsquare(d));
  getchar(); /* waits ret key */
}
```

Variables are now declared as double precision floating-point. Variables declaration has to happen before using them in a statement.
Note that we have to start the program with the function, in order to allow calling it further down.

EXAMPLE 3:
The alternative method is to use declare the function first, so that the interpreter knows its type, before actually writing the function. Here is an example using function declaration

```
/* 100 squares 4 */
/* #include <stdio.h> */
extern double dsquare();
main(){
 double d;
 for (d=1.0; d<=100.0; d+=1.0)
  printf(“(%lf)^2=%f¥n”,i,dsquare(d));
  getchar(); /* waits ret key */
}
double dsquare(x) /* square */
double x;
{
 return (x*x);
}
```

Note that a function declaration of line 3 does not specify the amount and type of parameters. ANSI C authorizes function prototyping, which would look like:
`extern double dsquare(double)`
Nevertheless, prototyping is not implemented in the C interpreter of the unit. It is therefore recommended to write functions before calling them, avoiding parameter errors that can be hard to debug.

6.1 Constants and Variables

6.1.1 Local variables and global variables

Local variables

A local variable is one that is declared within a function for use within that particular function only.
Since such variables are local, you can use the same variable name in multiple functions without any problem – each variable is treated independently, even though they have the same name. Have a look at the program listed below.

```
/* Local variable */
/* #include <stdio.h> */

void pr() /* print function */
{
 int i; /* local i */
 for(i=0;i<2;i++)
  printf(“%d “,i);
}

main(){
 int i;
 for (i=0; i<10; i++)
  pr();
}
```

This program displays ten sets of numbers 0 and 1. Both the main() function and the pr() function utilize variable “i” but the computer treats these as two entirely different variables. In the main() function, the value of “i” ranges from 0 to 9, while in pr() it is 0 or 1 only.

Global variables

A global variable is one that is commonly applied throughout all functions of a program. Global variables are declared in the line before preceding the main() line and the other functions using them. Have a look at the program listed below.

```
/* Global variable */
/* #include <stdio.h> */
int i /* global i */
void pr() /* print function */
{
 printf(“%d “,i);
}

main(){
 for (i=0; i<10; i++)
  pr();
}
```

Here, variable “i” is declared outside of any function, so “i” will be treated as a global variable. Consequently, it will retain its current value regardless of whether execution is in main() or pr(). In this program, variable “i” is assigned a value by the “for” loop in main(), and then the value of “i” is printed by function pr().
Note that any function has access to “i”, not only to read it but as well to modify it. This increases the risk of unexpected software errors and is a major drawback of global variables.
If you decide to use global variables, here are some basic rules to follow:

- Restrict the usage to variables that make sense to be global, but cannot be considered as a constant. Example: Screen_W, Dist_Unit.
- Use long, descriptive names to make obvious the type of value that is stored.

6.1.2 Pointers and variable storage locations

Entering values

Here, we will write a calculation program that performs specific integer arithmetic operations on values entered via the scanf() standard function. With this program, entry of “33+21 ↵ “ would for example produce the result “=54”.

```
/* scanf example */
/* #include <stdio.h> */
main(){
 char op;
 int x,y,xy;
 xy=0;
 scanf(“%d%c%d”,&x,&op,&y);
 if(op==’+’) xy=x+y;
 else if(op==’-‘) xy=x-y;
 else if(op==’*‘) xy=x*y;
 else if(op==’/‘) xy=x/y;
 else if(op==’%‘) xy=x%y;
 else printf(“unknown op”);
 printf(“=%d”¥n”,xy);
}
```

Variable “op” is a character type while “x”, “y”, and “xy” are integer type. Since we are using the scanf() function, arguments are expressed preceded by ampersands, becominf “&x”, “&op” and “&y”. In C, an argument such as “&x” represents the location in memory that the contents of variable “x” are stored. It is called an address.

The scanf() function understands arguments to be addresses, and represents the value stored at the address within the expression. See the Command Reference for detailed information on the scanf() function.

The line “scanf”"%d%c%d”, &x, &op, &y);” accepts input of integers for variables “x” and “y”, and a character code for variable “op”.
The execution of the next statement depends on the character assigned to variable “op”. If it is a plus sign, the first “if” statement is executed, if it a a minus sign, the second “if” statement is executed, etc.

Finally, the printf() statement displays the value of “xy” which is the result, no matter which arithmetic operation is performed.

6.1.3 Data types and lengths

The following table shows the data types and their respective lengths for the interpreter. These are almost identical on all computers, except for the integer (int) that may change.

Type declaration	Interpreter
char	8-bit integer
short	16-bit integer
int	16-bit integer
long	32-bit integer
float	32-bit single precision floating point
double	64-bit double precision floating point

6.1.4 Assigning variable names and function names

All variables must be declared before they can be used within a program. The following rules apply for variables, constants defined using the #define statement, and function names.

- The first character of a variable name must be an alphabetic character (A-Z, a-z), or an underline (_).
- Second and subsequent characters in a variable may be an alphabetic character, underline, or number. The computer differentiates between upper case and lower case letters when matching variable names.
- Reserved words cannot be used as variable names, though a part of a variable name may be a reserved word.
- The length of a variable name is unlimited, but only the first eight characters are used to discriminate one name from another. This means that “abc12345” and “abc12344” will be considered as the same variable, since the initial eight characters of either name are the same.

6.1.5 Data expressions

Character constants

Characters for the constant type char should be enclosed within single quotation marks as shown below:
‘C’ ‘8’ ‘¥n’

Just as many larger computers, the unit represents characters using ASCII codes, with some exceptions (see character table page 12).

In addition, the computer uses control characters such as (NL), (HT), (BS), (CR) which are expressed in C as escape sequences (using the ¥ symbol, when ANSI C uses \ symbol)

Code	Hex Code	Name	Meaning
¥a	0x07	Bell (BEL)	Sound buzzer
¥n	0x0A	New Line (NL)	Carriage return + Line feed
¥t	0x09	Horizontal tab (HT)	Horizontal tab
¥b	0x08	Backspace (BS)	Backspace (one character)
¥r	0x0D	Carriage return (CR)	Returns to line start
¥f	0x0C	Form feed	Change page
¥¥	0x5C	Yen symbol	Character ” ¥ ”
¥’	0x27	Single quote	Character “ ‘ “
¥”	0x22	Double quote	Character “ “ “
¥0	0x00	Null	Equivalent to zero
¥nnn		Octal notation	Character code for octal value nnn.
¥xmm	0xmm	Hexadecimal notation	Character code for hexadecimal value mm

Integer constants

Constants of the int type can be bradly classified as decimal, octal, and hexadecimal. The letter “L” or “l” must be affixed for long type integers.

Decimals
Example: 1121 -128 68000 123456789L (for long)
Note: Leading zeros cannot be used, because they mean an octal notation.

Octal:
Example: 033 0777 012 01234567L (for long)
Note: Leading zero required for octal notation. No number above 7!

Hexadecimal:
Example: ox1B 0xFFFF 0x09 0xffffffL (for long)
Note: 0x (or 0X) required for hexadecimal notation.

The following show the ranges of each type of notation. Negative integers are accomplished using unary minus operators with unsigned constants.

Decimal constants

int	0	-	32767
long	32768	-	2147483647

Octal constants

int	00	-	077777
unsigned int	0100000	-	0177777
long	0200000	-	017777777777

Hexadecimal constants

int	0x0000	-	0x7fff
unsigned int	0x8000	-	0xffff
long	0x10000	-	0x7ffffff

The ranges defined above also apply to entries for the scanf(), fscanf() and sscanf() functions.

Floating-point constants and double precision floating-point constants

Decimal values can be defined as float type or double type constants using the format shown below. Exponents are indicated by the letter “E” or “e”.
Example: 3.1416 -1.4141 1.0e-4 1.23456E5

The following shows the ranges of float and double.

float	0, ±1e-63	-	±9.99999e+63
double	0, ±1e-99	-	±9.999999999e+99

String constants

String constants are contained in double quotation marks. The structure of character strings is basically the same as for an ANSI compiler, with a 0 (null) being affixed at the end. The following shows an example of character string:

```
“How do you do?”
```

6.1.6 Storage classes

Storage classes are used to specify the memory storage area for a declared variable, as well that to specify the scope (range that program can read from / write to).
The following table shows the storage classes, as well as the variables that are available for each class.

Storage class	Variables
auto	Used for short-term storage within a program. This is the default case and “auto” can be omitted
static	Reserves area throughout execution of program. Values accessed and acted upon throughout entire program.
register	High frequency access. Variables, which are effective for increasing speed of execution by allocating values to microprocessor registers. Most compilers optimize automatically the executable code using registers for the most accessed variables, but it may still make sense to specify “register”. The C interpreter treats “auto” and “register” variables the same way.
extern	File-external or function external global variables. With the interpreter, file-external can be another program area. The extern statement is key to tell a compiler that the variable is already defined elsewhere, and that it should not book any space for it. When linking the various modules and libraries, the variable will get its address. With the interpreter, it is possible to declare in various program areas the same global variable twice without creating an error. It is nevertheless a good habit to use the “extern” statement for all declarations but one. The only mandatory use of “extern” is when you refer within a function to an extern global variable. Without an extern statement, the interpreter would create a local variable with the same name as the global variable, but superseding it within the function.

Note: The interpreter does not allow declaring a local “auto” variable within the code of a function.

```
func(a)
double a;
{
 int i,j,x;
 float fx,fy;
 long lx,ly;
 for(i=0;i<5;i++){
  …
 }
}
```

Program A: OK

```
func(a)
double a;
{
 int i,j,x;
 long lx,ly;
 for(i=0;i<5;i++){
  float fx,fy;
  …
 }
}
```

Program B: Error

```
func(a)
double a;
{
 int i,j;
 float fx,fy;
 long lx,ly;
 for(i=0;i<5;i++){
  …
  int x;
 }
}
```

Program C: Error

6.1.7 Arrays and pointers

Arrays

The interpreter allows use of arrays with an amount of dimensions only limited by the memory capacity. Nevertheless tables of more than 2 or 3 dimensions are rare.

```
int tab_4[2][12][31][2]
```

Note that if you refer to the name of a table without the brackets, you will not get an error. C will give you the address of the first element of the table.

`&tab_4[0][0][0][0]` is equal to `tab_4`

Initializing arrays

The interpreter let you initialize simple variables, but you cannot initialize arrays as easily:

```
char *month[12]={“Jan”,”Feb”,”Mar”, … ,”Dec”};
```

which is allowed in ANSI C will generate an “illegal initialization error”. Use instead:

```
char *month[12];
month[0]=“Jan”; month[1]=”Feb”; … ; month[11]=”Dec”;
```

Pointers

The pointer is a 16-bit variable that holds the address of a variable. For example:

```
x = *px;
```

Here, the content at the address pointed to by px is assigned to variable x. Note the following:

```
px = &x;
y = *px;
```

Here, the address of variable x is assigned to pointer px. Then, the content at the address pointed to by px is assigned to variable y. Consequently, this is equivalent to:

```
y = x;
```

You can also use a pointer within a character string to isolate single characters from the string.

```
/* Pointer example */
/* #include <stdio.h> */
main(){
 char *p;
 p=”Casio”;
 printf(“%c %s¥n”,*p,p);
}
```

Execution of this program will produce the following result:

```
C Casio

>_
```

This is because a string is actually a pointer to the first character, the “null” character (0) being added after the last character to close the string.

Now, lets assume we want to access the third letter of the string “Casio”. We need to increment the pointer p by 2. *(p+2) is character “s”.

Because p was declared as pointing toward characters (see line 4), the interpreter knows that an increment of 1 will select the next Byte in the memory.
If p were pointing toward long integers, each increment would select the next 4 Bytes.

As said earlier arrays are closely related to pointers as well.

```
int a[5], *pa
pa=a; /* equivalent to pa=&a[0] */
pa++; /* now, pa points toward a[1] */
```

6.2 Operators

C employs many operators not available with BASIC, FORTRAN or Pascal. Operators are represented by such symbols as “+”, “-“, “*” and “/”, and they are used to alter values assigned to variables. Basically, the C interpreter supports the same operators as a standard ANSI C compiler.

Precedence

When a single expression contains a number of operators, precedence determines which operator is executed first. Note the following:

```
a+b*c
```

In this case, the operation “b*c” is performed first, and then the result of this is added to “a”. This means that the precedence of multiplication is higher than that of addition.
Note the following example:
(a+b)*c
In this case, the (a+b) operation is performed first, because it is enclosed within parentheses.

The following table shows all of the operators used by C and their functions, explained in their order of precedence.

Primary Operators	
( ), func( )	Parenthetical, function argument operations.
x[ ], y[ ][ ]	Specify array elements.
Unary Operators	
*px	Specifies content indicated by a pointer.
&x	Address of variable x.
-x	Negative value x.
++x, --x	+1 / -1 before using variable x.
x++, x--	+1 / -1 after using variable x.
~x	NOT performed on each bit (inversion).
!x	Logical NOT (if x≠0, 0 returned; if x=0, 1 returned).
(type)x	Forced conversion / specification of x (cast operator).
sizeof(x)	Variable x Byte length value, sizeof(type) illegal.
Binomial operators	
x*y, x/y, x%y	Multiplication, division, modulus (remainder of x/y).
x+y, x-y	Addition, subtraction.
x<<y, x>>y	x left bit shift y times, x right bit shift y times.
x<y, x>y, x>=y, x<=y	Relational operators (true=1, false=0).
x==y	Equality (unequal=0, equal=1).
x!=y	Inequality (unequal=1, equal=0).
x&y	Bit AND of x and y.
x^y	Bit XOR of x and y.
x|y	Bit OR of x and y.
x&&y	Logical AND of x and y (1 if neither x nor y are 0)
x||y	Logical OR (1 if either x or y is not zero).
Trinomial (conditional) operators	
x?y:z	y if x is true (other than 0), z if x is false (0).
Assignment operators	
x=y	Assigns y to variable x.
x*=y	Multiplies x by y, and assigns result to x (x=x*y).
x/=y	Divides x by y and assigns result to x (x=x/y).
x%=y	Computes remainder of x/y and assigns result to x (x=x%y).
x+=y	Adds x and y and assigns the sum to x (x=x+y).
x-=y	Subtracts y to x and assigns the result to x (x=x-y).
x<<=y	Shifts the bits of x left y times, assigning result to x (x=x<<y).
x>>=y	Shifts the bits of x right y times, assigning result to x (x=x>>y).
x&=y	Computes a bit AND of x and y, assigning result to x (x=x&y).
x^=y	Computes a bit XOR of x and y, assigning result to x (x=x&y).
x|=y	Computes a bit OR of x and y, assigning result to x (x=x&y).

The following table shows the precedence of associativity of the C operators.

Precedence	Operators		Associativity
High		( ), [ ]	→ Left to right
	Unary	!, ~, ++, --, -, (type), *, &, sizeof	← Right to left
	Multiplication, division	*, /, %	→ Left to right
	Addition, subtraction	+, -	→ Left to right
	Shift	<<, >>	→ Left to right
	Relational	>, <, >=, <=	→ Left to right
	Equality	==, !=	→ Left to right
	Bit AND	&	→ Left to right
	Bit XOR	^	→ Left to right
	Bit OR	|	→ Left to right
	Logical AND	&&	→ Left to right
	Logical OR	||	→ Left to right
	Conditional	?:	← Right to left
	Assignment	=, +=, -=, *=, /=, <<=, >>=, &=, ^=, |=	← Right to left
Low	Order	,	→ Left to right

Note: Order of precedence is complicated. It is a good practice to use parenthesis wherever the intention of the statement can be confusing for someone reading the program, if not for the interpreter.

6.2.1 Cast operator

Data types are ranked as follows, with rank increasing from left to right:
Char < int < long < float < double …

In expressions with mixed data types, C will first convert all data to the same type as that of the highest ranked data included in the expression, and then perform the calculation. This is called implicit type conversion or type coercion.

This can become very complicated when unsigned types are involved. At the big difference of BASIC that allows for one numeric type only, programming in C forces to think carefully about minimum and maximum values that could occur, in order to select the right data type and avoid unexpected results.

6.3 C Command Reference

6.3.1 Manual Commands

RUN

PURPOSE: Execution of a C program.
EXAMPLE:

```
RUN
run
RUN>"PRN:"
```

PARAMETERS:
You can specify the output console being the printer instead of the screen.
EXPLANATION:
Execution starts at the beginning of the main() function of the program currently loaded.

EDIT

PURPOSE: Writing or editing a C program.
EXAMPLE:

```
EDIT
edit
```

EXPLANATION:
Enters the editor and opens the program area F 0-9 currently selected.

TRON

PURPOSE: Entering the TRACE mode for program debugging.
EXAMPLE:

```
TRON
tron
```

EXPLANATION:

1. If you run a program in TRACE mode, computer will stop at each statement showing program area number (F0-9), line number and statement.
2. After each statement, prompt "Break?_" appears. Press ↵ or T key to execute the next statement.
3. Press N when prompted "Break?_" to exit the TRACE mode and finish executing the program.
4. During TRACE mode execution of a program, you can press D when prompted "Break?_" to evaluate the content of variables. The "var>_" prompt allows you entering the name of the variable you want to evaluate. Entering only ↵ will resume the TRACE mode execution.
5. You can press BRK to exit the program, but stay in TRACE mode. This is useful if you want to re-run the program because you missed something.

TROFF

PURPOSE: Cancelling TRACE mode to switch back to normal program execution.
EXAMPLE:

```
TROFF
troff
```

6.3.1 Fundamental commands

abort()

PURPOSE: Program termination.
FORMAT: void abort();
EXPLANATION:

1. Calling abort() function will cause the program to terminate immediately, indicating an unsuccessful termination.
2. The following may occur: file buffers are not flushed, streams are not closed, and temporary files are not deleted.
3. In ANSI C, abort() function is part of library stdlib.

exit()

PURPOSE: Program termination.
FORMAT: void exit();
EXPLANATION:

1. Calling exit() function will cause the program to end normally.
2. In ANSI C, exit() function is part of library stdlib. And allows to pass a parameter indicating the termination status to the operating system.

breakpt()

PURPOSE: Stops program execution like in the TRACE mode.
FORMAT: void breakpt();
EXPLANATION:

1. The TRACE mode stops at each statement. I you just want to investigate a certain statement of your program, you can add a breakpt() statement.
2. Program will stop showing the "Break?_" prompt. You can
   - Press D to evaluate the content of variables. The "var>_" prompt allows you entering the name of the variable you want to evaluate. Entering only ↵ will go back to the "Break?_" prompt.
   - Press ↵ to carry on program execution.
   - Press T to enter TRACE mode (see TRON page 111)
3. breakpt() is not part of any ANSI C standard library.

SAMPLE PROGRAM:

```
/* breakpt example */
main() {
 int i=0,j=10;
 while(i<=10) {
  breakpt();
  i++;
  j–
 }
}
```

if() else

PURPOSE: Executes one statement when the specified condition is true (not zero). A second optional statement following the “else” is executed when the specified condition is false (0).

FORMAT: if (condition) statement 1 else statement 2

PARAMETERS:

Condition can be any variable or expression that will be considered true if not 0.

EXPLANATION:

1. The most simple conditional structure is: if (condition) statement. statement is executed only if condition is true (not 0)
2. You can add the else structure to process the case of condition being false (0).
3. Statement 1 and statement 2 can be if() then structure as well, allowing analyzing and processing multiple conditions.
4. The last else statement is often here to process unexpected entries or data configurations, for example generating an error warning.

SAMPLE PROGRAM:

```
/* if() else example */
/* upper case only! */
/* #include <stdio.h> */
main(){
 char c;
 c=getchar();
 if ((c>=’A’)&&(c<=’Z’) {
  /* Process upper case */
  . . .
 }
 else if((c>=’a’)&&(c<=’z’)){
  /* Change case */
  c-=32;
  . . .
 }
 else {
  printf(“%c is not a letter¥n“,c);
 }
}
```

SEE: switch() case break default

while()

PURPOSE: Executes repeatedly a statement as long as the specified condition is true (not zero). .

FORMAT: while (condition) statement

PARAMETERS:

Condition can be any variable or expression that will be considered true if not 0.

EXPLANATION:

1. The “while” loop first executes the condition. If the condition is met (true, returning a value other than 0), the statement is executed, and execution loops back to the “while” loop to evaluate the condition again.
2. Whenever the condition is not met (false, returning 0), execution of the “while” loop is ended.

SAMPLE PROGRAM:

```
/* While example */
/* #include <stdio.h> */
main(){
 char ch=’0’;
 while (ch<=’Z’){
  printf(“Char(%c) = Hex(0x%x)¥n“,ch,ch);
  getchar(); /* waits for return key */
  ch++;
 }
}
```

SEE: do while(), for(), break, continue

do while()

PURPOSE: Executes statement and carries on repeatedly as long as the specified condition is true (not zero). .

FORMAT: do statement while (condition);

PARAMETERS:

Condition can be any variable or expression that will be considered true if not 0.

EXPLANATION:

1. The “do” loop first executes the statement.
2. If the condition is met (true, returning a value other than 0), execution loops back to the “do” loop to execute the statement again.
3. Whenever the condition is not met (false, returning 0), execution of the “do” loop is ended.

SAMPLE PROGRAM:

```
/* Do While example */
/* #include <stdio.h> */
main(){
 int gcm,x=56,y=63;
 printf(“¥nGCM(%d,%d) = ”,x,y);
 do{
  gcm=x; x=y%x; y=gcm;
 }while (x!=0)
 printf(“%d¥n”,gcm);
}
```

for()

PURPOSE: Executes repeatedly a statement as long as the specified condition is true (not zero).
FORMAT: for (expression 1; condition; expression 2) statement
PARAMETERS:

1. expression 1 sets initial state.
2. condition allows the loop to repeat.
3. expression 2 is executed after the statement.

EXPLANATION:

1. First, expression 1 is executed on first pass only (initialization).
2. Then, condition is evaluated. If true (not 0), the statement is executed. If false, loop ends.
3. After execution of the statement, expression 2 is executed, and execution loops back to condition evaluation.
4. Note that the any “for” loop could be written:
   for (expression 1; condition; {statement; expression 2});
   Nevertheless, commonly accepted programming practice is to reserve the parenthesis after the “for” statement for loop control, putting all other statements after.

SAMPLE PROGRAM:

```
/* For example */
/* #include <stdio.h> */
main(){
 char ch;
 For (ch=’0’; ch<=’Z’; ch++){
  printf(“Char(%c) = Hex(0x%x)¥n“,ch,ch);
  getchar(); /* waits for return key */
 }
}
```

SEE: do while(), while(), break, continue

break

PURPOSE: exits from a “do while”, “while” of “for” loop.
FORMAT: break;
EXPLANATION:

1. Execution of a “break” is the loop statement, will exit the loop whatever the loop condition status is.
2. Any statement following the “break” within the loop is not executed.

SEE: do while(), while(), switch() case, continue

continue

PURPOSE: Returns execution to the beginning of a “do while”, “while” of “for” loop.
FORMAT: break;
EXPLANATION:

1. Any statement following the “continue” within the loop is not executed.
2. condition for loop is evaluated, and a new loop is executed if condition is true.

switch() case default

PURPOSE: executes various statements depending on the value of the parameter.
FORMAT: switch (expression) { [case constant i: statement i]; default: statement; };
PARAMETERS:

1. expression must be an integer type (char, int, long, signed or unsigned).
2. constant i (there is no limit to the number of “case: constant i” statements) is a constant from the same type as expression.

EXPLANATION:

1. expression is evaluated, and compared to each constant.
2. If a constant matches the value of expression, the statements following the corresponding case are executed, until a “break” statement is found.
3. If no constant matches the value of expression, the statements following “default” are executed.
4. Note: In absence of a “break”, the execution of statements carries on. See the second sample program.

SAMPLE PROGRAM:

```
/* Switch break example */
/* #include <stdio.h> */
main(){
 int a;
 printf(“¥nEnter a value:”);
 scanf(“%d”,&a);
 switch(a){
  case 1:
   printf(“¥nThis is case 1”);
   break;
 case 2:
  printf(“¥nThis is case 2”);
  break;
 case 3:
  printf(“¥nThis is case 3”);
  break;
 default:printf(“¥nDefault case”);
 }
}
```

```
/* Switch w/o break example */
/* #include <stdio.h> */
main(){
 int a;
 printf(“¥nHow Many Players:”);
 scanf(“%d”,&a);
 switch(a){
  case 4: Rst_Score(4);
  case 3: Rst_Score(3);
  case 2: Rst_Score(2);
  case 1: Rst_Score(1); break;
  default: printf(“¥nNot possible”);
 }
}
```

SEE: if() else, break

goto

PURPOSE: Branches unconditionally to a specified destination label.
FORMAT: goto label;
PARAMETERS: label is the name of a label defined within the same function.
EXPLANATION:

1. the goto statement and label concept are similar to the ones used in BASIC.
2. a label is defined writing an identifier followed by a colon.
3. it is possible and recommended to avoid using the goto statement in a C program.

6.3.1 Mathematical Functions

The math functions are part of a standard library in ANSI C, and it is recommended to add the following comment at the beginning of your program:

```
/* #include <math.h> */
```

abs()

PURPOSE: Returns the absolute value of an integer.
FORMAT: int abs(n) int n;

angle()

PURPOSE: Specifies the unit of angular measurement.
FORMAT: void angle(n) unsigned int n;
PARAMETERS: n = 0: unit = Degrees. n = 1: unit = Radians. n = 3: unit = Grads
SEE: sin(), cos(), tan(), asin(), acos(), atan()

acos()

PURPOSE: Returns the angle value for which cosine (angle value) = parameter.
FORMAT: double acos(x) double x;
PARAMETERS: x must be within the [-1, +1] range
EXPLANATION:

1. The unit of the returned value is specified using the angle() function.
2. The returned value is in the [0 , 180°] or [0 , π Radians] range.

SEE: angle(), cos()

acosh()

PURPOSE: Returns the value for which hyperbolic cosine (value) = parameter.
FORMAT: double acosh(x) double x;
PARAMETERS: x must be within the [1, $5x10^{99}$[range
EXPLANATION:

1. The mathematical formula for reverse hyperbolic cosine is:
   acosh(x) = ln ($x + \sqrt{x^2 - 1}$) where ln is the natural logarithm.
2. The returned value is in the [-230.2585092, +230.2585092] range.

SEE: cosh(), log()

asin()

PURPOSE: Returns the angle value for which sine (angle value) = parameter.
FORMAT: double asin(x) double x;
PARAMETERS: x must be within the [-1, +1] range
EXPLANATION:

1. The unit of the returned value is specified using the angle() function.
2. The returned value is in the [-90°, 90°] or [-π/2, π/2 Radians] range.

SEE: angle(), sin()

asinh()

PURPOSE: Returns the value for which hyperbolic sine (value) = parameter.
FORMAT: double asinh(x) double x;
PARAMETERS: x must be within the]-5x10^{99}, 5x10^{99}[range
EXPLANATION:

1. The mathematical formula for reverse hyperbolic sine is:
   asinh(x) = ln (x + $\sqrt{x^2 + 1}$) where ln is the natural logarithm.
2. The returned value is in the [-230.2585092, +230.2585092] range.

SEE: sinh(), log()

atan()

PURPOSE: Returns the angle value for which tangent (angle value) = parameter.
FORMAT: double atan(x) double x;
PARAMETERS: x must be within the [-1x10^{100}, +1x10^{100}] range.
EXPLANATION:

1. The unit of the returned value is specified using the angle() function.
2. The returned value is in the [-90°, 90°] or [-π/2, π/2 Radians] range.

SEE: angle(), tan()

atanh()

PURPOSE: Returns the value for which hyperbolic tangent (value) = parameter.
FORMAT: double atanh(x) double x;
PARAMETERS: x must be within the]-1, +1[range
EXPLANATION:

1. The mathematical formula for reverse hyperbolic tangent is:
   atanh(x) = (ln (1+x) – ln (1-x)) / 2 where ln is the natural logarithm .
2. The returned value is in the]-10^{100}, +10^{100}[range.

SEE: tanh(), log()

cos()

PURPOSE: Returns the value of cosine (parameter).
FORMAT: double cos(x) double x;
PARAMETERS: x must be within the]-1440°, +1440°[or [-8π , 8π Radians] range.
EXPLANATION:

1. The unit of the parameter x is specified using the angle() function.
2. The returned value is in the [-1, 1] range.

SEE: angle(), acos()

cosh()

PURPOSE: Returns the value of hyperbolic cosine (parameter).
FORMAT: double cosh(x) double x;
PARAMETERS: x must be within the [-230.2585092, +230.2585092] range.
EXPLANATION:

1. The mathematical formula for hyperbolic cosine is:
   cosh(x) = (e^x + e^{-x}) / 2 where e is 2.71828182845904523536028747135266...
2. The returned value is in the [-1, 5x10^{99}[range.

SEE: acosh(), log()

exp()

PURPOSE: Returns the value of $e^{(\text{parameter})}$.
FORMAT: double exp(x) double x;
PARAMETERS: x must be within the [-230.2585092, +230.2585092] range.
EXPLANATION:

1. The value of e is 2.71828182845904523536028747135266...
2. The returned value is in the]0, 10^{100}[range.

SEE: log()

log()

PURPOSE: Returns the natural logarithm of the parameter
FORMAT: double log(x) double x;
PARAMETERS: x must be within the]10^{-100}, 10^{100}[range.
EXPLANATION:

1. The returned value is in the [-230.2585092, +230.2585092] range.
2. log() is the inverse function of exp():
   For any positive x, exp(log(x))#x.

SEE: exp()

log10()

PURPOSE: Returns the common logarithm of the parameter
FORMAT: double log10(x) double x;
PARAMETERS: x must be within the]10^{-100}, 10^{100}[range.
EXPLANATION: The returned value is in the]-100, +100[range.
SEE: log()

pow()

PURPOSE: Returns x to the power of y.
FORMAT: double pow(x, y) double x,y;
PARAMETERS:

1. x is a double precision floating-point number.
2. y is the power.

EXPLANATION:

1. pow(x,y) is essentially computed using the method x^y = exp(y * log(x)). This means that any negative x may generate a mathematical error, despite the fact that x^y is mathematically valid. Example: $(-8)^{1/3}$ generates an error.

SEE: log(), log10()

sin()

PURPOSE: Returns the value of sine (parameter).
FORMAT: double sin(x) double x;
PARAMETERS: x must be within the]-1440°, +1440°[or [-8π, 8π Radians] range.
EXPLANATION:

1. The unit of the parameter x is specified using the angle() function.
2. The returned value is in the [-1, 1] range.

SEE: angle(), asin()

sinh()

PURPOSE: Returns the value of hyperbolic sine (parameter).
FORMAT: double sinh(x) double x;
PARAMETERS: x must be within the [-230.2585092, +230.2585092] range.
EXPLANATION:

1. The mathematical formula for hyperbolic sine is :
   sinh(x) = $(e^x - e^{-x}) / 2$ where e is 2.7182818284590452353602874713526...
2. The returned value is in the]-$5x10^{99}$, $5x10^{99}$[range.

SEE: acosh(), log()

sqrt()

PURPOSE: Returns the square root of the parameter.
FORMAT: double sqrt(x) double x;
PARAMETERS: x must be positive.
SEE: pow()

tan()

PURPOSE: Returns the value of tangent (parameter).
FORMAT: double tan(x) double x;
PARAMETERS: x must be within the]-1440°, +1440°[or [-8π , 8π Radians] range.
EXPLANATION:

1. The unit of the parameter x is specified using the angle() function.
2. x must be different from 90° or 270° (π/2 or 3π/2 Radians).
3. The returned value is in the]-1x10^{100}, 10^{100}[range.

SEE: angle(), atan()

tanh()

PURPOSE: Returns the value of hyperbolic tangent (parameter).
FORMAT: double tanh(x) double x;
PARAMETERS: x must be within the]-1x10^{100}, 10^{100}[range.
EXPLANATION:

1. The mathematical formula for hyperbolic tangent is :
   tanh(x) = (e^x - e^{-x}) / (e^x + e^{-x}) where e is 2.71828182845904523536028747...
2. The returned value is in the]-1, 1[range.

SEE: atanh(), log()

6.3.2 String Functions

The string functions are part of a standard library in ANSI C, and it is recommended to add the following comment at the beginning of your program:

```
/* #include <string.h> */
```

strcat()

PURPOSE: Appends a source string after the destination string.
FORMAT: char *strcat(dest, source) char *dest, *source;
PARAMETERS:

1. Destination string.
2. Source string.

EXPLANATION:

1. The source string stays untouched.
2. The destination string is modified by concatenation of the source string after it. Note that no control is made on the memory available for the resulting string. Using strcat() without enough memory booked for the result string may result in an overflow.
3. The returned value is the destination string, and is therefore equal to the first parameter.

strchr()

PURPOSE: Searches for a character in a string.
FORMAT: char *strchr(string, c) char *string; int c;
PARAMETERS:

1. string.
2. c is a character.

EXPLANATION:

1. The string stays untouched.
2. The returned value is a pointer to the first position of the character c in the string.
3. If the character cannot be found, the function returns the NULL pointer.

strcmp()

PURPOSE: Compares two strings.
FORMAT: int strcmp(string1, string2) char *string1, *string2;
PARAMETERS: 2 strings
EXPLANATION:

1. The parameter strings stays untouched.
2. Returned value is zero when the two strings are identical
3. Retuned value is negative when the first differing character of string1 is smaller than its counterpart character in string2.
4. Retuned value is positive when the first differing character of string1 is bigger than its counterpart character in string2.

strcpy()

PURPOSE: Copies the source string into the destination string.
FORMAT: char *strcpy(dest, source) char *dest, *source;
PARAMETERS:

1. Destination string.
2. Source string.

EXPLANATION:

1. The source string stays untouched.
2. The content of the source string is copied to the memory pointed by the destination string parameter. Note that no control is made on the memory available for the destination string. Using strcpy() without enough memory booked for the destination string may result in an overflow.
3. The returned value is the destination string, and is therefore equal to the first parameter.

strlen()

PURPOSE: Returns the length of a string.
FORMAT: int strlen(string) char *string;
PARAMETERS: string
EXPLANATION:

1. The string stays untouched.
2. The returned value is the number of characters in the string. The NULL character at the end of the string is not included.

6.3.3 Graphical Functions

clrscr()

PURPOSE: Clears display and moves cursor to upper left of screen
FORMAT: void clrscr() ;

getpixel()

PURPOSE: Returns the status of a pixel
FORMAT: int getpixel(x, y) unsigned int x, y;
PARAMETERS: (x, y) is a graphic coordinate.

1. x should be in the [0, 191] range.
2. y should be in the [0, 63] range.

EXPLANATION: Value returned is 1 if the pixel is active (black), 0 if the pixel is inactive.

line()

PURPOSE: Draws a line segment between two graphic coordinates.
FORMAT: void line(x1, y1, x2, y2) unsigned int x1, y1, x2, y2 ;
PARAMETERS:

1. (x1, y1) are the coordinates of the first graphic coordinate.
2. (x2, y2) are the coordinates of the second graphic coordinate.
3. x1 and x2 should be in the [0, 191] range.
4. y1 and y2 should be in the [0, 63] range.

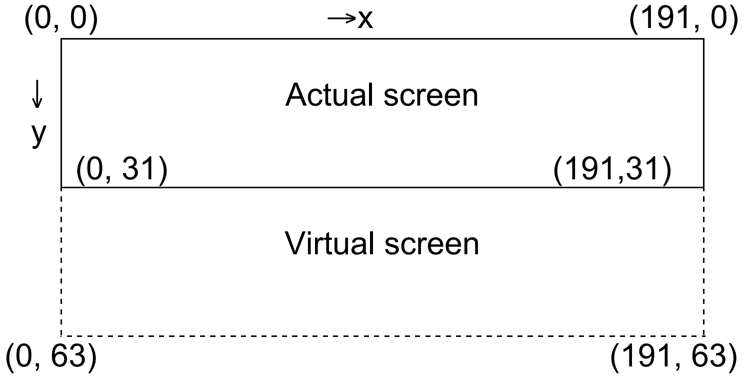
SEE: linec()

linec()

PURPOSE: Erases a line segment between two graphic coordinates.
FORMAT: void linec(x1, y1, x2, y2) unsigned int x1, y1, x2, y2 ;
PARAMETERS:

1. (x1, y1) are the coordinates of the first graphic coordinate.
2. (x2, y2) are the coordinates of the second graphic coordinate.
3. x1 and x2 should be in the [0, 191] range.
4. y1 and y2 should be in the [0, 63] range.

SEE: line()



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