

PC-1211

SHARP

POCKET COMPUTER

APPLICATIONS MANUAL

SHARP POCKET COMPUTER PC-1211 APPLICATIONS MANUAL

Thank you for your purchase of the Sharp Pocket Computer PC-1211.

This booklet covers a variety of fields of science and exemplifies computation programs pertinent to those fields. We shall be delighted if you arrange those programs yourself by reference to the practice in this book so that they best serve your purposes and your computer can display its full capability to be a help for your solving complicated problems.

This manual has been, on our side, edited in accordance with the following standard. We ask you to read it through before starting to operate your machine.

1. Title

Each program is given a brief TITLE summarizing the contents of the program.

2. Program No.

P4 shows this machine, next A ~ X shows the classification.

3. Formula

This column shows the nature of each program and the mathematical expressions pertinent to it.

4. Example

In this column, the calculation example is given.

5. Operation

This column gives the key operation needed to execute a given program based on data shown in the column "Example".

- **Every program requires DEF mode setting**

(For the way of DEF mode setting, consult the Instruction Manual of the PC-1211.

- "CLOAD ∇ Label ∇ ENTER " refers to the key operation that is required when programs recorded on a cassette tape are used. Therefore, this operation must not be made after programming has been accomplished in the PRO mode.

Labels are, in principle, identical to the codes given in the column "PROGRAM NO."

6. Program List

The list, made by a special device, reveals the process of entering the program concerned.

The relation of the program list and the key operation of the PC-1211 are explained in the next page. Write the program in the machine in accordance with the program list.

(Note) Before used, every program must be, after written in the machine, checked enough by reference to "Exampe," etc. whether it is perfect or not.

7. Memory Contents

This list gives a part of memory contents included in each program.

Meanwhile, note that the manual is subject to enlargement or revision without prior notice.

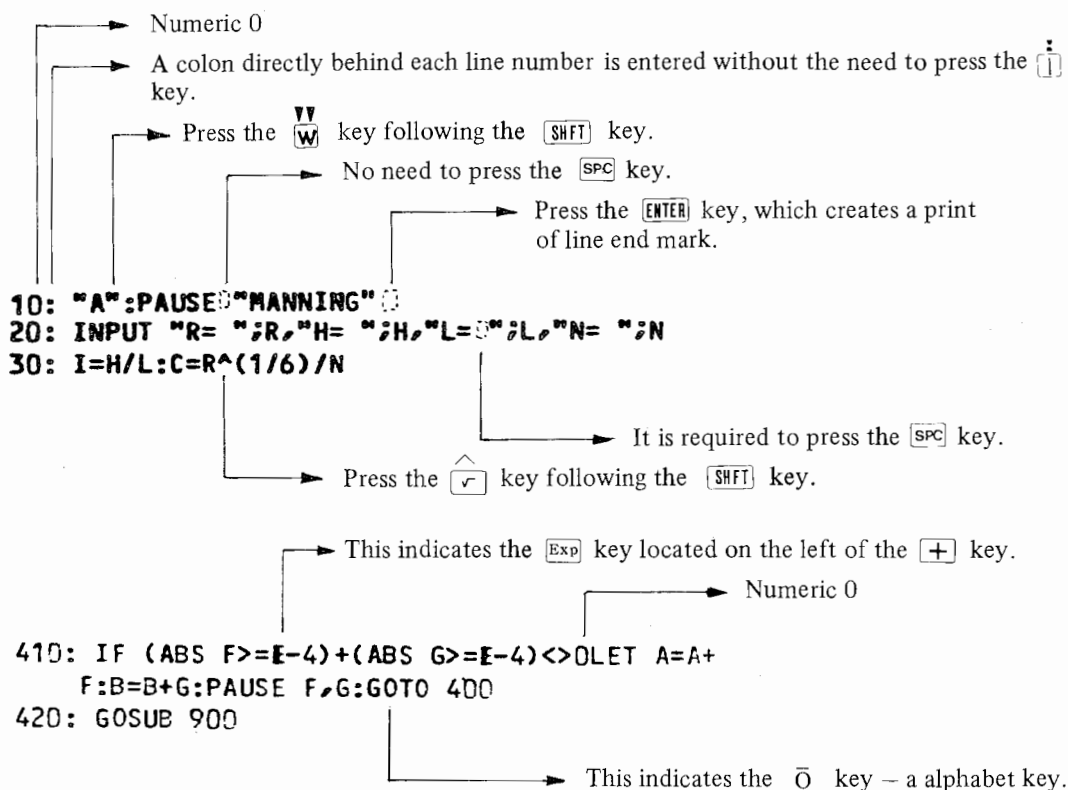
If you find any imperfections in the manual, please write to us.

(Notice) Our company is not reponsible at all for monetary losses and missed profits that could arise in the use of this applications manual.

A sub-routine uses, in principle, the 501th and subsequent lines. GO SUB 1 is two steps shorter than GO SUB 500. In terms of the number of steps, some programs are made so that smaller line numbers are affixed to their sub-routines.

For program lists, note the following instructions.

1. When you enter the program to the PC-1211 in accordance with the program list of this manual, set the machine at the PRO (program) mode and press the **N** **E** **W** **ENTER** keys to clear the program memory.
2. Press the **ENTER** key at the end of each line.
3. The above operation automatically forces a colon (:) to follow directly behind each line number. No colon needs to be written.
4. It requires a space command to create a blank between double wedges **∇ ∇**, but does not require it to create a blank behind each command that is expressed by two or more characters. The following exemplifies this.

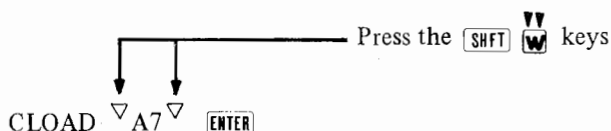


(Note) • Use the **ENTER** or **[SPC]** key properly.

- The number of the last line in the program list indicates the number of step used.

5. After entering the contents of the program list to the PC-1211, when you execute the program without using a cassette tape, skip the operation "CLOAD" **∇ ∇** label **∇ ∇** **ENTER** and set the machine at the DEF (definable) mode.

For [Operation],



When executing programs recorded on the tape (CLOAD), make the CA operation (press the **ON** key twice successively) before loading them. If the above operation is not made, an error could occur in print. The operation is not necessary when programs are written through keys.

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Title SIMULTANEOUS EQUATIONS	PROGRAM NO. P 4 - A - 1
--	--

[Formula]

This program solves simultaneous equations by sweeping-out method.

Express equations in matrices.

$$A x = b, \quad A = \{a_{ij}\}, \quad x = \{x_i\}, \quad b = \{b_i\} \quad (i, j = 1 \sim n)$$

$$p = a_{mm} \quad (m = 2 \sim n)$$

$$q = a_{im} / p \quad (i = 1 \sim m - 1)$$

$$a_{ij} = a_{ij} - q \cdot a_{mj} \quad (i = 1 \sim m)$$

$$b_i = b_i - q \cdot b_m$$

Thus repeating computations, the coefficient of $i < j$ is obtained as

$$a_{ij} = 0$$

Hence,

$$a_{11}x_1 = b_1, \quad \text{then } x_1 = b_1/a_{11}$$

$$a_{21}x_1 + a_{22}x_2 = b_2, \quad \text{then } x_2 = (b_2 - a_{21}x_1)/a_{22}$$

⋮

[Example]

(Ex. 1)
$$\begin{cases} 2x_1 - 2x_2 + 3x_3 = 2 \\ 5x_1 + 2x_2 - 3x_3 = 9 \\ x_1 + 5x_2 - 3x_3 = -12 \end{cases}$$

$$\begin{cases} x_1 = 1.5714 \\ x_2 = -4.9048 \\ x_3 = -3.6508 \end{cases}$$

When n memories:

$$n - 11 = i(i + 1)$$

i elements

Possible up to 9 elements.

A program ... data input

S program ... execute

B program ... re-display of results of computations

[Operation] CLOAD ▽ A1 ▽ **ENTER**

Input	Display	Note	Input	Display	Note
1 SHIFT A	ORDER ?		11 (a_{31}) 1 ENTER	?	
2 (No. of elements) 3 ENTER	?		12 (a_{32}) 5 ENTER	?	
3 (a_{11}) 2 ENTER	?		13 (a_{33}) -3 ENTER	?	
4 (a_{12}) -2 ENTER	?		14 (d_3) -12 ENTER	>	
5 (a_{13}) 3 ENTER	?		15	Execute	
6 (d_1) 2 ENTER	?		16 SHIFT S	1 1.571428571	x_1 display
7 (a_{21}) 5 ENTER	?		17 ENTER	2 -4.904761907	x_2 display
8 (a_{22}) 2 ENTER	?		18 ENTER	3 -3.650793657	x_3 display
9 (a_{23}) -3 ENTER	?		19		
10 (d_2) 9 ENTER	?		20		

Title			PROGRAM NO.
SIMULTANEOUS EQUATIONS			P 4 - A - 1
Memory content			
A	1	n	10: "A":INPUT "ORDER ?" ; A
B	2	m	20: GOSUB 600
C	3	Address	30: B=A:END
D	4	p	40: "S":GOSUB 570
E	5	q	50: D=A(K):IF D<>0GOTO 160
F	6	✓	60: FOR G=1TO B-1
G	7	i	70: GOSUB 500
H	8	j	80: D=A(C):IF D<>0GOTO 110
I	9	For input	90: NEXT G
J	10	✓	100: PRINT "NO SOLUTION": END
K	11	✓	110: FOR H=1TO B-1
L	12	b_i	120: GOSUB 520
M	13		130: A(K)=A(K)+A(C):NEXT H
N	14	After b_i	140: GOSUB 540
O	15	a_{ij}	150: A(K)=A(K)+A(C)
P	16	↓	160: FOR G=1TO B-1
Q	17		170: GOSUB 500
R	18		180: E=A(C)/D:FOR H=1TO B-1
S	19		190: GOSUB 520
T	20		200: A(C)=A(C)-E*A(K):NEXT H
U	21		210: GOSUB 540
V	22		220: A(C)=A(C)-E*A(K):NEXT G
W	23		230: B=B-1:IF B>1GOTO 40
X	24		240: FOR B=1TO A-1
Y	25		250: GOSUB 570
Z	26		260: A(C)=A(C)/A(K):E=A(C)
			270: FOR G=B+1TO A
			280: GOSUB 550
			290: A(C)=A(C)-E*A(K)
			300: NEXT G:NEXT B
			310: B=A:GOSUB 570
			320: A(C)=A(C)/A(K)
			330: "B":FOR G=1TO A
			340: GOSUB 550
			350: I=A(C)
			360: PRINT USING "####";G;" ";USING ;I
			370: NEXT G
			380: END
			500: K=A*B+B+11:C=A*G+B+11
			510: RETURN
			520: K=A*B+H+11:C=A*G+H+11
			530: RETURN
			540: K=B+11:C=G+11:RETURN
			550: C=G+11:K=A*G+B+11
			560: RETURN
			570: C=B+11:K=A*B+C:RETURN
			600: C=12:K=A+12
			610: FOR G=1TO A
			620: FOR H=1TO A
			630: PAUSE USING "####";G;H:INPUT I
			640: A(K)=I:K=K+1:NEXT H
			650: BEEP 1:INPUT I
			660: A(C)=I:C=C+1:NEXT G
			670: RETURN
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Title INVERSE MATRIX

PROGRAM NO.
P4 - A-2

[Formula]

This program determines an inverse matrix by sweeping-out method.

A matrix is given: $A = \{ a_{ij} \} \quad (i, j=1 \sim n)$

$$\begin{cases} a_{ii} = a_{ii} + 1 & (i=1 \sim n) \\ p = a_{nm} - 1 & (m=1 \sim n) \\ a_{mj} = a_{mj} / p & (j=1 \sim n) \\ a_{ij} = a_{ij} - a_{im} a_{mj} & (i=1 \sim n, i \neq m) \\ a_{ii} = a_{ii} - 1 & (i=1 \sim n) \end{cases}$$

As a result of computations above, $[a_{ij}]$ is changed to an inverse matrix of the original matrix.

[Example]

$$\begin{bmatrix} 4 & 3 & 2 & 1 \\ 3 & 3 & 2 & 1 \\ 2 & 2 & 2 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}^{-1} = \begin{bmatrix} 1 & -1 & 0 & 0 \\ -1 & 2 & -1 & 0 \\ 0 & -1 & 2 & -1 \\ 0 & 0 & -1 & 2 \end{bmatrix}$$

When n memories:
Possible up to $\sqrt{n-9}$ elements
Possible up to 11 elements.

- A** program ... data input
- S** program ... execute
- F** program ... correction of data

[Operation] CLOAD ∇ A2 ∇ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHFT A	ORDER ?		11	When correcting		
2	(n) 4 ENTER	?		12	SHFT F		
3	(a_{11}) 4 ENTER	?		13	(i) ENTER		
4	(a_{12}) 3 ENTER	?		14	(j) ENTER		
5	:	:		15	(Correct value) ENTER		
6	(a_{1n}) 1 ENTER	?		16			
7	(a_{21}) 3 ENTER	?		17			
8	:	:		18	Execute operation		
9	(a_{nn}) 1 ENTER	>		19	SHFT S	1 1 1.0000	(1,1) solution
10				20	ENTER	1 2 -1.0000	(1,2) solution

Title INVERSE MATRIX			PROGRAM NO. P 4 - A-2
Memory content			
A	1	n	10: "A":INPUT "ORDER ?";A
B	2	m	20: I=10:FOR E=1TO A
C	3	p, q	30: FOR F=1TO A
D	4		40: PAUSE USING "####";E;F:INPUT G
E	5	i	50: A(I)=G:I=I+1
F	6	j	60: NEXT F:NEXT E
G	7	For input	70: END
H	8	Address	80: "S":FOR B=1TO A
I	9	Address	90: GOSUB 500
J	10	a_{ij}	100: A(H)=A(H)+1
K	11		110: NEXT B
L	12		120: GOSUB 500
M	13		130: D=A(H)-1
N	14		140: IF D=0LET PRINT "NO SOLUTION":END
O	15		150: GOSUB 600
P	16		160: B=B-1
Q	17		170: IF B>0GOTO 120
R	18		180: FOR B=1TO A
S	19		190: GOSUB 500
T	20		200: A(H)=A(H)-1:NEXT B:BEEP 3
U	21		210: "B":I=10:FOR E=1TO A
V	22		220: FOR F=1TO A
W	23		230: PRINT USING "####";E;F;USING "#####.##
X	24		##";A(I)
Y	25		240: I=I+1
Z	26		250: NEXT F:NEXT E
			260: END
			270: "F":PAUSE"CORRECT":INPUT "I= ";E:INPUT
			"J= ";F:INPUT G
			280: GOSUB 510
			290: A(I)=G:GOTO 270
			500: C=B:GOTO 520
			510: C=F
			520: C=C-A+9 ?
			530: H=A*B+C:I=A*E+C
			540: RETURN
			600: FOR F=1TO A
			610: GOSUB 510
			620: A(H)=A(H)/D:NEXT F
			630: FOR E=1TO A
			640: IF B=EGOTO 690
			650: GOSUB 500
			660: D=A(I):FOR F=1TO A
			670: GOSUB 510
			680: A(I)=A(I)-D*A(H):NEXT F
			690: NEXT E:RETURN
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Title	DETERMINANT	PROGRAM NO. P 4 - A - 3
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[Formula]

This program transforms a matrix into a triangular matrix by sweeping-out method, and computes the determinant.

A matrix is given: $\{a_{ij}\} \quad (i, j=1 \sim n)$

$$\begin{cases} p = a_{mm} & (m=2 \sim n) \\ q = a_{im}/p & (i=1 \sim m-1) \\ a_{ij} = a_{ij} - q \cdot a_{mj} & (j=1 \sim m) \end{cases}$$

Thus calculating, with respect to the element of $i < j$, we obtain

$$a_{ij} = 0$$

$$\text{Hence, } \det = a_{11} \cdot a_{22} \cdot a_{33} \cdot \dots \cdot a_{nn}$$

[Example]

(Ex. 1)

$$\begin{vmatrix} 2 & 3 \\ 5 & 8 \end{vmatrix} = 1$$

(Ex. 2)

$$\begin{vmatrix} 2 & 5 \\ 7 & 2 \end{vmatrix} = -31$$

(Ex. 3)

$$\begin{vmatrix} 4 & 7 & 1 & 8 \\ 5 & -1 & 2 & -4 \\ 3 & 12 & -5 & 6 \\ 1 & 4 & 7 & 2 \end{vmatrix} = -3276$$

(Note)

Max. 10 elements

- A** program ... data input
- S** program ... execute
- F** program ... correction of data

[Operation] CLOAD ∇ A3 ∇ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	ORDER ?		11	When correcting		
2	(No. of rows) 2 ENTER	?		12	SHIFT F		
3	(a_{11}) 2 ENTER	?		13	(i) ENTER		
4	(a_{12}) 3 ENTER	?		14	(j) ENTER		
5	:	:		15	(Correct value) ENTER		
6	(a_{1n}) :	:		16			
7	(a_{21}) 5 ENTER	?		17			
8	:	:		18	Execute operation		
9				19	SHIFT S	DET 1	(Ex. 1)
10				20			

Title	PRODUCT OF MATRICES
PROGRAM NO. P 4 - A-4	

[Formula]

This program computes the product C (mn type) of an ml type matrix A and an ln type matrix B.

$$\begin{bmatrix} a_{11} & a_{12} & \dots & a_{1\ell} \\ a_{21} & a_{22} & \dots & a_{2\ell} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{m\ell} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1n} \\ b_{21} & b_{22} & \dots & b_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ b_{\ell 1} & b_{\ell 2} & \dots & b_{\ell n} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ c_{m1} & c_{m2} & \dots & c_{mn} \end{bmatrix}$$

$$c_{ij} = \sum_{k=1}^{\ell} a_{ik} \cdot b_{kj}$$

[Example]

$$\begin{bmatrix} 4 & 0 & -1 \\ -3 & 3 & 7 \\ -9 & 2 & 5 \\ 5 & -1 & 3 \end{bmatrix} \begin{bmatrix} -1 & 5 \\ -6 & -6 \\ 1 & 4 \end{bmatrix} = \begin{bmatrix} -5 & 16 \\ -8 & -5 \\ 2 & -37 \\ 4 & 43 \end{bmatrix}$$

$$m\ell + \ell n + mn \leq 144$$

[Operation] CLOAD ∇ A4 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	M=		11	(b_{11}) -1 ENTER	?	
2	(m) 3 ENTER	L=		12	$:$ $:$	$:$	
3	(ℓ) 3 ENTER	N=		13	(b_{1n}) ENTER	?	
4	(n) 1 ENTER	?		14	$:$ $:$	$:$	
5	(a_{11}) 4 ENTER	?		15	$(b_{\ell n})$ 1 ENTER	1 1 -3.0000	(1,1)
6	(a_{12}) 0 ENTER	?		16	ENTER	1 2	(1,2)
7	$:$ $:$	$:$		17	$:$	$:$ $:$	
8	(a_{21}) -3 ENTER	?		18	$:$	$:$ $:$	
9	$:$ $:$	$:$		19			
10	$(a_{m\ell})$ 5 ENTER	?		20			

Title PRODUCT OF MATRICES			PROGRAM NO. P 4 - A - 4
Memory content			
A	1	m	
B	2	l	
C	3	n	
D	4	Input	
E	5		10: "A":CLEAR
F	6		20: INPUT "M= ";A;"L= ";B;"N= ";C
G	7		30: FOR F=1TO A
H	8		40: FOR G=1TO B
I	9		50: GOSUB 500
J	10		60: E=B*(F-1)+G+10
K	11	Input data a_{11}	70: A(E)=D
L	12	a_{12}	80: NEXT G:NEXT F
M	13	$\vdots$	90: FOR F=1TO B
N	14	$\downarrow$ $\vdots$	100: FOR G=1TO C
O	15		110: GOSUB 500
P	16	After input data	120: E=C*(F-1)+G+A*B+10
Q	17	Output data	130: A(E)=D:NEXT G:NEXT F
R	18	c_{11}	140: FOR F=1TO A
S	19	$\vdots$	150: FOR G=1TO C
T	20		160: E=C*(F-1)+G+B*(A+C)+10
U	21		170: FOR H=1TO B
V	22		180: I=B*(F-1)+H+10
W	23		190: J=C*(H-1)+G+A*B+10
X	24		200: A(E)=A(E)+A(I)*A(J)
Y	25		210: NEXT H:NEXT G:NEXT F
Z	26		220: I=I-2:FOR F=1TO A
			230: FOR G=1TO C
			240: E=C*(F-1)+G+B*(A+C)+10:H=A(E)
			250: PRINT USING "####";F;G;USING "#####.##"
			##";H
			260: NEXT G:NEXT F:END
			500: PAUSE USING "####";F;G:INPUT D
			510: RETURN
			398

Title	MUTUAL CONVERSION, AND ADDITION AND SUBTRACTION BETWEEN DECIMAL NOTATION AND OTHER NOTATION	PROGRAM NO. P 4 -A- 5
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[Formula]

Mutual conversion, and addition and subtraction between decimal notation and p-based notation.

- Program A: conversion from p-based notation into decimal notation
 Program B: conversion from decimal notation into p-based notation
 Program C: addition in p-based notation
 Program X: subtraction in p-based notation
 Program M: setting of p, and clearing of memory for accumulative total of addition and subtraction

[Example]

When p is 7 (Decimal numerals are enclosed in parentheses):

- (1) $12 \rightarrow 9_{(10)}$, $20 \rightarrow 14_{(10)}$ (all heptal numerals, except 9, 14)
 (2) $12 + 20 + 156 - 23 \rightarrow 165$

- (NOTES) 1. When performing addition or subtraction, first set the value of p (operation of program M).
 2. When the base is larger than 10, the display is given in two digits each.
 3. Maximum 7 digits can be computed in up to decimal notation, and 5 digits in undecimal and higher notations.

When performing addition or subtraction, refer to the example of operation below.

[Operation] CLOAD ∇ A5 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHFT M	BASE ?		11	SHFT M	BASE ?	
2	(P) 7 ENTER	>		12	7 ENTER		
3				13	SHFT C	DATA=	
4	SHFT A	DATA=		14	12 ENTER	7 12	
5	12 ENTER	7 9	Base, value	15	ENTER	DATA=	
6	ENTER	DATA=		16	20 ENTER	7 32	
7	20 ENTER	7 14		17	ENTER	DATA=	
8				18	156 ENTER	7 221	
9				19	SHFT X	DATA=	
10				20	23 ENTER	7 165	

Title

MUTUAL CONVERSION BETWEEN RECTANGULAR
COORDINATES AND POLAR COORDINATES

PROGRAM NO.
P 4 - A - 6

[Formula]

Rectangular coordinates and polar coordinates are mutually converted in two- and three-dimensional space.

When angle designation is DEG, inputs and outputs are made in DEG, when RAD is designated, in RAD.

Two-dimensional space:

- Rectangular coordinates to polar When $x = y = 0$, $r = 0$: θ = undecided

$$\begin{cases} r = \sqrt{x^2 + y^2} \\ \text{When } y \geq 0, \theta = \cos^{-1}(x/r) \\ \text{When } y < 0, \theta = -\cos^{-1}(x/r) \end{cases}$$

- Polar coordinates to rectangular

$$\begin{cases} x = r \cos \theta \\ y = r \sin \theta \end{cases}$$

Three-dimensional space:

- Rectangular coordinates to polar

When $r = \sqrt{x^2 + y^2 + z^2}$, $x = y = z = 0$,
 $r = 0$: θ, ϕ : undecided

$$\theta = \sin^{-1}(z/r)$$

When $x > 0$,

$$\phi = \tan^{-1}(y/x)$$

When $x = 0$,

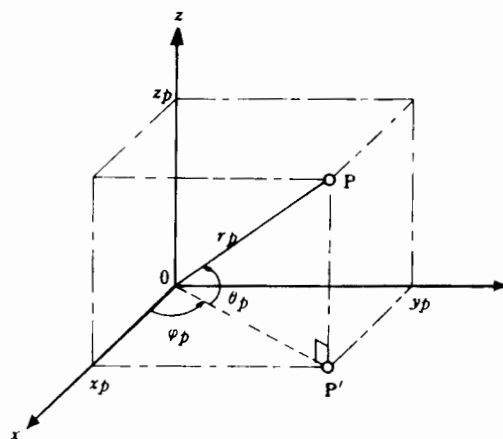
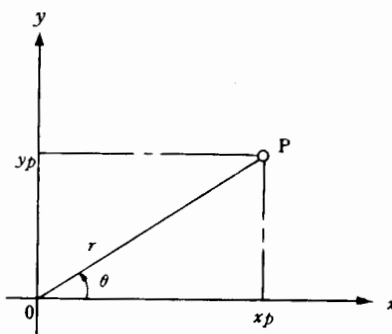
$$\text{If } y \geq 0, \phi = 90^\circ$$

$$\text{If } y < 0, \phi = -90^\circ$$

When $x < 0$,

$$\text{If } y \geq 0, \phi = \tan^{-1}(y/x) + 180^\circ$$

$$\text{If } y < 0, \phi = \tan^{-1}(y/x) - 180^\circ$$



Input	Display	Note	Input	Display	Note
1 [SHIFT] [A]	X=		11 [SHIFT] [C]	X=	
2 (x) -1 [ENTER]	Y=		12 (x) -1 [ENTER]	Y=	
3 (y) $\sqrt{3}$ [ENTER]	2 120		13 (y) 2 [ENTER]	Z=	
4			14 (z) -3 [ENTER]	R= 3.741657387	
5			15 [ENTER]	THETA=-53.30077479	
6			16 [ENTER]	PHI= 116.5650512	
7			17		
8			18		
9			19		
10			20		

Title	MUTUAL CONVERSION BETWEEN RECTANGULAR COORDINATES AND POLAR COORDINATES	PROGRAM NO. P4-A-6
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◦ Polar coordinates to rectangular

$$\begin{cases} x = r \cos \theta \cos \varphi \\ y = r \cos \theta \sin \varphi \\ z = r \sin \theta \end{cases}$$

- A** program ... two-dimensional, rectangular to polar
- B** program ... two-dimensional, polar to rectangular
- C** program ... three-dimensional, rectangular to polar
- D** program ... three-dimensional, polar to rectangular

[Operation] CLOAD ▽A6 ▽ **ENTER**

The examples refer to the case of DEG designation.

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title		MUTUAL CONVERSION BETWEEN RECTANGULAR COORDINATES AND POLAR COORDINATES	PROGRAM NO. P 4 - A - 6
Memory content			
A	1		
B	2		
C	3	θ	10: "A":GOSUB 500
D	4		20: R= $\sqrt{(X*X+Y*Y)}$
E	5		30: IF R=0PRINT "R=0 THETA, PHI = ?":END
F	6	φ	40: GOSUB 700
G	7		50: C=ACS (X/R)*A
H	8		60: PRINT R,C:END
I	9		70: "B":GOSUB 600:Y=R*SIN C
J	10		80: PRINT X,Y:END
K	11		90: "C":GOSUB 500
L	12		100: INPUT "Z= ";Z
M	13		110: R= $\sqrt{(X*X+Y*Y+Z*Z)}$
N	14		120: IF R=0GOTO 30
O	15		130: C=ASN (Z/R)
P	16		140: IF X>0LET F=ATN (Y/X):GOTO 180
Q	17		150: GOSUB 700
R	18	r	160: IF X=0LET F=A*ACS 0:GOTO 180
S	19		170: F=ATN (Y/X)+A*ACS -1
T	20		180: PRINT "R=",R:PRINT "THETA=",C:PRINT "PHI=",F
U	21		190: END
V	22		200: "D":GOSUB 600
W	23		210: INPUT "PHI= ";F
X	24	x	220: X=X*COS F:Y=Y*SIN F:Z=R*SIN C
Y	25	y	230: PRINT "X=",X:PRINT "Y=",Y:PRINT "Z=",Z
Z	26	z	240: END
			500: INPUT "X= ";X,"Y= ";Y
			510: USING :RETURN
			600: INPUT "R= ";R,"THETA= ";C
			610: USING :X=R*COS C:Y=R*SIN C:RETURN
			700: A=(Y=0)+SGN Y:RETURN
			432

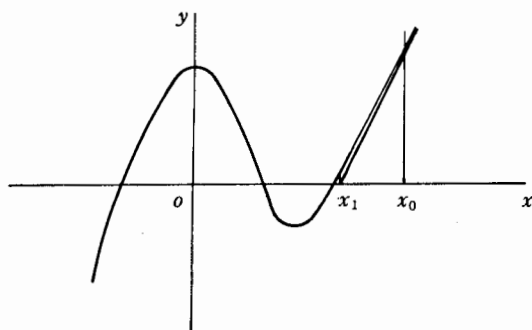
SHARP

Title ROOT DETERMINING CALCULATION ACCORDING TO NEWTON'S METHOD

PROGRAM NO.
P 4-A-7

[Formula]

Determine a root of a function according to Newton's method.



$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

When the absolute value of the difference between x_n and x_{n+1} becomes less than 10^{-8} , x_n is regarded as a root, and computation is terminated.

Here, $f'(x)$ of linear differential is defined as follows:

$$f'(x) = \frac{f(x+h) - f(x)}{h} \quad (h: \text{minor section})$$

When changing 10^{-8} , vary E-8 in line 60.

[Example]

$$x^3 - 2x^2 - x + 2 = 0$$

$$\left. \begin{array}{l} \text{Suppose, } x_0 = 3 \\ h = 10^{-4} \end{array} \right\} \text{ then, } x = 2$$

If error message is displayed in the process of operation, change x_0 , h , and retry.

Write the function, as subroutine, after line 500.

Method of writing (in the case of example above):

Set to PRO mode (by pressing proper **MODE** key).

500B=((X-2)*X-1)*X+2 **ENTER**

510RETURN **ENTER**

This ends writing.

Next, change to DEF mode, and execute.

[Operation] CLOAD ∇ A7 ∇ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	XO=		11			
2	(x_0) 3 ENTER	H=		12			
3	(h) 0.0001 ENTER	ANS. 2		13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title		ROOT DETERMINING CALCULATION ACCORDING TO NEWTON'S METHOD	PROGRAM NO. P 4 -A- 7
Memory content			
A	1	h	<pre> 10: "A":INPUT "X0= ";C,"H= ";A 20: X=C:GOSUB 500 30: Y=B:X=A+C 40: GOSUB 500 50: D=C:C=D-A*Y/(B-Y) 60: IF ABS (D-C)>=E-8GOTO 20 70: BEEP 3:PRINT "ANS.",C 80: END 500: B=((X-2)*X-1)*X+2 510: RETURN 134 </pre>
B	2	$f(x)$	
C	3	x_0	
D	4	$f(x+h)$	
E	5		
F	6		
G	7		
H	8		
I	9		
J	10		
K	11		Function (An example containing the following) $f(x) = ((x-2)x-1)x+2$ $= x^3 - 2x^2 - x + 2$
L	12		
M	13		
N	14		
O	15		
P	16		
Q	17		
R	18		
S	19		
T	20		
U	21		
V	22		
W	23		
X	24	x	
Y	25	$f(x)$	
Z	26		

Title QUADRATIC EQUATION	PROGRAM NO. P 4 -A- 8
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[Formula]

Determine the roots of a quadratic equation $ax^2 + bx + c = 0$ ($a \neq 0$).

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

1) When $b^2 - 4ac > 0$, the roots are real roots:

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

2) When $b^2 - 4ac = 0$, the roots are equal roots:

$$x = -\frac{b}{2a}$$

3) When $b^2 - 4ac < 0$, the roots are imaginary roots:

Rear part: $\frac{-b}{2a}$

Imaginary part: $\frac{\sqrt{4ac - b^2}}{2a}$

[Example]

(1) $4x^2 - x - 1 = 0$ Two real roots: $x = 0.64 \dots, -0.39 \dots$

(2) $5x^2 + 4x + 1 = 0$ Imaginary roots: real part, -0.4 ; imaginary part, 0.2

(NOTE) In the case of two real roots, **REAL** and x_1, x_2 are printed.
In the case of equal root, **EQUAL** and x_1 are printed.
In the case of imaginary roots, ****REAL****, **IMAGINARY**, and real part and imaginary part are printed.

[Operation] CLOAD ∇ A8 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	A=		11	SHIFT A	A=	
2	(a) 4 ENTER	B=		12	(a) 5 ENTER	B=	
3	(b) -1 ENTER	C=		13	(b) 4 ENTER	C=	
4	(c) -1 ENTER	REAL 6.40388 E-01		14	(c) 1 ENTER	**REAL** -0.4	
5	ENTER	REAL -3.90388 E-01		15	ENTER	IMAGINARY 0.2	
6				16			
7				17	Real part of imaginary root is displayed in **REAL** .		
8				18			
9				19			
10				20			

Title	EQUATION OF THIRD DEGREE	PROGRAM NO.
		P 4 - A - 9

[Formula]

This program solves a cubic equation by Cardan's solution.

$$Ax^3 + Bx^2 + Cx + D = 0 \quad (\text{where } A \neq 0, \text{ each coefficient being a real number.})$$

The following equation is obtained by dividing every coefficient by A.

$$x^3 + ax^2 + bx + c = 0$$

If the second order term is eliminated by the conversion $x = y - \frac{a}{3}$,

$$y^3 + 3py + q = 0$$

$$p = \frac{b}{3} - \frac{a^2}{9} \quad q = c - \frac{ab}{3} + \frac{2a^3}{27}$$

If y is let to equal $u + v$, the above equation $y^3 + 3py + q = 0$ is:

$$u^3 + v^3 + 3uv(u+v) + 3p(u+v) + q = 0$$

Here, if $u^3 + v^3$ is let to equal $-q$, $uv = -p$.

$$u^3 + v^3 = -q$$

$$u^3 v^3 = -p^3$$

This reveals that u^3 and v^3 are the roots of the quadratic equation $t^2 + qt - p^3 = 0$.

That is to say,

$$u^3 = \frac{1}{2} (-q + \sqrt{q^2 + 4p^3})$$

$$v^3 = \frac{1}{2} (-q - \sqrt{q^2 + 4p^3})$$

Hence, the roots of the equation $y^3 + 3py + q = 0$, α , β , and γ , are as follows:

$$\alpha = u + v$$

$$\beta = -\frac{1}{2}(u+v) + \frac{\sqrt{3}}{2}i(u-v)$$

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	A=		11			
2	(A) 1 [ENTER]	B=		12			
3	(B) 1 [ENTER]	C=		13			
4	(C) -2 [ENTER]	D=		14			
5	(D) -2 [ENTER]	REAL ROOT 1.414213562		15			
6	[ENTER]	-1.414213562 -9.99999E-01		16			
7				17			
8				18			
9				19			
10				20			

Title EQUATION OF THIRD DEGREE	PROGRAM NO. P4-A-9
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$$\gamma = -\frac{1}{2}(u+v) - \frac{\sqrt{3}}{2}i(u-v)$$

The equation above is divided into the real part and the imaginary part.

I) If $q^2 + 4p^3 > 0$

Since u^3 and v^3 are real numbers, u and v are supposed to take the real cubic roots of u^3 and v^3 , and the equation above may be used directly. This is the case of one real root and two imaginary roots.

II) If $q^2 + 4p^3 < 0$, u^3 and v^3 yield imaginary roots.

Suppose $u^3 = re^{i\theta}$

$$v^3 = re^{-i\theta}$$

$$r = \sqrt{-p^3}$$

$$\theta = \tan^{-1} \frac{\sqrt{-q^2 - 4p^3}}{-q}$$

Then,

$$u = \sqrt[3]{-p} \left(\cos \frac{\theta}{3} + i \sin \frac{\theta}{3} \right)$$

$$v = \sqrt[3]{-p} \left(\cos \frac{\theta}{3} + i \sin \frac{\theta}{3} \right)$$

Accordingly, the roots α, β, γ of $y^3 + 3py + q = 0$ are:

$$\alpha = 2\sqrt[3]{-p} \sin \left(\frac{\pi}{2} - \frac{\theta}{3} \right)$$

$$\beta = -2\sqrt[3]{-p} \sin \left(\frac{\pi}{6} + \frac{\theta}{3} \right)$$

$$\gamma = -2\sqrt[3]{-p} \sin \left(\frac{\pi}{6} - \frac{\theta}{3} \right)$$

These roots are all different real numbers.

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

SHARP

Title	EQUATION OF THIRD DEGREE	PROGRAM NO. P 4 - A - 9
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III) If $q^2 + 4p^3 = 0$ and $p \neq 0$, then $u^3 = v^3 = -\frac{q}{2}$

$$\text{Hence, } u = v = \sqrt[3]{-\frac{q}{2}}$$

$$\text{So, } \alpha = 2u$$

$$\beta = \gamma = -u$$

The roots are equal roots and a different real root.

IV) If $q^2 + 4p^3 = 0$ and $p = 0$, then $q = 0$. From $u = v = 0$, we obtain

$$\alpha = \beta = \gamma = 0.$$

This is the case of triple roots.

Finally, by adding $\frac{a}{3}$ to α, β, γ , respectively, the solutions of the original equation may be obtained.

Meanwhile, two different roots (or three roots) which are very close to each other may be judged as equal roots. Or, a reverse case to this may be also considered.

[Operation] CLOAD ∇ A9 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

SHARP

Title	EQUATION OF FOURTH DEGREE	PROGRAM NO. P 4 - A - 10
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[Formula]

This program solves an equation of fourth degree by using Ferrari's theorem.

$$\text{Given } Ax^4 + Bx^3 + Cx^2 + Dx + E = 0$$

Dividing each term by A yields

$$x^4 + a_1 x^3 + a_2 x^2 + a_3 x + a_4 = 0$$

Suppose $x = y - \frac{a_1}{4}$, then it follows

$$y^4 + ky^2 + \ell y + m = 0$$

Coefficients k, ℓ, m are

$$\left. \begin{aligned} k &= -\frac{3}{8}a_1^2 + a_2 \\ \ell &= \frac{1}{8}a_1^3 - \frac{1}{2}a_1 a_2 + a_3 \\ m &= -\frac{3}{256}a_1^4 + \frac{1}{16}a_1^2 a_2 - \frac{1}{4}a_1 a_3 + a_4 \end{aligned} \right\}$$

Attempt to rewrite the equation of fourth degree in terms of y , $y^4 + ky^2 + \ell y + m$, in the form of difference of squares, for instance,

$$(y^2 + \frac{u}{2})^2 - v(y-w)^2 \dots\dots\dots \textcircled{1}$$

This expression may be developed into

$$y^4 + (u-v)y^2 + 2vwy + (\frac{u^2}{4} - vw^2)$$

Comparing this with the equation above, we obtain

$$u-v = k, 2vw = \ell, \frac{u^2}{4} - vw^2 = m$$

Hence, $v = u - k$ is obtained from the first equation, and $w = 1/(2(u - k))$ from the second equation. Substitution into the third equation yields

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	A=		11			
2	(A) 1 [ENTER]	B=		12			
3	(B) -1 [ENTER]	C=		13			
4	(C) -3 [ENTER]	D=		14			
5	(D) 1 [ENTER]	E=		15			
6	(E) 2 [ENTER]	2 0		16			
7	[ENTER]	1 0		17			
8	[ENTER]	-1 0		18			
9	[ENTER]	-1 0		19			
10		Real part Imaginary part		20			

Title EQUATION OF FOURTH DEGREE

PROGRAM NO.
P 4-A-10

$$\frac{u^2}{4} - \frac{\ell^2}{4(u-k)} = m$$

By rearranging this, an equation of third degree in terms of u may be obtained as follows:

$$u^3 - ku^2 - 4mu + (4km - \ell^2) = 0$$

Regarding u as one root of this equation, it is substituted in eq. (1) and supposed as 0. That is, by solving

$$\left[y^2 + \sqrt{v} y + \frac{u}{2} - \sqrt{v} w \right] \left[y^2 - \sqrt{v} y + \frac{u}{2} + \sqrt{v} w \right] = 0$$

or,

$$y^2 + \sqrt{u-k} y + \left(\frac{u}{2} - \frac{\ell}{2\sqrt{u-k}} \right) = 0$$

$$y^2 - \sqrt{u-k} y + \left(\frac{u}{2} + \frac{\ell}{2\sqrt{u-k}} \right) = 0$$

x will be determined.

[Example]

$$x^4 - x^3 - 3x^2 + x + 2 = 0$$

Answer: 2, 1, -1, -1

[Operation] CLOAD ▽A10▽ENTER

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title		EQUATION OF FOURTH DEGREE		PROGRAM NO. P 4 - A - 10
Memory content				
A	1	10: "A":INPUT "A= ";X,"B= ";G,"C= ";H,"D= "		
B	2	;I,"E= ";J		
C	3	20: FOR Y=7TO 10		
D	4	30: A(Y)=A(Y)/X:NEXT Y		
E	5	40: G=G/4:F=G*G		
F	6	50: J=4*(F*H-3*F*F-G*I+J)		
G	7	60: I=8*F*G-2*G*H+I		
H	8	70: H=(H-6*F)/3		
I	9	80: A=3*H*J-I*I		
J	10	90: B=-J/3-H*H		
K	11	100: C=A-H*J-2*H*H*H		
L	12	110: Y=4*B*B*B+C*C		
M	13	120: IF Y>=0GOTO 160		
N	14	130: Y=ACS (C/(2*B* $\sqrt{(-B)}$))/3		
O	15	140: X=2* $\sqrt{(-D)}$ *SIN (ASN 1-Y)+H		
P	16	150: GOTO 180		
Q	17	160: Y= $\sqrt{Y}$:A=.5*(Y-C):B=.5*(-C-Y)		
R	18	170: X=ABS A^(1/3)*SGN A+ABS B^(1/3)*SGN B+H		
S	19	180: Y=3*H:A=-X-Y		
T	20	190: F= $\sqrt{ABS (X-Y)}$		
U	21	200: B=2*I/F:C=F/2		
V	22	210: IF Y>XGOTO 340		
W	23	220: K=0		
X	24	230: X=C-G:Y=(A-B)/4		
Y	25	240: IF Y>=0GOTO 300		
Z	26	250: Y= $\sqrt{ABS Y}$		
		260: BEEP 3:PRINT X,Y		
		270: PRINT X,-Y		
		280: IF K=1END		
		290: K=1:B=-B:C=-C:GOTO 230		
		300: BEEP 3:Y= $\sqrt{Y}$:PRINT C+Y-G,0		
		310: PRINT C-Y-G,0		
		320: IF K=1END		
		330: GOTO 290		
		340: B= $\sqrt{(A*A+B*B)}$		
		350: X= $\sqrt{(.5*(A+B))}/2$		
		360: Y= $\sqrt{(.5*(B-A))}/2$		
		370: BEEP 3:IF I>=0GOTO 430		
		380: PRINT X-G,C-Y		
		390: PRINT X-G,Y-C		
		400: PRINT -X-G,C+Y		
		410: PRINT -X-G,-C-Y		
		420: END		
		430: PRINT X-G,C+Y		
		440: PRINT X-G,-C-Y		
		450: PRINT -X-G,C-Y		
		460: PRINT -X-G,Y-C		
		470: END		
		684		

SHARP

Title APPROXIMATE DEFINITE INTEGRAL BY SIMPSON'S METHOD

PROGRAM NO.
P4 - A-11

[Formula]

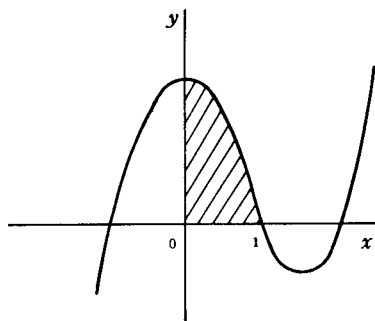
Compute a definite integral by using Simpson's rule.

$$S = \int_{x_0}^{x_{2p}} f(x) dx = \frac{h}{3} [(y_0 + y_{2p}) + 4(y_1 + y_3 + \dots + y_{2p-1}) + 2(y_2 + y_4 + \dots + y_{2p-2})]$$

$$h = \frac{(x_{2p} - x_0)}{2p}$$

p: number of divisions

[Example]



$$y = x^3 - 2x^2 - x + 2$$

$$= ((x-2)x-1)x+2$$

$$\int_0^1 y dx = \frac{13}{12}$$

Write in the function, as subroutine, after line 500.

How to write in (in the case of example above):

Set to PRO mode (by pressing proper **MODE** key).

500 Y=((x-2)*x-1)*x+2 **ENTER**

510 RETURN **ENTER** This ends writing.

Next, change to DEF mode, and execute.

[Operation] CLOAD ∇ A11 ∇ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	X0=		11			
2	(x ₀) 0 ENTER	X2P=		12			
3	(x _{2p}) 1 ENTER	P=		13			
4	(p) 20 ENTER	ANS. 1.08333333		14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

SHARP

Title FIRST ORDER DIFFERENTIAL EQUATION

PROGRAM NO.
P 4 - A - 12

[Formula]

This program is to solve a first order differential equation according to Runge-Kutta-Gill method.

The equation is $y' = f(x, y)$, and the initial condition is (x_0, y_0) .

Taking the value of x at intervals of h ,

$$x_n = x_0 + nh \quad (n = 1, 2, \dots)$$

the value of y at x_n , namely y_n , is obtained sequentially.

The formula to obtain x_{n+1}, y_{n+1} from x_n, y_n is given as follows according to Runge-Kutta-Gill method.

$$k_0 = hf(x_n, y_n) \quad r_1 = (1/2)(k_0 - 2q_0)$$

$$y^{(1)} = y_n + r_1 \quad q_1 = q_0 + 3r_1 - (1/2)k_0 \quad k_1 = hf(x_n + h/2, y^{(1)})$$

$$r_2 = (1 - \sqrt{1/2})(k_1 - q_1)$$

$$y^{(2)} = y^{(1)} + r_2 \quad q_2 = q_1 + 3r_2 - (1 - \sqrt{1/2})k_1 \quad k_2 = hf(x_n + h/2, y^{(2)})$$

$$r_3 = (1 + \sqrt{1/2})(k_2 - q_2)$$

$$y^{(3)} = y^{(2)} + r_3 \quad q_3 = q_2 + 3r_3 - (1 + \sqrt{1/2})k_2 \quad k_3 = hf(x_{n+1}, y^{(3)})$$

$$r_4 = (1/6)(k_3 - 2q_3)$$

$$y_{n+1} = y^{(3)} + r_4 \quad q_4 = q_3 + 3r_4 - (1/2)k_3$$

Thus, y_{n+1} is determined from y_n .

Here, $n = 0, 1, 2, \dots$

The value of q_0 is 0 at start point x_0 , and q_4 is taken as new q_0 thereafter.

* As for the function, refer to the Programming list.

[Example]

Equation $y' = -xy$ is solved, under the initial condition of $x_0 = 0$, provided $y_0 = 10$.

However, suppose $h = 0.01$, and y is obtained when $x = 0.01, 0.02, \dots$

[Operation] CLOAD ∇ A12 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	X0 =		11			
2	(x ₀) 0 ENTER	Y0 =		12			
3	(y ₀) 10 ENTER	H =		13			
4	(h) 0.01 ENTER	0.01 9.999500012		14			
5	ENTER	0.02 9.9980002		15			
6	ENTER	0.03 9.995501013		16			
7	ENTER	0.04 9.9920032		17			
8				18			
9				19			
10				20			

SHARP

Title	MULTI-ELEMENT SIMULTANEOUS FIRST ORDER DIFFERENTIAL EQUATIONS	PROGRAM NO. P 4 - A - 13
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[Formula]

This program solves multi-element simultaneous first order differential equations by using Runge-Kutta-Gill method.

An n -th order differential equation is, when it is constituted as follows,

$$\begin{cases} y_1 = y' \\ y_2 = y_1' \\ \vdots \\ y_n = y_{n-1}' \end{cases}$$

divided into n -element simultaneous first order differential equations.

The multi-element simultaneous first order differential equations

$$\frac{dy_i}{dx} = f_i(x, y_1, \dots, y_m) \quad (i = 1, 2, \dots, m)$$

are solved under the initial condition of

$$x = x_0 \text{ provided } y_i = y_{i0} \quad (i = 1, 2, \dots, m).$$

Taking the value of x at intervals of h , the value of y_i at

$$x_n = x_0 + nh \quad (n = 1, 2, \dots)$$

namely y_{in} is obtained sequentially.

Suppose x is written as y_0 and considered to be an unknown function, we obtain

$$\frac{dy_0}{dx} = 1$$

Thus,

$$\frac{dy_1}{dx} = f_i(y_0, y_1, \dots, y_m) \quad (i = 0, 1, 2, \dots, m)$$

is solved. ($f_0 = 1$)

The formula to determine the value of y_i at $x = x_n + 1$, namely, $y_i, n + 1$, from the value of y_i at $x = x_n$, namely, y_i, n , is given as follows according to Runge-Kutta-Gill method.

	Input	Display	Note		Input	Display	Note
1	SHIFT A	ORDER =		11	ENTER	2 1.040813509	
2	(No. of elements) 2 ENTER	INTERVAL =		12	:	:	
3	(Interval) 0.01 ENTER	?		13	:	:	
4	(x_0) 0 ENTER	?		14			
5	(y_1) 1 ENTER	?		15			
6	(y_2) 1 ENTER	0 0.01	x display	16			
7	ENTER	1 1.010100671	y_1 "	17			
8	ENTER	2 1.020201678	y_2 "	18			
9	ENTER	0 0.02		19			
10	ENTER	1 1.0204054		20			

SHARP

Title	MULTI-ELEMENT SIMULTANEOUS FIRST ORDER DIFFERENTIAL EQUATIONS	PROGRAM NO. P 4 - A - 18
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$$\begin{aligned}
 k_{i0} &= hf_i(x_n, y_{0n}, y_{1n}, \dots, y_{mn}) \\
 r_{i1} &= (1/2)(k_{i0} - 2q_{i0}) \\
 y_i^{(1)} &= y_{in} + r_{i1} \\
 q_{i1} &= q_{i0} + 3r_{i1} - (1/2)k_{i0} \\
 k_{i1} &= hf_i(x_n + \frac{h}{2}, y_0^{(1)}, y_1^{(1)}, \dots, y_m^{(1)}) \\
 r_{i2} &= (1-1/2)(k_{i1} - q_{i1}) \\
 y_i^{(2)} &= y_i^{(1)} + r_{i2} \\
 q_{i2} &= q_{i1} + 3r_{i2} - (1-\sqrt{1/2})k_{i1} \\
 k_{i2} &= hf_i(y_0^{(2)}, y_1^{(2)}, \dots, y_m^{(2)}) \\
 r_{i3} &= (1+1/2)(k_{i2} - q_{i2}) \\
 y_i^{(3)} &= y_i^{(2)} + r_{i3} \\
 q_{i3} &= q_{i2} + 3r_{i3} - (1+\sqrt{1/2})k_{i2} \\
 k_{i3} &= hf_i(y_0^{(3)}, y_1^{(3)}, \dots, y_m^{(3)}) \\
 r_{i4} &= (1/6)(k_{i3} - 2q_{i3}) \\
 y_{i, n+1} &= y_i^{(3)} + r_{i4} \\
 q_{i4} &= q_{i3} + 3r_{i4} - (1/2)k_{i3}
 \end{aligned}$$

Thus, from y_i, n , the values of $y_i, n+1$ are determined.

Here, $i = 0, 1, 2, \dots, m$.

The value of q_{i0} is all 0 at start point x_0 , and q_{i4} should be a new q_{i0} thereafter.

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title

**MULTI-ELEMENT SIMULTANEOUS FIRST ORDER
DIFFERENTIAL EQUATIONS**

PROGRAM NO.

P4 - A - 13

[Example]

Solve $yy'' - y'^2 - y^2 = 0$.

The initial condition is $x = 0$. Suppose $y = y' = 1$, $y = y_1$, and $y_2 = y'$, then it follows that

$$\begin{cases} y_1' = y_2 \\ y_2' = \frac{y_1'^2}{y_1} + y_1 \\ (x, y_1, y_2) = (0, 1, 1) \end{cases}$$

(Solution: $y = e^{\frac{x^2}{2} + x}$)

Determine at every $x = 0.1$ at intervals of $h = 0.01$.

[Operation]

CLOAD ∇ A13 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title			MULTI-ELEMENT SIMULTANEOUS FIRST ORDER DIFFERENTIAL EQUATIONS	PROGRAM NO. P 4 - A - 13
Memory content				
A	1	✓	10: "A":CLEAR :USING	
B	2	Interval h	20: INPUT "ORDER= ";F,"INTERVAL= ";B	
C	3	✓	30: C=F	
D	4	✓	40: FOR A=9TO C+9	
E	5		50: INPUT A(A)	
F	6	No. of elements	60: NEXT A	
G	7	✓	70: GOSUB 500	
H	8	✓	80: FOR A=9TO C+9	
I	9	x_0	90: BEEP 3:PRINT A-9,A(A)	
J	10	y_1	100: NEXT A:GOTO 70	
K	11	y_2	110: END	
L	12	y_3	500: GOSUB 900	
M	13	y_2'	510: FOR A=10TO C+9	
N	14	q_1	520: GOSUB 800	
O	15	q_2	530: H=G/2-A(D)	
P	16		540: A(A)=A(A)+H	
Q	17		550: A(D)=A(D)+3*H-.5*G	
R	18		560: NEXT A	
S	19		570: I=I+B/2:GOSUB 900	
T	20		580: FOR A=10TO C+9	
U	21		590: GOSUB 800	
V	22		600: H=(G-A(D))*(1-r.5)	
W	23		610: A(A)=A(A)+H	
X	24		620: A(D)=A(D)+3*H-(1-r.5)*G	
Y	25		630: NEXT A	
Z	26		640: GOSUB 900	
			650: FOR A=10TO C+9	
			660: GOSUB 800	
			670: H=(G-A(D))*(1+r.5)	
			680: A(A)=A(A)+H	
			690: A(D)=A(D)+3*H-G*(1+r.5)	
			700: NEXT A	
			710: I=I+B/2	
			720: GOSUB 900	
			730: FOR A=10TO C+9	
			740: GOSUB 800	
			750: H=(G-2*A(D))/6	
			760: A(A)=A(A)+H	
			770: A(D)=A(D)+3*H-G/2	
			780: NEXT A:RETURN	
			800: D=A+C:G=B*A(D)	
			810: D=D+C:RETURN	
			900: L=K:M=L*L/J+J	
			910: RETURN	
			528	
An example containing:				
$\begin{cases} y_1' = y_2 \\ y_2' = y_1'^2/y_1 + y_1 \end{cases} \quad (\text{line 900})$				

Title EIGENVALUE	PROGRAM NO. P4 - A - 14
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[Formula]

Set up a characteristic equation according to Danilevski's method, and solve the equation by using Hitchcock's method to determine the eigenvalue.

A matrix is given as $A = [a_{ij}]$ (here, A is an n -element square matrix.)

Deform the matrix, first supposing $m = 1$, $m' = m + 1$.

Matrix $T = [t_{ij}]$, and $T^{-1} = [t'_{ij}]$ are set up as follows. (1)

When $j = m'$,

$$\begin{cases} t_{ij} = -\frac{a_{im}}{a_{m'm}} & (i \neq m') \\ t_{m'j} = \frac{1}{a_{m'm}} \\ t'_{ij} = a_{im} \end{cases}$$

When $j \neq m'$,

$$\begin{cases} t_{ij} = t'_{ij} = 0 & (i \neq j) \\ t_{ij} = t'_{ij} = 1 \end{cases}$$

Thus, the matrix is deformed from TAT^{-1} into A.

If $m' \neq n$, $m + 1$ is changed to m , and $m' + 1$ to m' , thus returning to eq. (1).

If $m' = n$, the deformation is terminated.

Now, matrix A is deformed as follows, except for the final row:

$$\begin{cases} a_{ij} = 0 & (i \neq j+1) \\ a_{ij} = 1 & (i = j+1) \end{cases}$$

From the final row, the coefficient $[r_i]$ may be determined as follows.

	Input	Display	Note		Input	Display	Note
1	SHIFT A	ORDER		11	(a_{31}) 71 ENTER	?	
2	(n) 4 ENTER	?		12	(a_{32}) 21 ENTER	?	
3	(a_{11}) 38 ENTER	?		13	(a_{33}) 85 ENTER	?	
4	(a_{12}) -83 ENTER	?		14	(a_{34}) 15 ENTER	?	
5	(a_{13}) -21 ENTER	?		15	(a_{41}) -18 ENTER	?	
6	(a_{14}) 76 ENTER	?		16	(a_{42}) 65 ENTER	?	
7	(a_{21}) -27 ENTER	?		17	(a_{43}) -74 ENTER	?	
8	(a_{22}) 54 ENTER	?		18	(a_{44}) 46 ENTER	89.40408949 0	
9	(a_{23}) 86 ENTER	?		19	ENTER	-49.70138121 0	
10	(a_{24}) -18 ENTER	?		20	ENTER	91.64864585 88.72786289	
					ENTER	91.64864585 -88.72786289	

Title EIGENVALUE	PROGRAM NO. P 4 - A - 14
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$$r_i = -a_{kn} \quad (k=n-i+1)$$

As a result, the following equation is obtained as the characteristic equation.

$$\lambda^n + r_1 \lambda^{n-1} + \dots + r_{n-1} \lambda + r_n = 0$$

Thus is obtained a characteristic equation, which is solved by using Hitchcock's method.

[Example]

(Ex. 1)

$$\begin{bmatrix} 38 & -83 & -21 & 76 \\ -27 & 54 & 86 & -18 \\ 71 & 21 & 85 & 15 \\ -18 & 65 & -74 & 46 \end{bmatrix}$$

* The equation cannot be calculated when a_{ij} is an imaginary number.

Also, calculation is impossible when $a_{mm'}$ is 0.

The characteristic equation may not always converge.

Especially when the roots are equal roots, there is a possibility of failure in convergence.

At every repetition, the state of convergence is displayed.

As the displayed figures approaches 0, it is understood that convergence is near at end.

Enables use in the range of $2 \leq n \leq 7$.

(Ex. 2)

$$\begin{bmatrix} 38 & -83 \\ -27 & 54 \end{bmatrix} \quad \text{Answer: } \lambda_1 = 94.01042$$

$$\lambda_2 = -2.01042$$

[Operation] CLOAD ▽A14 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title $n, \Sigma, \bar{x}, \sigma$	PROGRAM NO. P 4-B-1
------------------------------------	------------------------

[Formula]

Determine the number of data, total sum, mean value, and standard deviation.

Input of weighted data and deletion of input data are possible.

The standard deviation is computed in the equation below.

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

[Example]

x_i	14.1	14.2	14.3	14.4	14.5
f_i	8	19	23	15	10

[Operation]

CLoad ∇ B1 ∇ **ENTER**

SHFT **A**

(1) With weight, 1 **ENTER** ; without weight, 2 **ENTER**

(2) To cut data, press **SHFT** and **C** keys.

This operation is valid, however, only when "X=" is on the display.

SHFT **B** n
 Σ
 $\bar{x}$
 σ

	Input	Display	Note		Input	Display	Note
1	SHFT A	WEIGHT-1 NO WEIGHT-2		11	14.5 ENTER	FI =	
2	1 ENTER	X=		12	10 ENTER	X=	
3	14.1 ENTER	FI =		13	SHFT B	75	n
4	8 ENTER	X=		14	ENTER	1072.5	Σ
5	14.2 ENTER	FI =		15	ENTER	14.3	$\bar{x}$
6	19 ENTER	X=		16	ENTER	1.196842693 E-01	σ
7	14.3 ENTER	FI =		17			
8	23 ENTER	X=		18			
9	14.4 ENTER	FI =		19			
10	15 ENTER	X=		20			

[illegible]

SHARP

Title	POISSON DISTRIBUTION AND BINOMIAL DISTRIBUTION	PROGRAM NO. P4 - B-2
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[Formula]

In Poisson distribution and binomial distribution, determine probability at x and cumulative probability from 0 to x .

- o Poisson distribution

$$P(X=x) = \frac{e^{-m} m^x}{x!} \quad L(p) = \sum_{i=0}^x P(X=i)$$

- o Binomial distribution

$$P(X=x) = {}_n C_x p^x (1-p)^{n-x} \quad L(p) = \sum_{i=0}^x P(X=i)$$

[Example]

Poisson distribution $m = 3$, $x = 5$

Binomial distribution $n = 100$, $p = 0.02$, $x = 2$

[Operation]

CLOAD ∇ B2 ∇ ENTER

- SHFT A Poisson distribution
- SHFT B Binomial distribution

	Input	Display	Note		Input	Display	Note
1	SHFT A	M, X ?	Poisson distribution	11	SHFT B	N, P, X ?	Binomial distribution
2	3 ENTER	?		12	100 ENTER	?	
3	5 ENTER	M= 3		13	0.02 ENTER	?	
4		X= 5		14	2 ENTER	N= 100	
5		P= 1.00818 E-01	Probability	15		P= 0.02	
6	ENTER	L(P)= 9.16082 E-01	Cumulative probability	16		X= 2	
7				17		P= 2.73413 E-01	Probability
8				18	ENTER	L(P)= 6.76685 E-01	Cumulative probability
9				19			
10				20			

[illegible]

Title NORMAL DISTRIBUTION AND PERCENTILE

PROGRAM NO.
P 4-B-3

[Formula]

Determine the normal distribution function $\phi(x)$ and inverse function thereof (percentile) according to Hasting's best approximate equation.

• $\phi(x)$

Suppose, $\phi(x) = \int_{-\infty}^x \phi_t dx$

$$\phi_t = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}$$

$$t = \frac{1}{1+px}$$

we obtain,

$$\phi(x) = 1 - \phi_t (c_1 t + c_2 t^2 + c_3 t^3 + c_4 t^4 + c_5 t^5)$$

$$P = 0.2316419$$

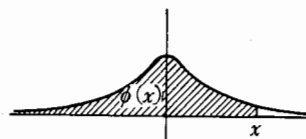
$$c_1 = 0.31938153$$

$$c_2 = -0.356563782$$

$$c_3 = 1.78147937$$

$$c_4 = -1.821255978$$

$$c_5 = 1.330274429$$



• Percentile

$$x = \sqrt{1 \ln Q^{-2}}$$

$$t_Q = x - \frac{c_0 + c_1 x + c_2 x^2}{1 + d_1 x + d_2 x^2 + d_3 x^3}$$

$$c_0 = 2.515517$$

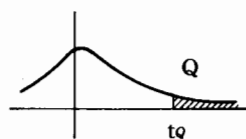
$$d_1 = 1.432788$$

$$c_1 = 0.802853$$

$$d_2 = 0.189269$$

$$c_2 = 0.010328$$

$$d_3 = 0.00138$$



[Example] $\phi(x) \dots\dots x = 2$; percentile $\dots\dots Q = 0.05$

[Operation] CLOAD ∇ B3 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	2 [SHIFT] [A]	P 9.77249 E-01	$\phi(x)$	11			
2				12			
3				13			
4	0.05 [SHIFT] [B]	TQ 1.645361125	t_Q	14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

—43—

SHARP

Title	ESTIMATION OF INTERVAL OF POPULATION MEAN AND POPULATION VARIANCE	PROGRAM NO. P 4 - B-4
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[Formula]

Estimate a population mean or a population variance. (Both population mean and population variance should be unknown normal population.)

- Estimation of population mean

Supposing the confidence coefficient to be α , t_a to satisfy the following equation is found:

$$P(-t_a < \frac{\bar{X} - \mu}{\sqrt{V/n}} < t_a) = \alpha$$

Then, the intended interval is

$$\bar{X} \pm \sqrt{V/n} t_a$$

t_a plots t-table of $n-1$ degree of freedom.

- Estimation of population variance

Supposing the confidence coefficient to be α , x_1 , x_2 to satisfy the following equation is found:

$$P(\chi_1^2 < S_{xx}/\sigma^2 < \chi_2^2) = \alpha$$

Then, the intended interval is

$$\frac{S_{xx}}{\chi_2^2} \sim \frac{S_{xx}}{\chi_1^2}$$

x_1^2, x_2^2 plot χ^2 -table of $n-1$ degree of freedom.

[Example]

12.3 12.4 12.1 12.4 12.2

$$\left(\begin{array}{l} n=5, \quad \bar{x}=12.28 \\ \sigma=1.303840481 \text{ E}-01 \end{array} \right)$$

From the data above, the population mean is estimated at $\alpha = 0.95$.

28.0 27.7 27.0 27.7 25.7 27.7

28.3 27.8 26.4 26.5 27.1

$$\left(\begin{array}{l} n=11 \\ \sigma=7.965838939 \text{ E}-01 \end{array} \right)$$

From the data above, the population variance is estimated at $\alpha = 0.98$.

[Operation]

CLOAD ∇ B4 ∇ **ENTER**

- SHFT** **A** Estimation of population mean, processed data
- SHFT** **B** Estimation of population mean, unprocessed data
- SHFT** **X** Estimation of population variance, processed data
- SHFT** **Z** Estimation of population variance, unprocessed data

	Input	Display	Note		Input	Display	Note
1	SHFT A	N, X, S, T ?		11	SHFT B	?	Upon completion of data input, press ENTER key alone.
2	5 ENTER	?	No. of pieces	12	12.3 ENTER	?	
3	12.28 ENTER	?	Mean	13	12.4 ENTER	?	
4	0.1303840481 ENTER	?	Standard deviation	14	12.1 ENTER	?	
5	2.78 ENTER	LOWER 12.11789954	Lower limit	15	12.4 ENTER	?	
6	ENTER	CENTER 12.28	Median	16	12.2 ENTER	?	
7	ENTER	UPPER 12.44210046	Upper limit	17	ENTER	T=	
8				18	2.78 ENTER	LOWER 12.11789954	Lower limit
9				19	ENTER	CENTER 12.28	Median
10				20	ENTER	UPPER 12.44210046	Upper limit

SHARP

Title	ESTIMATION OF INTERVAL OF POPULATION MEAN AND POPULATION VARIANCE	PROGRAM NO. P 4 - B - 4
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	Input	Display	Note		Input	Display	Note
1	[SHIFT] [X]	N, S, A, B ?		11	[SHIFT] [Z]	?	Press the [ENTER] key alone when data are completely processed.
2	11 [ENTER]	?		12	28 [ENTER]	?	
3	7965838939 [ENTER]	?		13	:	:	
4	2. 558 [ENTER]	?		14	Repeat thereafter	:	
5	23. 209 [ENTER]	LOWER 2.73405 E-01	Lower limit	15	[ENTER]	A, B ?	
6	[ENTER]	CENTER 6.34545 E-01	Middle	16	2. 558 [ENTER]	?	
7	[ENTER]	UPPER 2.480632575	Upper limit	17	23. 209 [ENTER]	LOWER 2.73405 E-01	Lower limit
8				18	[ENTER]	CENTER 0.634545673	Middle
9				19	[ENTER]	UPPER 2.480632029	Upper limit
10				20			

Title TEST OF MEAN AND VARIANCE	PROGRAM NO. P 4 - B - 5
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[Formula]

Test a hypothesis about mean or a hypothesis about variance.

(Both population mean and population variance should be unknown normal population.)

The mean conforms to t-distribution of $\phi = n - 1$, while the variance conforms to χ^2 -distribution of $\phi = n - 1$. Therefore, these values are printed out respectively.

[Example]

1790	1780	1800	1800	1800	$n = 10$
1810	1790	1780	1810	1790	$\bar{x} = 1795$
					$\sigma = 10.8012345$

From the samples above, is it permissible to judge the population means as 1800?

0.41	0.39	0.44	0.64	0.42	0.59	$n = 12$
0.49	0.44	0.64	0.42	0.60	0.38	$\sigma = 1.001665281 \text{ E} - 01$

From the data above, test $\sigma^2 = 0.04$.

[Operation]

CLOAD ∇ B5 ∇ **ENTER**

- [SHIFT]** **[A]** Test of mean, processed data
- [SHIFT]** **[B]** Test of mean, unprocessed data
- [SHIFT]** **[X]** Test of variance, processed data
- [SHIFT]** **[Z]** Test of variance, unprocessed data

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	M,N,X,S ?		11	[SHIFT] [B]	M =	Upon completion of data input, press [ENTER] key.
2	1800 [ENTER]	?	μ	12	1800 [ENTER]	?	
3	10 [ENTER]	?	n	13	1790 [ENTER]		
4	1795 [ENTER]	?	$\bar{x}$	14	:		
5	10.8012345 [ENTER]		σ	15	Repeat thereafter		
6		-1.463850109	t	16	[ENTER]	-1.46385011	t
7	[ENTER]	9	ϕ	17		9	ϕ
8				18			
9				19			
10				20			

SHARP

Title

TEST OF MEAN AND VARIANCE

PROGRAM NO.
P 4-B-5

	Input	Display	Note		Input	Display	Note
1	SH FT X	M,N,S ?		11	SH FT Z	M =	ENTER Press the key after inputting data.
2	0.04 ENTER	?	σ^2	12	0.04 ENTER	?	
3	12 ENTER	?	n	13	0.41 ENTER	?	
4	0.1001665281 ENTER	2.759166673	σ, χ^2	14	:	:	
5	ENTER	11	ϕ	15	Repeat thereafter		
6				16	ENTER	2.759166678	χ^2
7				17	ENTER	11	ϕ
8				18			
9				19			
10				20			

Title

TEST OF DIFFERENCE IN MEANS, RATIO OF VARIANCES

PROGRAM NO.
P 4 - B - 6

[Formula]

- Test of difference in means

Test the hypothesis that the means of two normal populations, of which variances are known to be equal to each other but values are not known, are equal to each other.

The equation

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{S_{xx1} + S_{xx2}}} \sqrt{\frac{n_1 n_2 (n_1 + n_2 - 2)}{n_1 + n_2}}$$

conforms to t-distribution of $\phi = n_1 + n_2 - 2$.

- Test of ratio of variances

Test whether the variances of two populations are equal to each other or not.

$F = V_1/V_2$ conforms to F-distribution of

$$\phi_1 = n_1 - 1,$$

$$\phi_2 = n_2 - 1.$$

However, when $V_1 < V_2$, exchange 1 and 2.

[Example]

- Test of difference in means

1	2.3	1.6	2.1	2.2	2.3	2.0	1.9	2.2
2	2.3	2.5	2.0	2.1	2.2	2.1		

$$\left(\begin{array}{l} n_1 = 8, \bar{x}_1 = 2.075 \\ \sigma_1 = 2.375469878 \text{ E-01} \\ n_2 = 6, \bar{x}_2 = 2.2 \\ \sigma_2 = 1.788854382 \text{ E-01} \end{array} \right)$$

Carry out t-test by using the data above.

- Test of ratio of variances

1	1.375	1.407	1.068	1.752	1.201
	1.042	1.223	1.633	1.773	0.779
2	1.033	1.217	1.615	0.673	
	1.252	0.984	1.693	0.840	

$$\left(\begin{array}{l} n_1 = 10, \sigma_1 = 3.261141757 \text{ E-01} \\ n_2 = 8, \sigma_2 = 3.564527359 \text{ E-01} \end{array} \right)$$

Carry out F-test by using the data above.

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	N1,N2,X1,X2,S1,S2 ?		11	[SHIFT] [B]	?	After each input of 1, 2, press [ENTER] key.
2	8 [ENTER]	?		12	2.3 [ENTER]	?	
3	6 [ENTER]	?		13	: :		
4	2.075 [ENTER]	?		14	: [ENTER]		
5	2.2 [ENTER]	?		15	: :		
6	.2375469878 [ENTER]	?		16	[ENTER]	-1.076244005 12	t, ϕ
7	.1788854382 [ENTER]	-1.076244005 12	t, ϕ	17			
8				18			
9				19			
10				20			

SHARP

Title

TEST OF DIFFERENCE IN MEANS, RATIO OF VARIANCES

PROGRAM NO.

P 4 - B - 6

[Operation]

CLOAD ▽B6 ▽ ENTER

SHIFT A

.....

Test of difference in means, processed data

SHIFT B

.....

Test of difference in means, unprocessed data

SHIFT X

.....

Test of ratio of variances, processed data

SHIFT Z

.....

Test of ratio of variances, unprocessed data

	Input	Display	Note		Input	Display	Note
1	SHIFT X	N1, N2, S1, S2 ?		11	SHIFT Z	?	After each input of 1, 2, press ENTER key.
2	10 ENTER	?		12	1.375 ENTER	:	
3	8 ENTER	?		13	:	:	
4	3261141757 ENTER	?		14	Repeat thereafter		
5	3564527359 ENTER	?	1.194715643 F	15	ENTER	1.194715649	F
6		7. 9.	ϕ_1, ϕ_2	16	ENTER	7. 9.	ϕ_1, ϕ_2
7				17			
8				18			
9				19			
10				20			

SHARP

Title REJECTION TEST, TEST OF CORRELATION COEFFICIENT, TEST OF GOODNESS OF FIT

PROGRAM NO.
P4 - B-7

[Formula]

- Rejection test If the data contains one sample which is extremely large (or small) as compared with the others, it is judged whether such sample can be ignored or not.

If the value of t is larger than the values shown in the table below, it may be ignored.

N	1 %	5 %	N	1 %	5 %	N	1 %	5 %
3	1.414	1.412	11	2.606	2.343	19	2.932	2.600
4	1.723	1.689	12	2.663	2.387	20	2.959	2.623
5	1.955	1.869	13	2.714	2.426	21	2.984	2.644
6	2.130	1.996	14	2.759	2.461	22	3.008	2.664
7	2.265	2.093	15	2.800	2.493	23	3.030	2.683
8	2.374	2.172	16	2.837	2.523	24	3.051	2.701
9	2.464	2.237	17	2.871	2.551	25	3.071	2.717
10	2.540	2.294	18	2.903	2.577			

- Test of correlation coefficient

Test a hypothesis, $r = 0$.

Use t-distribution of $\phi = n - 2$.

- Test of goodness of fit

Test the goodness of fit of a distribution.

When the measured frequencies are $n_1, n_2, \dots, n_k$,

and the expected frequencies are $m_1, m_2, \dots, m_k$,

$$\chi^2 = \sum \frac{(n_i - m_i)^2}{m_i} \quad \text{will conform to } \chi^2\text{-distribution of } \phi = k - 1.$$

	Input	Display	Note		Input	Display	Note
1	SHIFT A	?		11	SHIFT C	N=	
2	118 ENTER	?		12	100 ENTER	R=	
3	120 ENTER	?		13	0.36 ENTER	N= 100	
4	124 ENTER	?		14	ENTER	R= .36	
5	125 ENTER	?		15	ENTER	T= 3.819936094	
6	126 ENTER	?		16	ENTER	DF = 98	
7	127 ENTER	?		17	SHIFT X	N=	
8	140 ENTER	?		18	16 ENTER	M=	
9	SHIFT B	?		19	10 ENTER	N=	
10	140 ENTER	140 2.177001632		20	8 ENTER	M=	
	ENTER	?					

SHARP

Title	REJECTION TEST, TEST OF CORRELATION COEFFICIENT, TEST OF GOODNESS OF FIT	PROGRAM NO. P 4 - B - 7
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[Example]

- (1) The following data contains an extremely large number, 140.

Test to see whether it can be ignored or not.

118 120 124 125

126 127 140

- (2) Given $n = 100$ and $r = 0.36$. Test for correlation.

- (3) Records of accidents are classified into days of the week, and the following results were obtained.

Monday, 16 Tuesday, 8 Wednesday, 12 Thursday, 11

Friday, 14 Saturday, 9

Is it possible to assume that 10 cases of accident occur evenly on every day of the week?

[Operation]

CLOAD ▽B7 ▽ **ENTER**

SHFT **A** Data input of rejection test

SHFT **B** Rejection test

SHFT **C** Test of correlation coefficient

SHFT **X** Data input of test of goodness of fit

SHFT **Z** Test of goodness of fit

	Input	Display	Note		Input	Display	Note
1	10 ENTER	N=		11	ENTER	DF= 5	
2	12 ENTER	M=		12			
3	10 ENTER	N=		13			
4	11 ENTER	M=		14			
5	10 ENTER	N=		15			
6	14 ENTER	M=		16			
7	10 ENTER	N=		17			
8	9 ENTER	M=		18			
9	10 ENTER	N=		19			
10	SHFT Z	CHI SQUARE = 6.2		20			

Title	2 x 2 CONTINGENCY TABLE, 2 x n CONTINGENCY TABLE	PROGRAM NO. P 4 - B - 8*
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[Formula]

In 2 x 2 contingency table, or 2 x n contingency table, determine the value of χ^2 .

Also, in 2 x 2 contingency table, perform Yates' correction.

[Example]

	B ₁	B ₂
A ₁	286	178
A ₂	64	22

	1	2	3	4	5	6	7
Good piece	157	190	256	430	362	229	486
Defective piece	13	25	19	52	32	16	27

[Operation]

CLOAD ▽B8 ▽ **ENTER**

SHFT **A** 2 x 2 contingency table

SHFT **B** 2 x n contingency table, data input

SHFT **C** 2 x n contingency table, χ^2 value

	Input	Display	Note		Input	Display	Note
1	SHFT A	2*2 CONTINGENCY TABLE		11	SHFT B	2*N CONTINGENCY TABLE	
2	ENTER	A1B1=		12	ENTER	A=	
3	286 ENTER	A1B2=		13	157 ENTER	B=	
4	178 ENTER	A2B1=		14	13 ENTER	A=	
5	64 ENTER	A2B2=		15	:	:	
6	22 ENTER	5.121898501 4.583981467 χ^2 , χ^2_s		16	SHFT C	15.31961442 6 χ^2 , ϕ	
7				17			
8				18			
9				19			
10				20			

Title	$m \times n$ CONTINGENCY TABLE	PROGRAM NO. P 4 - B - 9
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[Formula]

In an $m \times n$ contingency table as shown on the right, calculate the value of χ^2 .

$$\chi^2 = \sum_{i=1}^m \sum_{j=1}^n \frac{(E_{ij} - a_{ij})^2}{E_{ij}}$$

where, $E_{ij} = \frac{R_i \cdot C_j}{N}$

Degree of freedom

$$(d.f.) = (m-1) \cdot (n-1)$$

$i \backslash j$	1	.....	j	.....	n	計
1	a_{11}	.....	a_{1j}	.....	a_{1n}	R_1
$\vdots$	$\vdots$		$\vdots$		$\vdots$	$\vdots$
i	a_{i1}	.....	a_{ij}	.....	a_{in}	R_i
$\vdots$	$\vdots$		$\vdots$		$\vdots$	$\vdots$
m	a_{m1}	.....	a_{mj}	.....	a_{mn}	R_m
Total	C_1	.....	C_j	.....	C_n	N

[Example]

($m=3, n=4$)

23	40	16	2	81
11	75	107	14	207
1	31	60	10	102
35	146	183	26	390

(NOTE 1) Calculation is possible only in contingency table where $m + n \leq 16$.
When $m + n > 16$, ERROR message is displayed, which can be cleared by **ENTER** button.

(NOTE 2) The input order of a_{ij} is:
 $a_{11}, a_{12}, a_{13}, \dots, a_{1n}, a_{21}, \dots$
 $a_{m,n-1}, a_{mm}$

[Operation]

CLOAD ▽B9 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	M =		11	:	:	
2	3 ENTER	N =		12	10 ENTER	D.F. = 6.	
3	4 ENTER	R(I) =		13	ENTER	CHI SQ = 69.38932827	
4	81 ENTER	"		14			
5	:	:		15			
6	102 ENTER	C(J) =		16			
7	35 ENTER	"		17			
8	:	:		18			
9	26 ENTER	L;A(I, J) =		19			
10	23 ENTER	"		20			

Title CORRECTION MOVING AVERAGE	PROGRAM NO. P 4 - B - 10
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[Formula]

Determine the correction moving average.

Data: $X_1, X_2, X_3, \dots, X_i, \dots$

1: when n is an odd number

$$\bar{X}_1 = \sum_{i=1}^n X_i / n$$

$$\bar{X}_2 = \sum_{i=2}^{n+1} X_i / n$$

⋮

2: when n is an even number

$$\bar{X}_1 = \left(\frac{X_1}{2} + \frac{X_{n+1}}{2} + \sum_{i=2}^n X_i \right) / n$$

$$\bar{X}_2 = \left(\frac{X_2}{2} + \frac{X_{n+2}}{2} + \sum_{i=3}^n X_i \right) / n$$

⋮

In the event of regression analysis, when the moving average is taken by adjusting to the period, if any, effects of minor period fluctuations may be canceled. ($n \leq 21$)

[Example]

Correction moving average of 4 terms

Data: 56, 79, 0, 97, 20, 23,
99, 68, 34, 93, 31

[Operation]

CLOAD ▽B10 ▽ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	HOW MANY TERMS ?		11	99 ENTER	99. 47.375	
2	4 ENTER	X=		12	ENTER	X=	
3	56 ENTER	X=		13	68 ENTER	68. 56.125	
4	79 ENTER	X=		14	ENTER	X=	
5	0 ENTER	X=		15	34 ENTER	34. 54.25	
6	97 ENTER	X=		16	ENTER	X=	
7	20 ENTER	20. 53.5	Input value, mean	17	93 ENTER	93. 64.75	
8	ENTER	X=		18	ENTER	X=	
9	23 ENTER	23. 42		19	31 ENTER	31. 65.	
10	ENTER	X=		20			

SHARP

Title	RANDOM NUMBERS	PROGRAM NO. P 4 - B - 11
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[Formula]

Generate random numbers according to the congruence method.

$$x_{n+1} = 23x_n - \text{int}\left(\frac{23x_n}{10^8+1}\right) \times (10^8+1)$$

x_0 is an arbitrary 8-digits integer.

[Example]

Clear all memories, and generate ten random numbers at the initial value = 0.

[Operation]

CLOAD ▽B11 ▽ **ENTER**

(Note) Make sure the memory X is loaded with no character. If the memory is loaded with character, an error will occur.

	Input	Display	Note		Input	Display	Note
1	SHFT A	INITIAL VALUE =		11	ENTER	9. 13784262	
2	0 ENTER	NUMBER =		12	ENTER	10. 17038023	
3	10 ENTER	1 10100381		13			
4	ENTER	2 32308761		14			
5	ENTER	3 43101496		15			
6	ENTER	4 91334399		16			
7	ENTER	5 691156		17			
8	ENTER	6 15896588		18			
9	ENTER	7 65621521		19			
10	ENTER	8 9294968		20			

Title	SUM OF PRODUCTS, CORRELATION COEFFICIENT, LINEAR REGRESSION ($y = ax + b$)	PROGRAM NO. P 4-B-12
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[Formula]

Determine the covariance between two related variables, correlation coefficient, and linear regression coefficient, and estimate on the basis thereof.

$$S_{xx} = \sum x_i^2 - n \bar{x}^2$$

$$S_{xy} = \sum x_i y_i - n \bar{x} \bar{y}$$

$$S_{yy} = \sum y_i^2 - n \bar{y}^2$$

$$C = S_{xy}/n \quad \text{..... covariance}$$

$$r = S_{xy}/\sqrt{S_{xx} S_{yy}} \quad \text{..... correlation coefficient}$$

$$\left. \begin{array}{l} a = S_{xy}/S_{xx} \\ b = \bar{y} - a \bar{x} \end{array} \right\} \text{ regression coefficient } (y = ax + b)$$

[Example]

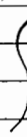
x	6.9	7.6	7.6	9.0	8.1	6.5	6.4	6.9
y	12	10	9	5	6	15	14	12

[Operation]

CLOAD ▽B12▽

[SHIFT] [A] Data input

[SHIFT] [B] Result

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	X, Y		11	[ENTER]	C -3.060714286	
2		 Data contents		12	[ENTER]	A -3.942042318	
3				13	[ENTER]	B 39.4475621	
4				14	[ENTER]	R -9.69396E-01	
5				15	[ENTER]	ESTIMATION	
6	[SHIFT] [B]	MEAN		16	[ENTER]	X=	
7	[ENTER]	7.375 10.375		17	[10] [ENTER]	10 0.02713892	
8	[ENTER]	VARIANCE		18			
9	[ENTER]	7.76428E-01 12.83928571		19			
10	[ENTER]	SXY -21.425		20			

Title EXPONENTIAL REGRESSION

PROGRAM NO.
P 4 - B - 13

[Formula]

Fit two sets of data, x_i, y_i , to the exponential curve $y = ab^x$, and determine coefficients a, b , and correlation coefficient r .

$$\bar{x} = \sum x_i / n, \quad \bar{Y} = \sum \ln y_i / n$$

$$S_{xx} = \sum x_i^2 - n \bar{x}^2$$

$$S_{xy} = \sum x_i \ln y_i - n \bar{x} \bar{Y}$$

$$S_{yy} = \sum (\ln y_i)^2 - n \bar{Y}^2$$

$$r = \frac{S_{xy}}{\sqrt{S_{xx} S_{yy}}}, \quad b' = \frac{S_{xy}}{S_{xx}}, \quad a = e^{\bar{Y} - b' \bar{x}} \quad b = e^{b'}$$

[Example]

x	0.5	1.2	3.1	7.4
y	7.01	11.72	44.54	936.71

Fit this data to $y = ab^x$, and estimate when $x = 8.3, -1.2$

[Operation]

CLOAD ∇ B13 ∇ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	X,Y		11	SHIFT B	R 9.99994E-01	
2	.5 ENTER	?		12	ENTER	A 4.960331916	
3	7.01 ENTER	X,Y		13	ENTER	B 2.03057723	
4	1.2 ENTER	?		14	ENTER	ESTIMATION	
5	11.72 ENTER	X,Y		15	ENTER	X=	
6	3.1 ENTER	?		16	8.3 ENTER	8.3 1773.179438	
7	44.54 ENTER	X,Y		17	ENTER	X=	
8	7.4 ENTER	?		18	-1.2 ENTER	-1.2 2.12015359	
9	936.71 ENTER	X,Y		19			
10				20			

Title CORRECTION EXPONENTIAL CURVE	PROGRAM NO. P 4 - B - 14
--	---

[Formula]

In a correction exponential curve expressed in $y = k - ab^x$, supposing the value of k is known and unknown, calculate coefficients (also k if unknown), and estimate the value of y with respect to the value of unknown x .

1. k known

$$y = k - ab^x$$

$$k - y = ab^x$$

Taking the logarithm of both sides yields

$$\ln(k - y) = \ln a + x \ln b$$

Now, assuming $Y = \ln(k - y)$, $A = \ln a$, $B = \ln b$, then we obtain

$$Y = A + Bx$$

Hence, the coefficients can be calculated by the method of least squares as follows:

$$A = \frac{\sum x^2 \sum Y - \sum x \sum x Y}{n \sum x^2 - (\sum x)^2}$$

$$B = \frac{n \sum x Y - \sum x \sum Y}{n \sum x^2 - (\sum x)^2}$$

$$\begin{cases} a = e^A \\ b = e^B \end{cases}$$

2. k unknown

Expressing the data as $3n$ (discarding fractions of 3), the data is divided into three kinds: $0 \leq x \leq n$, $n \leq x \leq 2n$, $2n \leq x < 3n$.

Respective partial sums are expressed as follows:

$$\sum_{i=0}^{n-1} y_i$$

	Input	Display	Note		Input	Display	Note
1	SHIFT A	N=		11	35 ENTER	Y=	
2	5 ENTER	K=		12	545 ENTER	X=	
3	550 ENTER	DATA		13	60 ENTER	Y=	
4		X=		14	547 ENTER	A= 10.0556453	
5	1 ENTER	Y=		15	ENTER	B= 9.80118E-01	
6	540.2 ENTER	X=		16	ENTER	ESTIMATION	
7	2 ENTER	Y=		17	ENTER	X=	
8	540.4 ENTER	X=		18	5 ENTER	5. 540.9050113	
9	12 ENTER	Y=		19	ENTER	X=	
10	542 ENTER	X=		20	15 ENTER	15. 542.5597658	

Title	CORRECTION EXPONENTIAL CURVE	PROGRAM NO. P 4 - B - 14
-------	------------------------------	-----------------------------

$$\sum_2 y = \sum_{i=n}^{2n-1} y_i$$

$$\sum_3 y = \sum_{i=2n}^{3n-1} y_i$$

Hence,

$$b = \left(\frac{\sum_3 y - \sum_2 y}{\sum_2 y - \sum_1 y} \right)^{\frac{1}{n}}$$

$$a = (\sum_1 y - \sum_2 y) \frac{b-1}{(b^n-1)^2}$$

$$k = \frac{1}{n} \left[\sum_1 y + \left(\frac{b^n-1}{b-1} \right) a \right]$$

[Example]

1. k known

$k=550$

x_i	y_i
1	540.2
2	540.4
12	542
35	545
60	547

Estimation

$x = 5$

$x = 15$

2. k unknown

The table on the right is a record of yield of rice in Japan.

Plot the record in curve, and estimate when $x = 15, 16$.

Year	t	Yield (million koku) y
1883 ~ 1887	0	33.8
1888 ~ 1892	1	38.9
1893 ~ 1897	2	37.7
1898 ~ 1902	3	42.5
1903 ~ 1907	4	46.3
Σ_1		199.2
1908 ~ 1912	5	50.6
1913 ~ 1917	6	55.2
1918 ~ 1922	7	58.9
1923 ~ 1927	8	58.0
1928 ~ 1932	9	60.5
Σ_2		283.2
1933 ~ 1937	10	62.8
1938 ~ 1942	11	63.5
1943 ~ 1947	12	60.4
1948 ~ 1952	13	63.9
1953 ~ 1957	14	68.2
Σ_3		318.8

Input	Display	Note	Input	Display	Note
1 [SHIFT] [B]	HOW MANY DATA ?		11 15 [ENTER]	15. 65.95848202	
2 15 [ENTER]	Y=		12 [ENTER]	X=	
3 33.8 [ENTER]	Y=		13 16 [ENTER]	16. 66.43785267	
4 :	Y=		14		
5 Repeat thereafter	Y=		15		
6 68.2 [ENTER]	A= 39.91657038		16		
7 [ENTER]	B= 8.42236 E-01		17		
8 [ENTER]	K= 68.9970248		18		
9 [ENTER]	ESTIMATION		19		
10 [ENTER]	X=		20		

SHARP

Title CORRECTION EXPONENTIAL CURVE

PROGRAM NO.
P 4-B-14

[Operation]

CLOAD ∇ B14 ∇ **ENTER**

SHIFT **A** k known

SHIFT **B** k unknown

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title LOGISTIC CURVE

PROGRAM NO.
P 4 - B - 15

[Formula]

In a logistic curve expressed in $y = \frac{k}{1 + me^{-ax}}$, supposing k is known and unknown, determine the coefficients m , a (also k if unknown), and find the estimation of y with respect to the value of unknown x .

1. k known

$$y = \frac{k}{1 + me^{-ax}}$$

$$\left(\frac{k}{y} - 1\right) = me^{-ax}$$

$$\ln\left(\frac{k}{y} - 1\right) = \ln m - ax$$

Assuming $Y = \ln\left(\frac{k}{y} - 1\right)$, $A = \ln m$, $B = -a$, we obtain

$$Y = A + Bx$$

Hence, according to the method of least squares, it follows that

$$A = \frac{\sum x^2 \sum Y - \sum x \sum x Y}{n \sum x^2 - (\sum x)^2}$$

$$B = \frac{n \sum x Y - \sum x \sum Y}{n \sum x^2 - (\sum x)^2}$$

$$\therefore \begin{cases} m = e^A \\ a = -B \end{cases}$$

2. k unknown

Taking inverse numbers of both sides of an equation expressing a curve,

$$\frac{1}{y} = \frac{1}{k} + \frac{m}{k} e^{-ax}$$

Now, assuming $Y = \frac{1}{y}$, $K = \frac{1}{k}$, $A = -\frac{m}{k}$, $B = e^{-a}$, we obtain

	Input	Display	Note		Input	Display	Note
1	SHIFT A	N=		11	ENTER	M=48.10443978	
2	8 ENTER	K=		12	ENTER	ESTIMATION	
3	195 ENTER	DATA		13	ENTER	X=	
4		X =		14	5 ENTER	5. 39.8192162	
5	2 ENTER	Y =		15	ENTER	X	
6	11 ENTER	X =		16	12 ENTER	12. 174.80336050	
7	6 ENTER	Y =		17			
8	54 ENTER	X =		18			
9	10 ENTER	Y =		19			
10	150 ENTER	A=5.02626 E-01		20			

Title LOGISTIC CURVE

PROGRAM NO.
P 4 - B - 15

$$Y = K - AB^x$$

This can be determined by the method of correction exponential curve as follows:

$$B = \left(\frac{\sum_3 Y - \sum_2 Y}{\sum_2 Y - \sum_1 Y} \right)^{\frac{1}{n}}$$

$$A = (\sum_1 Y - \sum_2 Y) \frac{B-1}{(B^n - 1)^2}$$

$$K = \frac{1}{n} \left[\sum_1 Y + \left(\frac{B^n - 1}{B - 1} \right) A \right]$$

$$\therefore \begin{cases} a = -\ln B \\ k = 1/K \\ m = -kA \end{cases}$$

[Example]

1. k known

$$k = 195$$

x_i	y_i
2	11
6	54
10	150

(Estimation)

$$x = 5$$

$$x = 15$$

2. k unknown

The table on the right shows the number of TV sets in a certain local district.

Plot the data in curve. And, estimate the value of y when $x = 20, 21, 22$.

Year	Term	t	Yt Total (100 sets)
1956	1	0	40
	2	1	50
	3	2	67
	4	3	88
1957	1	4	119
	2	5	146
	3	6	182
	4	7	223
1958	1	8	273
	2	9	322
	3	10	388
	4	11	475
1959	1	12	591
	2	13	713
	3	14	845
	4	15	983
1960	1	16	1,143
	2	17	1,256
	3	18	1,377
	4	19	(1,513)
		$\sum_{t=0}^{18}$	9,281

Input	Display	Note	Input	Display	Note
1 [SHIFT] [B]	HOW MANY DATS ?		11 20 [ENTER]	20 1584.558488	
2 20 [ENTER]	Y=		12 [ENTER]	X=	
3 40 [ENTER]	Y=		13 21 [ENTER]	21. 1677.979932	
4 :			14 [ENTER]	X=	
5 Repeat thereafter			15 22 [ENTER]	22. 1758.671085	
6 1256 [ENTER]	A= 2.50744 E-01		16		
7 [ENTER]	M= 50.49168896		17		
8 [ENTER]	K= 2115.67291		18		
9 [ENTER]	ESTIMATION ?		19		
10 [ENTER]	X=		20		

SHARP

Title LOGISTIC CURVE

PROGRAM NO.
P 4-- B-15

[Operation]

CLOAD ▽B15▽ **ENTER**

SHIFT **A** k known

SHIFT **B** k unknown

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title 1-WAY LAYOUT

PROGRAM NO.
P 4 - B - 16

[Formula]

This program calculates analysis of variance by 1-way layout.

Level of factor A_i ($i = 1 \sim m$)

Number of replications j ($j = 1 \sim n$)

Data at j -th time in A_i level x_{ij}

$$T_i = \sum_{j=1}^n x_{ij}$$

$$CT = (\sum T_i)^2 / mn$$

$$S_T = \sum x_{ij}^2 - CT$$

$$S_A = \sum T_i^2 / n - CT$$

$$S_E = S_T - S_A$$

$$\phi_T = mn - 1$$

$$\phi_A = m - 1$$

$$\phi_E = \phi_T - \phi_A = m(n - 1)$$

$$V_A = S_A / \phi_A$$

$$V_E = S_E / \phi_E$$

$$F = V_A / V_E$$

[Example]

Level	x_{ij}				
A_1	-1	2	1	1	-4
A_2	1	2	-4	3	-1
A_3	-3	0	-2	-2	-4
A_4	7	1	2	3	3

[Operation] CLOAD ∇ B16 ∇

	Input	Display	Note		Input	Display	Note
1	SHIFT A	N=		11	ENTER	DF A= 3	
2	5 ENTER	A=		12	ENTER	DF E= 16	
3	4 ENTER	X=		13	ENTER	DF T= 19	
4	-1 ENTER	X=		14	ENTER	VA= 24.85	
5	2 ENTER	X=		15	ENTER	VE= 5.2	
6	:	:		16	ENTER	F= 4.778846154	
7	:	:		17			
8	3 ENTER	SA= 74.55		18			
9	ENTER	SE= 83.2		19			
10	ENTER	ST= 157.75		20			

SHARP

Title 2-WAY LAYOUT

PROGRAM NO.
P4-B-17

[Formula]

2-way layout data (with no repetition)

Data	A ₁	A ₂	...	A _i	...	A _a	Total	Mean
B ₁	x ₁₁	x ₂₁	...	x _{i1}	...	x _{a1}	T ₁	$\bar{x}_{.1}$
B ₂	x ₁₂	x ₂₂	...	x _{i2}	...	x _{a2}	T ₂	$\bar{x}_{.2}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
B _j	x _{1j}	x _{2j}	...	x _{ij}	...	x _{aj}	T _j	$\bar{x}_{.j}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
B _b	x _{1b}	x _{2b}	...	x _{ib}	...	x _{ab}	T _b	$\bar{x}_{.b}$
Total	T _{1.}	T _{2.}	...	T _{i.}	...	T _{a.}	T.	
Mean	$\bar{x}_{1.}$	$\bar{x}_{2.}$	...	$\bar{x}_{i.}$	...	$\bar{x}_{a.}$		$\bar{x}_{..}$

Correction term $CT = T^2 / a \cdot b$

Total variation $S_T = \sum_i \sum_j (x_{ij} - \bar{x}_{..})^2$
 $= \sum_i \sum_j x_{ij}^2 - CT$
 $\phi_T = a \cdot b - 1$

A variation $S_A = b \cdot \sum_i (\bar{x}_{i.} - \bar{x}_{..})^2$
 $= \sum_i T_i^2 / b - CT$
 $\phi_A = a - 1$

Factor	Sum of squares	Degree of freedom ϕ	Unbiased variance V	Unbiased variance ratio F
[A]	S _A	$\phi_A = a - 1$	$V_A = S_A / \phi_A$	$F_{0A} = V_A / V_e$
[B]	S _B	$\phi_B = b - 1$	$V_B = S_B / \phi_B$	$F_{0B} = V_B / V_e$
e	S _e	$\phi_e = (a-1)(b-1)$	$V_e = S_e / \phi_e$	
Total	S _T	$\phi_T = a \cdot b - 1$		

B variation $S_B = a \sum_j (\bar{x}_{.j} - \bar{x}_{..})^2$
 $= \sum_j T_j^2 / a - CT$
 $\phi_B = b - 1$

Error variation $S_e = \sum_i \sum_j (x_{ij} - \bar{x}_{i.} - \bar{x}_{.j} + \bar{x}_{..})^2$
 $= S_T - S_A - S_B$
 $\phi_e = (a-1)(b-1)$

* a is not limited in the level. $b \leq 17$

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [B]	A, B ?		11	⋮	⋮	
2	4 [ENTER]	?		12	⋮	⋮	
3	3 [ENTER]	X=	x ₁₁	13	⋮	⋮	
4	24 [ENTER]	X=	x ₁₂	14	⋮	⋮	
5	23 [ENTER]	X=	x ₁₃	15	⋮	⋮	
6	25 [ENTER]	X=	x ₂₁	16	⋮	⋮	
7	19 [ENTER]	X=	x ₂₂	17	⋮	⋮	
8	⋮	⋮		18	18 [ENTER]	X=	x ₄₁
9	⋮	⋮		19	58 [ENTER]	X=	x ₄₂
10	⋮	⋮		20	29 [ENTER]		x ₄₃

SHARP

Title	2-WAY LAYOUT	PROGRAM NO. P 4 - B - 17
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[Example]

Data

	A ₁	A ₂	A ₃	A ₄	Total	Mean
B ₁	24	19	39	18	100	.25
B ₂	23	40	64	58	185	46.25
B ₃	25	31	53	29	138	34.55
Total	72	90	105	105	423	
Mean	24	30	52	35		35.25

Factor	Sum of squares	Degree of freedom ϕ	Unbiased variance V	Unbiased variance ratio F
(A)	S _A = 1304.25	3	434.75	5.37
(B)	S _B = 906.50	2	453.25	5.60
e	S _e = 4855.50	6	80.92	
Total	S _T = 2696.25	11		

[Operation]

CLOAD ▽B 17 ▽ ENTER

	Input	Display	Note		Input	Display	Note
1		SA 1304.25		11	ENTER	VE 80.9166667	
2	ENTER	SB 906.5		12	ENTER	FA 5.372811534	
3	ENTER	SE 485.5		13	ENTER	FB 5.601441812	
4	ENTER	ST 2696.25		14			
5	ENTER	DF A 3		15			
6	ENTER	DF B 2		16			
7	ENTER	DF E 6		17			
8	ENTER	DF T 11		18			
9	ENTER	VA 434.75		19			
10	ENTER	VB 453.25		20			

Title 2-WAY LAYOUT			PROGRAM NO. P 4-B-17
Memory content			
A	1	j, ϕ_E	<pre> 10: "B":INPUT "A,B?" ,C,B 20: FOR A=5TO 9+B 30: A(A)=0:NEXT A 40: I=1 50: D=0:FOR A=10TO 9+B 60: INPUT "X=" ;H 70: A(A)=A(A)+H:D=D+H 80: G=G+H*H 90: NEXT A 100: E=E+D*D:F=F+D 110: IF I<>CLET I=I+1:GOTO 50 120: H=0 130: FOR A=10TO 9+B 140: H=H+A(A)*A(A) 150: NEXT A 160: F=F*B/B/C:G=G-F:E=E/B-F:H=H/C-F 170: I=C*B-1:C=C-1:B=B-1 180: D=G-E-H:A=I-B-C:J=E/C:K=H/B:L=D/A 190: PRINT "SA",E:PRINT "SB",H:PRINT "SE",D 200: PRINT "ST",G:PRINT "DF A",C:PRINT "DF B",B 210: PRINT "DF E",A:PRINT "DF T",I:PRINT "VA",J 220: PRINT "VB",K:PRINT "VE",L:PRINT "FA",J/L 230: PRINT "FB",K/L:END 400 </pre>
B	2	b, ϕ_B	
C	3	a, ϕ_A	
D	4	T_i, S_E	
E	5	$\Sigma T^2_i, S_A$	
F	6	T, CT	
G	7	$\Sigma x^2_{ij}, S_T$	
H	8	$x_{ij}, \Sigma T^2 \cdot j, S_B$	
I	9	i, ϕ_T	
J	10	T_1, V_A	
K	11	T_2, V_B	
L	12	T_3, V_E	
M	13	$T_4,$	
N	14	$\}$	
O	15		
P	16		
Q	17		
R	18		
S	19		
T	20		
U	21		
V	22		
W	23		
X	24		
Y	25		
Z	26		

SHARP

Title 2-WAY LAYOUT (WITH REPETITIONS)

PROGRAM NO.
P 4 - B - 18

[Formula]

This program calculates analysis of experimental data of 2-way layout having repetitions.

Number of replications, n

Level of factor of A, a

Level of factor of B, b ($b \leq 33$)

Find the sum of n times of repetition from the original table, and make up T-table.

That is,

$$T_{ij} = \sum_{k=1}^n x_{ijk}$$

Thereafter, calculate by using the original table and T-table.

Correction term $CT = (\sum x_{ijk})^2 / abn$

Total variation $ST = \sum x_{ijk}^2 - CT$

Among class variation $SAB = \sum T_{ij}^2 / n - CT$

Error variation $SE = ST - SAB$

A variation $SA = \sum_{j=1}^b (T_{ij})^2 / b - CT$

B variation $SB = \sum_{i=1}^a (T_{ij})^2 / a - CT$

Interaction $SAB = SAB - SA - SB$

Original table

	A ₁	A ₂	.....	A _a
B ₁	x ₁₁₁	x ₂₁₁	.....	x _{a11}
	x ₁₁₂	x ₂₁₂	.....	x _{a12}
				
	x _{11n}	x _{21n}	.....	x _{a1n}
B ₂	x ₁₂₁	x ₂₂₁	.....	x _{a21}
	x ₁₂₂	x ₂₂₂	.....	x _{a22}
				
	x _{12n}	x _{22n}	.....	x _{a2n}
B _b	x _{1b1}	x _{2b1}	.....	x _{ab1}
	x _{1b2}	x _{2b2}	.....	x _{ab2}
				
	x _{1bn}	x _{2bn}	.....	x _{abn}

Input	Display	Note	Input	Display	Note
1 [SHIFT] [A]	N, A, B		11 13 [ENTER]	X(IJK)=	
2 2 [ENTER]	?		12 13.5 [ENTER]	"	
3 4 [ENTER]	?		13 13.5 [ENTER]	"	
4 3 [ENTER]	N=2 A=4 B=3 OK?		14 12 [ENTER]	"	
5 [ENTER]	X(IJK)=		15 13 [ENTER]	"	
6 14 [ENTER]	"		16 13 [ENTER]	"	
7 13.5 [ENTER]	"		17 13.5 [ENTER]	"	
8 13 [ENTER]	"		18 13.5 [ENTER]	"	
9 13 [ENTER]	"		19 13.5 [ENTER]	"	
10 13.5 [ENTER]	"		20 11 [ENTER]	"	

Title 2-WAY LAYOUT (WITH REPETITIONS)

PROGRAM NO.
P 4 - B - 18

Find the degree of freedom
of each variation.

$$\phi_T = a b n - 1$$

$$\phi_{AB} = a b - 1$$

$$\phi_E = a b (n - 1)$$

$$\phi_A = a - 1$$

$$\phi_B = b - 1$$

$$\phi_{A \times B} = (a - 1)(b - 1)$$

Find the unbiased variance.

$$V_{AB} = S_{AB} / \phi_{AB}$$

$$V_E = S_E / \phi_E$$

$$V_A = S_A / \phi_A$$

$$V_B = S_B / \phi_B$$

$$V_{A \times B} = S_{A \times B} / \phi_{A \times B}$$

Find the variance ratio.

$$F_{AB} = V_{AB} / V_E$$

$$F_A = V_A / V_E$$

$$F_B = V_B / V_E$$

$$F_{A \times B} = V_{A \times B} / V_E$$

Summarize the data above into
a variance analytical table.

T-table

	A ₁	A ₂	.....	A _a
B ₁	T ₁₁	T ₂₁	.....	T _{a1}
B ₂	T ₁₂	T ₂₂	.....	T _{a2}
⋮	⋮	⋮	⋮	⋮
B _b	T _{1b}	T _{2b}	.....	T _{ab}

Variance analytical table

Factor	S	φ	V	F
A	S _A	φ _A	V _A	F _A
B	S _B	φ _B	V _B	F _B
A×B	S _{A×B}	φ _{A×B}	V _{A×B}	F _{A×B}
Among class	A _{AB}	φ _{AB}	V _{AB}	F _{AB}
E	S _E	φ _E	V _E	—
Total	S	φ	—	—

	Input	Display	Note		Input	Display	Note
1	12 ENTER	X(IJK)=		11	ENTER	VA= 1.624999887	
2	12.5 ENTER	//		12	ENTER	FA= 7.799999459	
3	13 ENTER	//		13	ENTER	SB= 5.395833	
4	11.5 ENTER	//		14	ENTER	DF, B= 2	
5	12.5 ENTER	//		15	ENTER	VB= 2.6979165	
6	11 ENTER	//		16	ENTER	FB= 12.9499992	
7	12 ENTER	//		17	ENTER	SA*B= 2.68750034	
8	13 ENTER	//		18	ENTER	DF.A*B= 6	
9	13 ENTER	SA= 4.87499966		19	ENTER	VA*B= 4.47916E-01	
10	ENTER	DF A= 3		20	ENTER	FA*B= 2.150000272	

SHARP

Title 2-WAY LAYOUT (WITH REPETITIONS)

PROGRAM NO.
P 4 - B - 18

[Example]

When molding a synthetic resin, the operation was conventionally carried out at molding temperature of 80°C, polymer time of 4 minutes, and catalyst amount of 1%. But the strength is not sufficient under those conditions. So, it is desired to modify the job standard by varying the molding temperature and catalyst amount.

Therefore, at different molding temperatures 80, 90, 100, 110°C (A_1, A_2, A_3, A_4), and catalyst amounts 0.5, 1.0, 1.5% (B_1, B_2, B_3), experiments were conducted under the conditions of $3 \times 4 = 12$ twice each, totaling 24 times. The results are summarized in the table shown on the right. Attempt to analyze the data.

	A_1	A_2	A_3	A_4
B_1	14.0	13.5	13.5	11.5
	13.5	13.5	13.5	12.5
B_2	13.0	12.0	11.0	11.0
	13.0	13.0	12.0	12.0
B_3	13.5	13.0	12.5	13.0
	13.0	13.5	13.0	13.0

[Operation]

CLOAD ▽B18 ▽

	Input	Display	Note		Input	Display	Note
1	ENTER S =	12.958333		11			
2	ENTER DF =	11		12			
3	ENTER V =	1.178030273		13			
4	ENTER F =	5.654545311		14			
5	ENTER SE =	2.5		15			
6	ENTER DF·E =	12		16			
7	ENTER VE =	2.08333E-01		17			
8	ENTER ST =	15.458333		18			
9	ENTER DF·T =	23		19			
10				20			

Title 2-WAY LAYOUT (WITH REPETITIONS)			PROGRAM NO. P4-B-18
Memory content			
A	1	a	10: "A":CLEAR
B	2	b	20: INPUT "N/A,B",C,A,B
C	3	n	30: PRINT "N=";USING "###";C;" A=";A;" B=";
D	4	For input	B;" OK?"
E	5	Index	40: FOR F=1TO A
F	6	i	50: FOR G=1TO B
G	7	j	60: FOR H=1TO C
H	8	k	70: INPUT "X(IJK)=";D
I	9	CT	80: L=D+L;J=J+D*D
J	10	ST	90: NEXT H
K	11	SA	100: Q=Q+L;P=P+L*L
L	12	$T \rightarrow \phi_A$	110: E=G+17:A(E)=A(E)+L:L=0
M	13	VA	120: NEXT G
N	14	FA	130: K=K+Q*Q
O	15	SB	140: I=I+Q;Q=0
P	16	SAB	150: NEXT F
Q	17	$T_{i.} \rightarrow S_E$	160: FOR E=18TO 17+B
R	18	$T_{.2} \rightarrow \phi_E$	170: O=0+A(E)*A(E)
S	19	$T_{.2} \rightarrow V_E$	180: NEXT E
T	20		190: I=I*I/(A*B*C)
U	21		200: J=J-I
V	22		210: K=K/(B*C)-I
W	23	: X(IJK)	220: O=O/(A*C)-I
X	24	:	230: P=P/C-I
Y	25	:	240: Q=J-P
Z	26		250: R=A*B*(C-1):S=Q/R
			260: BEEP 2:USING :E=K:L=A-1:GOSUB 500
			270: PRINT "SA=";K:PRINT "DF.A=";L:PRINT "VA
			=";M:PRINT "FA=";N
			280: K=0,L=B-1:GOSUB 500
			290: PRINT "SB=";K:PRINT "DF.B=";L:PRINT "VB
			=";M:PRINT "FB=";N
			300: K=P-O-E:L=(A-1)*(B-1):GOSUB 500
			310: PRINT "SA*B=";K:PRINT "DF.A*B=";L:
			PRINT "VA*B=";M:PRINT "FA*B=";N
			320: K=P-L:A*B-1:GOSUB 500
			330: PRINT "S=";K:PRINT "DF=";L:PRINT "V=";M
			:PRINT "F=";N
			340: K=Q:L=R:M=S
			350: PRINT "SE=";K:PRINT "DF.E=";L:PRINT "VE
			=";M
			360: K=J:L=A*B*C-1
			370: PRINT "ST=";K:PRINT "DF.T=";L
			380: END
			500: M=K/L:N=M/S
			510: RETURN
			681

Title $\bar{x}$ - R CONTROL CHART, Pn CONTROL CHART

PROGRAM NO.
P 4 - B-19

[Formula]

1. Find the control limit of $\bar{x}$ -R control chart.
2. Find the control limit of pn control chart.

$$LCL = \bar{p}n - 3\sqrt{\bar{p}n(1-\bar{p})}$$

$$CL = \bar{p}n$$

$$UCL = \bar{p}n + 3\sqrt{\bar{p}n(1-\bar{p})}$$

[Example]

1. $\bar{x}$ -R control chart

Group No.	x_1	x_2	x_3
1	22.10	23.75	22.37
2	21.17	20.75	20.82
3	20.52	20.62	21.25
4	20.98	20.88	21.73

2. pn control chart

n = 250

Set No.	1	2	3	4	5	6	7
No. of defects	18	26	16	12	31	16	24

A_2, D_3, D_4 constant table

n	A_2	D_3	D_4
2	1.880	0	3.267
3	1.023	0	2.575
4	.729	0	2.282
5	.577	0	2.115
6	.483	0	2.004
7	.419	.076	1.924
8	.373	.136	1.864
9	.337	.184	1.816
10	.308	.223	1.777

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	N, A2, D3, D4		11	[SHIFT] [B]	LCL 20.461225	$\bar{x}$
2	3 [ENTER]	?		12	[ENTER]	CL 21.4075	"
3	1.023 [ENTER]	?		13	[ENTER]	UCL 22.353775	"
4	0 [ENTER]	?		14	[ENTER]	LCL 0.	R
5	2.575 [ENTER]	X=		15	[ENTER]	CL 0.925	"
6	22.10 [ENTER]	X=		16	[ENTER]	UCL 2.381875	"
7	23.75 [ENTER]	X=		17			
8	22.37 [ENTER]	X--= 22.74		18			
9	: :	R= 1.65		19			
10	Repeat steps 6 to 8 thereafter			20			

Title $\bar{x}$ -R CONTROL CHART, Pn CONTROL CHART

PROGRAM NO.
P 4 - B - 19

[Operation]

CLOAD ∇ B19 ∇ **ENTER**

SHIFT **A** $\bar{x}$ -R control chart, data input

SHIFT **B** $\bar{x}$ -R control chart, result

SHIFT **C** pn control chart, data input

SHIFT **D** pn control chart, result

	Input	Display	Note		Input	Display	Note
1	SHIFT C	N=		11	SHIFT D	LCL 7.43498117	
2	250 ENTER	RI=		12	ENTER	CL 20.42857143	
3	18 ENTER	PI 7.2		13	ENTER	UCL 33.422161669	
4	ENTER	:		14			
5	26 ENTER	:		15			
6	:	:		16			
7	Repeat thereafter			17			
8				18			
9				19			
10				20			

SHARP

Title L₈ ORTHOGONAL ARRAY TABLE

PROGRAM NO.
P 4 - B - 20

[Formula] [Example]

Row No. \ No.	1	2	3	4	5	6	7	Data	Example
1	1	1	1	1	1	1	1	X ₁	9
2	1	1	1	2	2	2	2	X ₂	12
3	1	2	2	1	1	2	2	X ₃	8
4	1	2	2	2	2	1	1	X ₄	15
5	2	1	2	1	2	1	2	X ₅	16
6	2	1	2	2	1	2	1	X ₆	20
7	2	2	1	1	2	2	1	X ₇	13
8	2	2	1	2	1	1	2	X ₈	13

This program performs experiments of two levels according to the orthogonal table above and analyzes the data.

$$S_1 = \frac{1}{8} [(\text{sum of level 1}) - (\text{sum of level 2})]^2$$

$$= \frac{1}{8} (X_1 + X_2 + X_3 + X_4 - X_5 - X_6 - X_7 - X_8)^2$$

$$\phi_1 = 1, V_1 = S_1 / \phi_1$$

Compute similarly in row 2 and thereafter, and find the total S_T.

[Operation]

CLOAD ▽B20 ▽

	Input	Display	Note		Input	Display	Note
1	SHIFT A	DATA		11	ENTER	S5 = 4.5	
2	ENTER	X =		12	ENTER	S6 = 0	
3	9 ENTER	X =		13	ENTER	S7 = 8	
4	:			14	ENTER	ST = 103.5	
5	:			15			
6	Repeat thereafter			16			
7	13 ENTER	S1 = 40.5		17			
8	ENTER	S2 = 8		18			
9	ENTER	S3 = 18		19			
10	ENTER	S4 = 24.5		20			

SHARP

Title L₁₆ ORTHOGONAL ARRAY TABLE

PROGRAM NO.
P 4 - B - 21

[Formula]

This program analyzes the data of experiment conducted according to L₁₆ (2¹⁵) orthogonal array table.

F value is not outputted, which should be calculated manually.

$$S_1 = \frac{1}{16} [(\text{sum of data in level 2}) - (\text{sum of data in level 1})]^2$$

Calculate similarly until S₁₅.

$$\phi_1 \sim \phi_{15} = 1$$

$$\phi = 15$$

$$V_1 = S_1$$

⋮

$$V_{15} = S_{15}$$

Summarize the data above into a variance analytical table.

	S	φ	V
1	S ₁	1	V ₁
2	S ₂	1	V ₂
3	S ₃	1	V ₃
⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮
15	S ₁₅	1	V ₁₅
Total	S	15	

[Example]

In order to increase the yield of a certain reaction process, experiments were conducted by L₁₆ (2⁵) with five factors — reaction time (A), temperature (B), quantity of component (C), pressure (D), and apparatus (E) — being varied in two levels. The effects intended to know are the main effect and interaction of two factors, namely, A × B, A × C, B × C, A × D, B × D. Therefore, A, B, C, D, and E were allotted respectively to 1, 2, 8, 15, and 7, and experiments were done 16 times by randomizing. As a result, the data shown in the table below was obtained. Attempt to analyze the data.

	Input	Display	Note		Input	Display	Note
1	SHFT [A]	?		11	94.9 [ENTER]	?	
2	78.3 [ENTER]	?		12	92.8 [ENTER]	?	
3	85.7 [ENTER]	?		13	94.7 [ENTER]	?	
4	77.8 [ENTER]	?		14	82.3 [ENTER]	?	
5	86 [ENTER]	?		15	90 [ENTER]	?	
6	89.1 [ENTER]	?		16	81.7 [ENTER]	?	
7	90.5 [ENTER]	?		17	90.2 [ENTER]	1 60.84000 1	
8	89.2 [ENTER]	?		18	[ENTER]	2 0.16000 1	
9	91.4 [ENTER]	?		19	[ENTER]	3 249.64000 1	
10	92.6 [ENTER]	?		20	[ENTER]	4 0.01000 1	

SHARP

Title	L ₁₆ ORTHOGONAL ARRAY TABLE	PROGRAM NO. P 4 - B-21
-------	--	---------------------------

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Data
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	78.3
	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	85.7
	1	1	1	2	2	2	2	1	1	1	1	2	2	2	2	77.8
	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1	86.0
	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	89.1
	1	2	2	1	1	2	2	2	2	1	1	2	2	1	1	90.5
	1	2	2	2	2	1	1	1	1	2	2	2	2	1	1	89.2
	1	2	2	2	2	1	1	2	2	1	1	1	1	2	2	91.4
	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	92.6
	2	1	2	1	2	1	2	2	1	2	1	2	1	2	1	94.9
	2	1	2	2	1	2	1	1	2	1	2	2	1	2	1	92.8
	2	1	2	2	1	2	1	2	1	2	1	1	2	1	2	94.7
	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	82.3
	2	2	1	1	2	2	1	2	1	1	2	2	1	1	2	90.0
	2	2	1	2	1	1	2	1	2	2	1	2	1	1	2	81.7
	2	2	1	2	1	1	2	2	1	1	2	1	2	2	1	90.2
Factor allotted	A	B	(A × B)				E	C	(A × C)	(B × C)			(B × D)	(A × D)	D	

[Operation]

CLOAD ▽B21 ▽

	Input	Display	Note		Input	Display	Note
1	ENTER	5 0.09000 1		11	ENTER	15 0.09000 1	
2	ENTER	6 0.04000 1		12	ENTER	T 445.56	
3	ENTER	7 0.16000 1		13			
4	ENTER	8 98.01000 1		14			
5	ENTER	9 0.09000 1		15			
6	ENTER	10 0.00000 1		16			
7	ENTER	11 36.00000 1		17			
8	ENTER	12 0.25000 1		18			
9	ENTER	13 0.09000 1		19			
10	ENTER	14 0.09000 1		20			

Title L ₁₆ ORTHOGONAL ARRAY TABLE			PROGRAM NO. P 4 - B - 21
Memory content			
A	1		
B	2		
C	3		
D	4		
E	5		
F	6		
G	7		
H	8	Data	
I	9		
J	10		
K	11		
L	12		
M	13		
N	14		
O	15		
P	16		
Q	17		
R	18		
S	19		
T	20		
U	21		
V	22	Difference, S _i	
W	23		
X	24		
Y	25		
Z	26	~ 31	
	34	Sum of one component	
	35	Orthogonal table	
	36	One digit component	
	37	Index	
	38	i	
	39	Sum	

```

10: "A":A(39)=0
20: FOR A(35)=1TO 16
30: INPUT A(A(35))
40: A(39)=A(39)+A(A(35))
50: NEXT A(35)
60: A(17)=3333:A(18)=330033:A(19)=33000033
70: A(20)=3030303:A(21)=30300303:A(22)=3003
    3003
80: A(23)=3303003:A(24)=11111111:A(25)=2222
    1111
90: A(26)=22112211:A(27)=11222211:A(28)=212
    12121
100: A(29)=12122121:A(30)=12211221:A(31)=211
    21221
110: FOR A(37)=17TO 31
120: A(35)=A(A(37)):GOSUB 500
130: NEXT A(37)
140: A(38)=0:A(2)=1
150: BEEP 2:FOR A(34)=1TO 15
160: A(39)=A(34)+16:A(1)=A(A(39)):A(38)=A(1)
    +A(38)
170: PRINT USING "###";A(34);USING "#####
    .#####";A(1);USING "#####";A(2)
175: NEXT A(34)
180: USING :PRINT "T",A(38)
190: END
500: A(34)=0
510: FOR A(38)=1TO 8
520: A(36)=A(35):A(35)=INT (.1*A(35)):A(36)=
    A(36)-10*A(35)
530: A(33)=2*A(38):A(32)=A(33)-1
540: A(34)=(A(36)-INT (A(36)*.5)*2)*A(A(32))
    +INT (A(36)*.5)*A(A(33))+A(34)
550: NEXT A(38)
560: A(33)=A(39)-2*A(34):A(A(37))=A(38)*A(38
    )/16
570: RETURN
740

```

SHARP

Title

**SPEARMAN RANK ORDER CORRELATION
COEFFICIENT**

PROGRAM NO.

P 4 - B - 22

[Formula]

Regarding the rank order just like measured values, this program is intended to find the correlation coefficient.

$$r_s = 1 - \frac{6 \sum (x_i - y_i)^2}{n^3 - n}$$

In the equation above, x_i and y_i are rank orders, and the identical rank orders should be settled to a mean value. For instance, if the third rank is occupied by two samples, the mean of 3 and 4, namely 3.5, is taken; if there are three samples in the same rank, the mean of 3, 4, 5, namely 4, is taken.

The test should utilize the fact that

$$t = \frac{r_s \sqrt{n-2}}{\sqrt{1-r_s^2}}$$

conforms to t-distribution of $n-2$ degree of freedom.

The critical region should be determined by the right side test.

[Example]

x_i	5	3	4	1	8	9	2	7	6
y_i	5	4	1	3	6	9	2	8	7

[Operation]

CLOAD ▽B22 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	X=		11	SHIFT B	R= 8.33333 E-01	
2	5 ENTER	Y=		12	ENTER	T= 3.988620175	
3	5 ENTER	X=		13	ENTER	DF= 7.	
4	:			14			
5	Repeat thereafter			15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title		SPEARMAN RANK ORDER CORRELATION COEFFICIENT	PROGRAM NO. P4-B-22
Memory content			
A	1		
B	2		
C	3		
D	4		
E	5		
F	6		
G	7		
H	8		
I	9		
J	10		
K	11		
L	12		
M	13		
N	14	n	
O	15		
P	16		
Q	17		
R	18	rs	
S	19	$\sum (x_i - y_i)^2$	
T	20		
U	21		
V	22		
W	23		
X	24	x_i	
Y	25	y_i	
Z	26	$x_i - y_i$	

```

10: "A":N=0,S=0
20: INPUT "X=";X
30: INPUT "Y=";Y
40: Z=X-Y:S=S+Z*Z
50: N=N+1:GOTO 20
60: "B":R=1-6*S/(N*(N-1))
70: N=N-2
80: PRINT "R=",R
90: PRINT "T=",R*sqrt(N/(1-R*R))
100: PRINT "DF=",N
110: END
144

```

SHARP

Title	ANGLE CALCULATIONS	PROGRAM NO. P4 - C - 1
-------	--------------------	---------------------------

[Formula]

Inputting angles in degrees, minutes, seconds, the angles are added, subtracted, multiplied, and divided. This program also multiplies and divides by multiples and divisors of integer. In this case, the angle is expressed in (degrees. minutes-seconds).

In the case of subtraction, inputs are to be entered in negative numerals. The limit of digits is up to 4 digits of the integer part in the total angle expression, and up to 2 digits in multiples and divisors.

The second unit in display is rounded off, but all the digits are stored in the calculator.

[Example]

$$123^{\circ}45'12'' + 54^{\circ}32'10'' - 30^{\circ}20'10'' = 147^{\circ}57'12''$$

$$147^{\circ}57'12'' \div 3 = 49^{\circ}19'04''$$

$$\times 3 = 147^{\circ}57'12''$$

[Operation]

C LOAD ∇ C 1 ∇ **ENTER**

- A** program: For angle totaling
- B** program: For angle division
- C** program: For angle multiplication

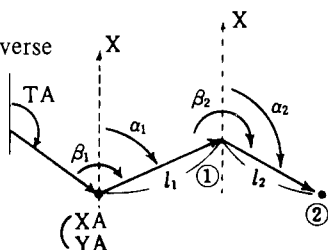
Input	Display	Note	Input	Display	Note
1 SHIFT A	A =		11 SHIFT C	TOTAL = 49.1904	
2 123.4512 ENTER	A = 123.4512		12 ENTER	X	
3 54.3210 ENTER	A = 54.3210		13 3 ENTER	X 3	
4 -30.2010 ENTER	A = -30.2010		14	49.1904 $\times$ 3 = 147.5712	
5	A =		15		
6 SHIFT B	TOTAL = 147.5712		16		
7 ENTER	/		17		
8 3 ENTER	/ 3		18		
9	147.5712 $\div$ 3 = 49.1904		19		
10			20		

Title OPEN AND RADIATE TRAVERSE

PROGRAM NO.
P4 - C - 2

[Formula]

A) Open traverse



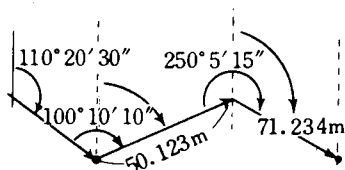
Input direction angles at starting point and coordinates, then included angle at each point and distance, and find the direction angle and coordinates.

$$\text{Direction angle: } \alpha_i = \alpha_{i-1} + \beta_i + 180^\circ - (360^\circ)$$

$$\text{Coordinates: } X_i = X_{i-1} + l_i \cos \alpha_i$$

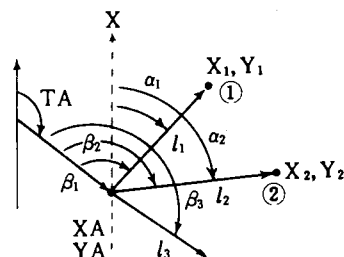
$$Y_i = Y_{i-1} + l_i \sin \alpha_i$$

[Example] (Open traverse)



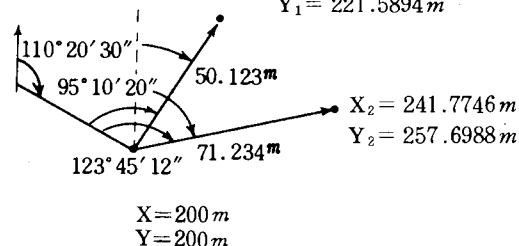
$$\begin{array}{lll} X = 100 & X_1 = 143.1825 & X_2 = 130.0806 \\ Y = 100 & Y_1 = 125.4477 & Y_2 = 195.4664 \end{array}$$

B) Radiate traverse



(Radiate traverse)

$$\begin{array}{l} X_1 = 245.2350 \text{ m} \\ Y_1 = 221.5894 \text{ m} \end{array}$$



[Operation]

C LOAD ∇ C 2 ∇ **ENTER**

A program: Open traverse

B program: Radiate traverse

NOTE) Coordinates are expressed by rounding off the 5th decimal.

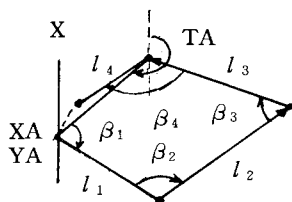
Input	Display	Note	Input	Display	Note
1 SHIFT A	OPEN		11 SHIFT B	RADIATE	
2 (TA)110.2030 ENTER	TA = 110.2030		12 (TA)110.2030 ENTER	TA = 110.2030	
3 (XA)100 ENTER	XA = 100		13 (XA)200 ENTER	XA = 200	
4 (YA)100 ENTER	YA = 100		14 (YA)200 ENTER	YA = 200	
5 (B ₁)100.1010 ENTER	B = 100.1010		15 (B ₁)95.1020 ENTER	B = 95.1020	
6 (l ₁)50.123 ENTER	L = 50.123		16 (l ₁)50.123 ENTER	L = 50.123	
7	A = 30.3040	(α)	17	A = 25.3050	
8 ENTER	143.1825 125.4477	(X, Y)	18 ENTER	245.2350 221.5894	
9 ENTER	Repeat from step 5 on.		19 ENTER	Repeat from step 15 on.	
10			20		

Title OPEN AND RADIATE TRAVERSE			PROGRAM NO. P 4 - C - 2
Memory content			
A	1	TA ^{o'''}	
B	2	XA	
C	3	YA	10: "A":PAUSE "OPEN":I=0:GOTO 30
D	4	β	20: "B":PAUSE "RADIATE":I=1
E	5	l	30: DEGREE :INPUT "TA= ";A,"XA= ";B,"YA= ";
F	6	α_i	C
G	7	X _i	40: INPUT "B= ";D,"L= ";E
H	8	Y _i	50: F=DEG A+DEG D+180
I	9	Discriminant	60: IF DMS F>=360LET F=DEG (DMS F-360):
J	10		GOTO 60
K	11		70: G=B+E* $\cos F$:H=C+E* $\sin F$
L	12		80: F=INT (DMS (F+.00014)*E4)/E4
M	13		90: PRINT USING "#####.####";"A=",F
N	14		100: PRINT G,H
O	15		110: IF I=0LET A=F:B=G:C=H
P	16		120: GOTO 40
Q	17		237
R	18		
S	19		
T	20		
U	21		
V	22		
W	23		
X	24		
Y	25		
Z	26		

Title CLOSED AND FIXED TRAVERSE (COMPASS RULE)

PROGRAM NO.
P 4 - C - 3

[Formula]



After inputting the difference in coordinates, feed the included angle (corrected) at each point and distance, and find the error of closure in latitude and departure, sum of distance, and accuracy. Also, using the result of the calculation of error of closure, this program distributes the error of coordinates according to the compass rule.

Error of closure in latitude $\sum \Delta X_i = EX$

Error of closure in departure $\sum \Delta Y_i = EY$

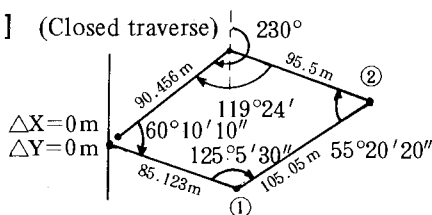
Sum of distance $\sum l_i$

Accuracy $\sum l_i / \sqrt{(\sum \Delta X_i)^2 + (\sum \Delta Y_i)^2}$

Corrected total latitude $X_i = X_{i-1} + \Delta X_i + \frac{l_i}{\sum l_i} EX$

Corrected total departure $Y_i = Y_{i-1} + \Delta Y_i + \frac{l_i}{\sum l_i} EY$

[Example] (Closed traverse)



Error of closure in latitude 5.968 m

Error of closure in departure 7.542 m

Accuracy 39

Included angle	Distance	Direction angle	Total latitude	Total departure
		230°	0m	0m
60°10'10"	85.123m	110°10'10"	-30.701	78.196
125° 5'30"	105.05	55°15'40"	27.494	162.416
55°20'20"	95.5	290°36'	59.579	71.107
119°24'	90.456	230°	0	0

Sum of
distance 376.129

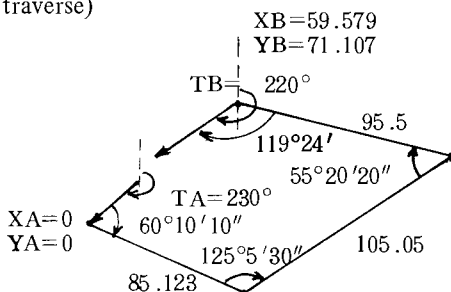
[Operation] C LOAD ▽ C 3 ▽

Input	Display	Note	Input	Display	Note
1 SHIFT A			11 (B ₃)55.202 ENTER	B = 55.202	
2 (TA)230 ENTER	TA = 230		12 (I ₃)95.5 ENTER	L = 95.5	
3 (ΔX) 0 ENTER	DX = 0	XA -- XB	13 ENTER	A = 290.3600	
4 (ΔY) 0 ENTER	DY = 0	YA -- YB	14 (B ₄)119.24 ENTER	B = 119.24	
5 (B ₁)60.1010 ENTER	B = 60.1010		15 (I ₄)90.456 ENTER	L = 90.456	
6 (I ₁)85.123 ENTER	L = 85.123		16 ENTER	A = 230.0000	
7 ENTER	A = 110.1010 (α)		17 SHIFT B	EX = 5.9680	
8 (B ₂)125.0530 ENTER	B = 125.0530		18 ENTER	EY = 7.5416	
9 (I ₂)105.05 ENTER	L = 105.05		19 ENTER	TL = 376.1290	
10 ENTER	A = 55.1540		20 ENTER	ACCURACY = 39	

Title CLOSED AND FIXED TRAVERSE (COMPASS RULE)

PROGRAM NO.
P 4 - C - 3

- A** program: For traverse starting
B program: For error calculation
C program: For coordinates output
(Fixed traverse)



In this case, input as follows:

$$\begin{aligned}\Delta X &= X_A - X_B = -59.579 \\ \Delta Y &= Y_A - Y_B = -71.107 \\ l_n &= 0\end{aligned}$$

$$\begin{aligned}EX &= 4.5330 \\ EY &= 5.7279 \\ TL &= 285.673 \\ \text{ACCURACY} &= 39\end{aligned}$$

Included angle	Distance	Direction angle	Total latitude	Total departure
		230°	0m	0m
60°10'10"	85.123m	110°10'10"	-30.7009	78.1962
125° 5'30"	105.05	55°15'40"	27.4935	162.4155
55°20'20"	95.5	290°36'	59.5790	71.1069
119°24'	0	230°		

- NOTES) • To round off the coordinates, the 5th decimal is discarded.
• If the accuracy is infinite (∞), it results in an error. But the operation can be progressed to a next step after pressing CL key.
• There is not limit to the number of measure points. Each piece of data, however, should be inputted twice correctly.

Input	Display	Note	Input	Display	Note
1 [SHIFT] [C]		(Example of closure)	11 (L)95.5 [ENTER]	L = 95.5	
2 (XA) 0 [ENTER]	XA = 0		12 [ENTER]	59.5792 71.1070	
3 (YA) 0 [ENTER]	YA = 0		13 (B)119.24 [ENTER]	B = 119.24	
4 (B)60.1010 [ENTER]	B = 60.1010		14 (L)90.456 [ENTER]	L = 90.456	
5 (L)85.123 [ENTER]	L = 85.123		15	-0.0000 -0.0000	
6 [ENTER]	-30.7008 78.1962	(x, y)	16		
7 (B)125.0530 [ENTER]	B = 125.0530		17		
8 (L)105.05 [ENTER]	L = 105.05		18		
9 [ENTER]	27.4937 162.4155		19		
10 (B)55.202 [ENTER]	B = 55.202		20		

[illegible]

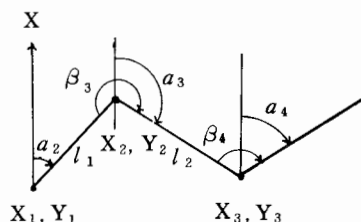
Title INVERSE CALCULATIONS OF OPEN AND RADIATE TRAVERSE

PROGRAM NO.
P 4 - C - 4

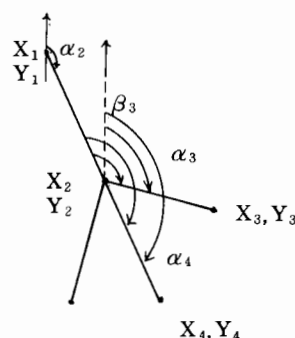
[Formula]

Giving coordinates successively, find the distance between two points, direction angle, and included angle.

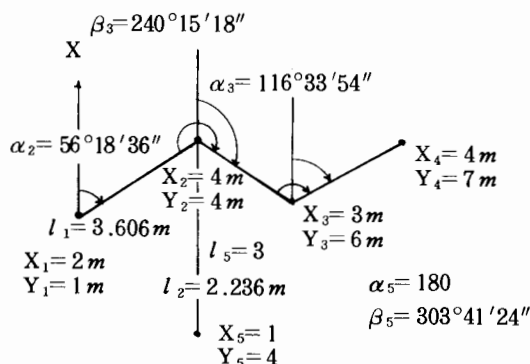
(A) Open traverse



(B) Radiate traverse



[Example]



[Operation]

C LOAD ∇ C 4 ∇ **ENTER**

NOTE) Distance is expressed by rounding off the 5th decimal.

- A** program: Inverse calculation of open traverse
- B** program: Inverse calculation of radiate traverse

	Input	Display	Note		Input	Display	Note
1	SHIFT A	OPEN		11		B = 240.1518	
2	(X ₁) 2 ENTER	X ₁ = 2		12	ENTER	A = 116.3354	
3	(Y ₁) 1 ENTER	Y ₁ = 1		13	ENTER	L = 2.2360	
4	(X ₂) 4 ENTER	X = 4		14	ENTER		
5	(Y ₂) 4 ENTER	Y = 4		15		Repeat from step 9 on.	
6		A = 56.1836		16	SHIFT B	RADIATE	
7	ENTER	L = 3.6055		17		Calculate radiate traverse	
8	ENTER			18		similarly thereafter.	
9	(X ₃) 3 ENTER	X = 3		19			
10	(Y ₃) 6 ENTER	Y = 6		20			

Title COORDINATE AREA CALCULATION

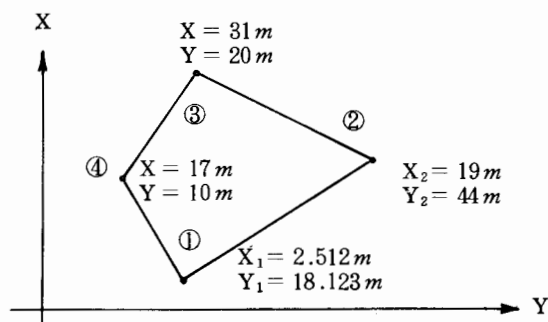
PROGRAM NO.
P 4 - C - 5

[Formula]

Determine the area of a polygon by inputting the coordinates of each vertex, according to the equation below.

$$2S = \sum \{ (X_{i+1} - X_i)(Y_{i+1} + Y_i) \}$$

[Example]



[Operation]

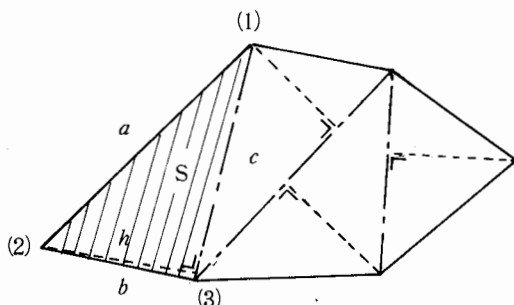
C LOAD ▽ C 5 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A			11		S = 482.419000	
2	(n) 4 ENTER	N = 4	No. of vertices	12		Input coordinates n times	
3	(X ₁) 2.512 ENTER	X ₁ = 2.512		13			
4	(Y ₁) 18.123 ENTER	Y ₁ = 18.123		14			
5	(X ₂) 19 ENTER	X = 19		15			
6	(Y ₂) 44 ENTER	Y = 44		16			
7	(X ₃) 31 ENTER	X = 31		17			
8	(Y ₃) 20 ENTER	Y = 20		18			
9	(X ₄) 17 ENTER	X = 17		19			
10	(Y ₄) 10 ENTER	Y = 10		20			

Title DIAGONAL AND PERPENDICULAR AREA CALCULATION

PROGRAM NO.
P 4 - C - 6

[Formula]



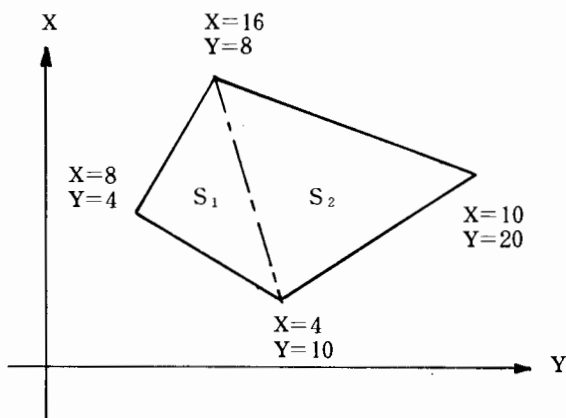
Feed the coordinates at three points sequentially, and find the area of each triangle.

$$S = \frac{1}{2} h L \quad (L: \text{longest side of } a, b, c)$$

where, h is the height, discarding 4th decimal.

(NOTE) Each side length is expressed in maximum 4 digits in integer part, rounding off the 4th decimal.

[Example]



[Operation]

C LOAD ▽ C 6 ▽ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT [A]			11	ENTER	TS = 31.996580	
2	(X ₁) 4 ENTER	?		12	ENTER	Repeat from step 2 on.	
3	(Y ₁) 10 ENTER	?		13			
4	(X ₂) 8 ENTER	?		14			
5	(Y ₂) 4 ENTER	?		15			
6	(X ₃) 16 ENTER	?		16			
7	(Y ₃) 8 ENTER	?		17			
8		A = 7.211 B = 8.944		18			
9	ENTER	C = 12.166 H = 5.260		19			
10	ENTER	S = 31.996580		20			

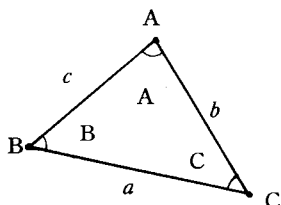
SHARP

Title TRIANGLE CALCULATIONS

PROGRAM NO.
P 4 - C - 7

[Formula]

A) Given two sides and the included angle. Find the other one side, two angle, and area.



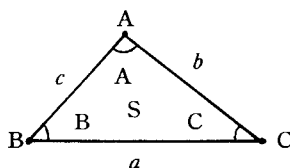
$$a = \sqrt{b^2 + c^2 - 2bc \cos A}$$

$$B = \cos^{-1} \frac{a^2 + c^2 - b^2}{2ac}$$

$$C = 180 - A - B$$

$$S = \frac{1}{2} bc \sin A$$

B) Given two angles and the included side. Find the other one angle and two side lengths.

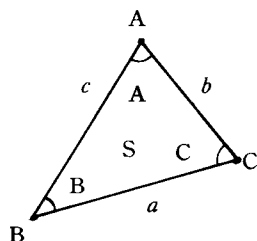


$$A = 180 - (B + C)$$

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

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

C) Given three side lengths. Find the area and interior angles.



$$A = \cos^{-1} \frac{b^2 + c^2 - a^2}{2bc}$$

$$B = \cos^{-1} \frac{a^2 + c^2 - b^2}{2ac}$$

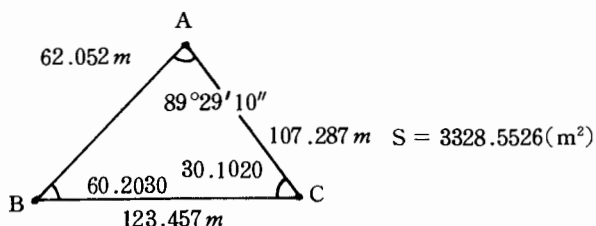
$$C = 180 - A - B$$

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]			11	[SHIFT] [B]		
2	(b) 107.287 [ENTER]	SB = 107.287		12	(a) 123.456 [ENTER]	SA = 123.456	
3	(c) 62.052 [ENTER]	SC = 62.052		13	(B) 60.203 [ENTER]	B = 60.203	
4	(A) 89.2910 [ENTER]	A = 89.2910		14	(C) 30.1020 [ENTER]	C = 30.1020	
5		SA = 123.4565		15		A = 89.2910	
6	[ENTER]	B = 60.2030		16	[ENTER]	SB = 107.2865	
7	[ENTER]	C = 30.1020		17	[ENTER]	SC = 62.0515	
8	[ENTER]	S = 3328.5525		18	[ENTER]	S = 3328.5163	
9	[ENTER]	Reaffirmation possible		19	[ENTER]	Reaffirmation possible	
10				20			

Title TRIANGLE CALCULATIONS

PROGRAM NO.
P 4 - C - 7

[Example]



[Operation]

C LOAD ▽ C 7 ▽ **ENTER**

NOTE) Side length and area are expressed by discarding the 5th digit.

- A** program: Calculation with two sides and included angle given.
- B** program: Calculation with two angles and included side given.
- C** program: Calculation with three side lengths given.

	Input	Display	Note		Input	Display	Note
1	SHIFT C			11			
2	(a) 123.457 ENTER	SA = 123.457		12			
3	(b) 107.287 ENTER	SB = 107.287		13			
4	(c) 62.052 ENTER	SC = 62.052		14			
5		A = 89.2912	←	15			
6	ENTER	B = 60.2029		16			
7	ENTER	C = 30.1020		17			
8	ENTER	S = 3328.5527		18			
9	ENTER	Reaffirmation possible		19			
10				20			

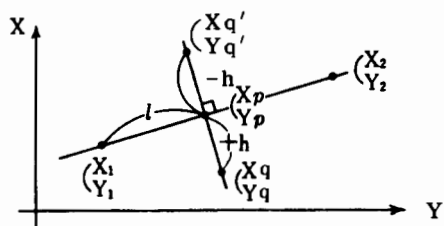
Title			TRIANGLE CALCULATIONS	PROGRAM NO. P 4- C - 7
Memory content				
A	1	a		
B	2	b		
C	3	c		
D	4	A , A°	10: "A":DEGREE :INPUT "SB= ";B,"SC= ";C,"A= ";D	
E	5	B , B°	20: D=DEG D	
F	6	C , C°	30: GOSUB 500	
G	7	θ°	40: GOSUB 600	
H	8		50: GOSUB 700	
I	9		60: F=180-D-E	
J	10		70: PRINT USING "#####.####";"SA=",A	
K	11		80: G=E:GOSUB 800	
L	12		90: PRINT "B=",G:G=F:GOSUB 800	
M	13		100: PRINT "C=",G	
N	14		110: PRINT "S=",S:GOTO 70	
O	15		120: "B":DEGREE :INPUT "SA= ";A,"B= ";E,"C= ";F	
P	16		130: E=DEG E:F=DEG F	
Q	17		140: D=180-E-F	
R	18		150: B=A*SIN E/SIN D	
S	19	S	160: C=A*SIN F/SIN D:GOSUB 700	
T	20		170: G=D:GOSUB 800	
U	21		180: PRINT USING "#####.####";"A=",G	
V	22		190: PRINT "SB=",B	
W	23		200: PRINT "SC=",C	
X	24		210: PRINT "S=",S:GOTO 180	
Y	25		220: "C":DEGREE :INPUT "SA= ";A,"SB= ";B,"SC = ";C	
Z	26		230: D=ACS ((B*B+C*C-A*A)/2/B/C)	
			240: GOSUB 600	
			250: F=180-D-E	
			260: GOSUB 700	
			270: G=D:GOSUB 800	
			280: PRINT USING "#####.####";"A=",G:G=E:GOSUB 800	
			290: PRINT "B=",G:G=F:GOSUB 800	
			300: PRINT "C=",G	
			310: PRINT "S=",S:GOTO 270	
			500: A=SQR(B*B+C*C-2*B*C*COS D):RETURN	
			600: E=ACS ((A*A+C*C-B*B)/2/A/C):RETURN	
			700: S=B*C*SIN D/2:RETURN	
			800: G=DMS (G+.00014):RETURN	
			584	

Title POINT ON STRAIGHT LINE AND PARALLEL MOVING POINT

PROGRAM NO.
P 4 - C - 8

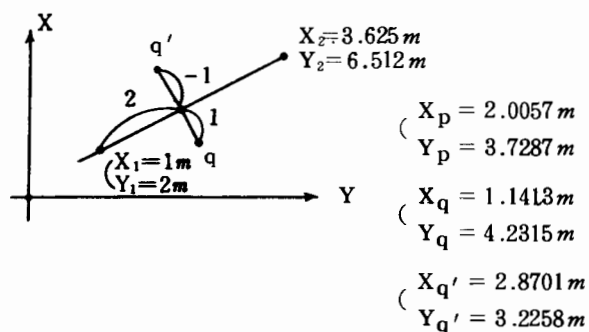
[Formula]

Given coordinates of two points, moving distance, and vertical distance. This program find the coordinates of the point of parallel movement.



NOTE) The coordinates of the result are given in 5 digits of integral part, discarding 5th decimal.

[Example]



[Operation]

C LOAD ▽ C 8 ▽ ENTER

	Input	Display	Note		Input	Display	Note
1	[SFT] [A]			11			
2	(X ₁)1 [ENTER]	X ₁ = 1		12			
3	(Y ₁)2 [ENTER]	Y ₁ = 2		13			
4	(X ₂)3.625 [ENTER]	X ₂ = 3.625		14			
5	(Y ₂)6.512 [ENTER]	Y ₂ = 6.512		15			
6	(L) 2 [ENTER]	L = 2		16			
7	(h) 1 [ENTER]	H = 1		17			
8		P : 2.0057 3.7287	(x _P , y _P)	18			
9	[ENTER]	Q : 1.1413 4.2315	(x _Q , y _Q)	19			
10	[ENTER]		Repeat	20			

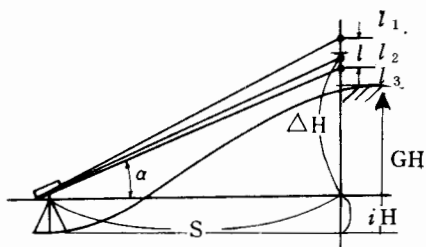
Title		POINT ON STRAIGHT LINE AND PARALLEL MOVING POINT	PROGRAM NO. P 4 - C - 8
Memory content			
A	1	X_1	<pre> 10: "A":DEGREE :INPUT "X1= ";A,"Y1= ";B,"X2 = ";C,"Y2= ";D 20: X=C-A:Y=D-B 30: C=√(X*X+Y*Y) 40: X=ACS (X/C):IF Y<0LET X=360-X 50: INPUT "L= ";E,"H= ";F 60: G=E*COS X+A:H=E*SIN X+B 70: PRINT USING "#####.####";"P:";G;H 80: I=X+SGN F*90:F=ABS F 90: J=F*COS I+G:K=F*SIN I+H 100: PRINT "Q:";J;K 110: GOTO 50 219 </pre>
B	2	Y_1	
C	3	X_2, γ	
D	4	Y_2	
E	5	l	
F	6	h	
G	7	X_P	
H	8	Y_P	
I	9	θ'	
J	10	X_Q	
K	11	Y_Q	
L	12		
M	13		
N	14		
O	15		
P	16		
Q	17		
R	18		
S	19		
T	20		
U	21		
V	22		
W	23		
X	24	$\Delta X, \theta$	
Y	25	ΔY	
Z	26		

Title STADIA CALCULATION

PROGRAM NO.
P 4 - C - 9

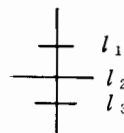
[Formula]

This is the calculation method using the stadia hair of the transit. This program computes the horizontal distance S and ground height GH from the stadia reading length and angle of elevation.



$$S = K l \cos^2 \alpha + C \cos \alpha$$

$$\Delta H = \frac{1}{2} K l \sin 2 \alpha + C \sin \alpha$$



K: stadia multiplier constant

C: stadia addition constant

iH: machine height

$$GH = \Delta H + iH - l_2$$

[Example]

$$K = 100, C = 0.3, iH = 1$$

$$l_1 = 1.625m, \alpha = 8^\circ 47' \Rightarrow S = 129.707$$

$$l_2 = 0.962m$$

$$GH = 20.079$$

$$l_3 = 0.3m$$

[Operation]

C LOAD ▽ C 9 ▽ **ENTER**

NOTE) Distance is expressed by discarding the 5th decimal.

A program: For input of constants

B program: For input of survey data

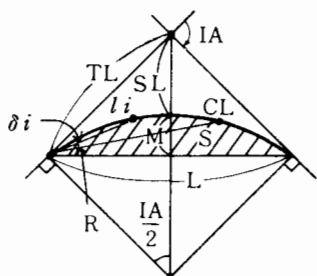
Input	Display	Note	Input	Display	Note
1 SHIFT A			11 SHIFT B		
2 (K)100 ENTER	K = 100	Initial setting	12 (l ₁)1.625 ENTER	L ₁ = 1.625	
3 (C).3 ENTER	C = .3		13 (l ₂).962 ENTER	L ₂ = .962	
4 (iH) 1 ENTER	iH = 1		14 (l ₃).3 ENTER	L ₃ = .3	
5			15 (α) 8.47 ENTER	A = 8.47	
6			16	S = 129.7070	
7			17 ENTER	GH = 20.0790	
8			18		
9			19		
10			20		

Title SINGLE CURVE CALCULATIONS

PROGRAM NO.
P 4 - C - 1 0

[Formula]

This program determines each element of a single curve by giving intersecting angle IA and radius R. Also, the deflection angle and chord length are found by giving the curve length.



$$\text{Tangential length} \quad TL = R \tan \frac{IA}{2}$$

$$\text{Curve length} \quad CL = R \frac{\pi}{180} IA$$

$$\text{Chord length} \quad L = 2 R \sin \frac{IA}{2}$$

$$\text{Exterior line length} \quad SL = R \left(\sec \frac{IA}{2} - 1 \right)$$

$$\text{Middle ordinate} \quad M = R \left(1 - \cos \frac{IA}{2} \right)$$

$$\text{Area} \quad S = \frac{R^2}{2} \left(\frac{\pi \cdot IA}{180} - \sin IA \right)$$

$$\text{Deflection angle} \quad \delta_i = \frac{90}{\pi} \cdot \frac{L_i}{R}$$

$$\text{Chord length} \quad l_i = 2 R \sin \delta_i$$

[Example]

R = 100 m
IA = 36° 20'

TL = 32.814 m
CL = 63.414 m
L = 62.356 m
SL = 5.246 m
M = 4.985 m
S = 208.2717 m

[Operation]

C LOAD ▽ C 10 ▽ ENTER

NOTE) Distance is expressed by discarding the 5th decimal.

A program: (R, IA) input

B program: (R, L) input

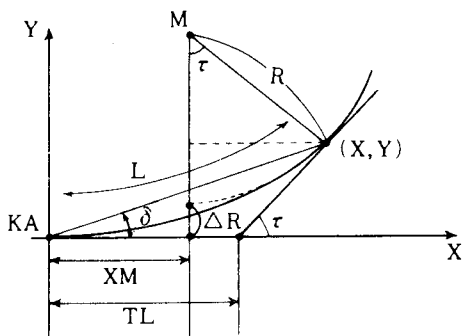
Input	Display	Note	Input	Display	Note
1 [SHIFT] A			11 [SHIFT] B		
2 (R)100 [ENTER]	R = 100		12 (R)100 [ENTER]	R = 100	
3 (IA)36.20 [ENTER]	IA = 36.20		13 (L ₁)10 [ENTER]	L = 10	
4	TL = 32.8138		14	A = 2.5153 L = 9.9958	(δ, l)
5 [ENTER]	CL = 63.4136		15 [ENTER]		
6 [ENTER]	L = 62.3564	Reaffirmation possible	16		Repeat
7 [ENTER]	SL = 5.2461		17		
8 [ENTER]	M = 4.9846		18		
9 [ENTER]	S = 208.2717		19		
10 [ENTER]			20		

Title CLOTHOID CURVE

PROGRAM NO.
P 4 - C - 11

[Formula]

Of the clothoid curve elements, A and R , or A and L are inputted, and X, Y, τ , etc. are determined.



$$L = \frac{A^2}{R}$$

$$I = \frac{A}{R}$$

$$X \doteq Al \left(1 - \frac{l^4}{40} + \frac{l^8}{3456} - \frac{l^{12}}{599040} \right)$$

$$Y \doteq \frac{Al^3}{6} \left(1 - \frac{l^4}{56} + \frac{l^8}{7040} - \frac{l^{12}}{1612800} \right)$$

$$\text{Tangential angle } \tau = \frac{L}{2R} \times \frac{180}{\pi}$$

$$\begin{aligned} \text{XM} &= X - R \sin \tau & \delta &= \tan^{-1} \frac{Y}{X} \\ \text{TL} &= X - Y \cot \tau \\ \text{TK} &= Y \cdot \operatorname{cosec} \tau & \text{SC} &= Y \cdot \operatorname{cosec} \delta \\ \text{Shift } \triangle R &= Y + R \cos \tau - R \end{aligned}$$

[Example]

A = 100	X = 49.922	XM = 24.987 <i>m</i>
R = 200 <i>m</i>	Y = 2.081	TL = 33.361 <i>m</i>
L = 50	t = 7° 09' 43"	$\triangle R = 0.521 \text{ } m$
	SC = 49.965	$\delta = 2^{\circ} 23' 13''$
		TK = 16.692

[Operation] C LOAD[▽] C 11[▽] [ENTER]

[A] program: (A, R) input

B program: (A, L) input

NOTE) Distance is expressed by discarding the 5th decimal.

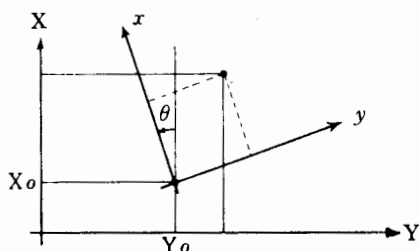
Input						Display		Note		Input						Display		Note	
1	[SHIFT]		[A]								11	[ENTER]		D		2.2313			
2	(A)100		[ENTER]		?						12	[ENTER]		SC		49.9652			
3	(R)200		[ENTER]		?						13								
4					L		50.0000				14	[SHIFT]		[B]					
5			[ENTER]		49.9219		2.0810		(X , Y)		15	(A)100		[ENTER]		?			
6			[ENTER]		T		7.0943				16	(L) 50		[ENTER]		L=			
7			[ENTER]		XM		24.9869				17					R		200.0000	
8			[ENTER]		TL		33.3606				18					↓			
9			[ENTER]		TK		16.6915				19					↓		Similarly thereafter	
10			[ENTER]		DR		0.5205				20								

Title COORDINATES CONVERSION

PROGRAM NO.
P 4 - C - 1 2

[Formula]

This program converts the local coordinates into original coordinates, and vice versa.



$$X = X_0 + x \cos \theta - y \sin \theta$$

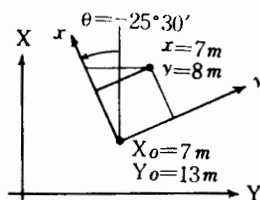
$$Y = Y_0 + x \sin \theta + y \cos \theta$$

$$x = (X - X_0) \cos \theta + (Y - Y_0) \sin \theta$$

$$y = (Y - Y_0) \cos \theta - (X - X_0) \sin \theta$$

θ should be negative if counterclockwise.

[Example]



[Operation]

C LOAD ▽ C 12 ▽ **ENTER**

NOTE) Coordinates are expressed by discarding the 5th decimal.

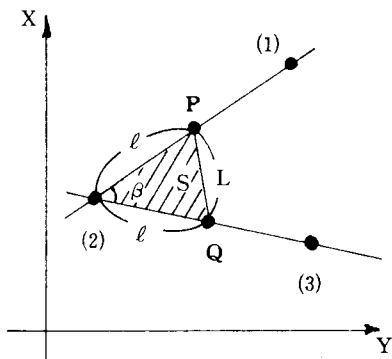
- A** program: For input of constants
- B** program: Original coordinates calculation
- C** program: Local coordinates calculation

	Input	Display	Note		Input	Display	Note
1	SHIFT A			11	SHIFT C		
2	(X ₀)7 ENTER	X ₀ = 7		12	(X)16.762 ENTER	X = 16.762	
3	(Y ₀)13 ENTER	Y ₀ = 13		13	(Y)17.207 ENTER	Y = 17.207	
4	(θ)-25.3 ENTER	A = -25.3		14		6.9998 7.9998	(x , y)
5				15			
6	SHIFT B			16			
7	(x) 7 ENTER	SX = 7		17			
8	(y) 8 ENTER	SY = 8		18			
9		16.7621 17.2071	(X , Y)	19			
10				20			

Title CHAMFER CALCULATION

PROGRAM NO.
P 4 - C - 1 3

[Formula]



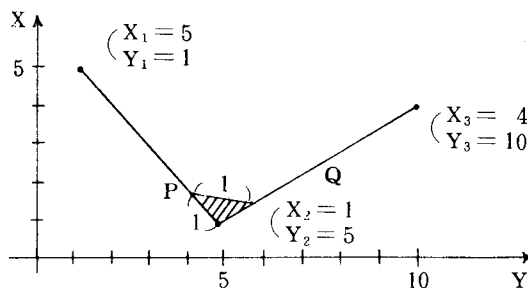
By specifying points (1), (2), (3), and 1 or L, this program determines the side length L, chamfered area, and coordinates of points P and Q.

$$L = 2 \cdot l \sin \frac{\beta}{2}$$

$$S = \left(\frac{L}{2} \right)^2 \cdot \cot \frac{\beta}{2}$$

The order of points (1), (2), (3) may be inverted to (3), (2), (1), but the positions of P and Q are also inverted in this case.

[Example]



$l = 1$
 $L = 1.576$
 $S = 0.4851$
 $X_P = 1.707$
 $Y_P = 4.293$
 $X_Q = 1.514$
 $Y_Q = 5.857$

[Operation]

C LOAD ▽ C 13 ▽ **ENTER**

A program: l input

B program: L input

NOTE) The distance, area, and coordinates are expressed by discarding the 5th decimal.

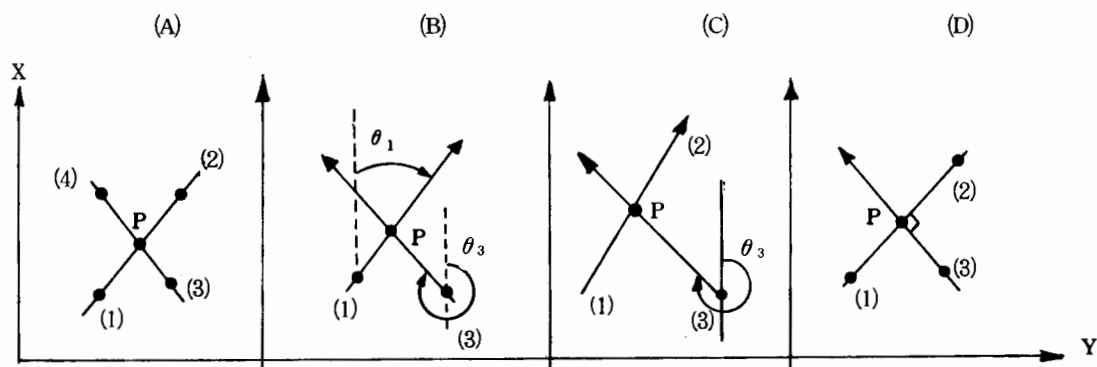
Input	Display	Note	Input	Display	Note
1 SHIFT A			11 ENTER	1.7071 4.2928	(x_P, y_P)
2 (X ₁) 5 ENTER	X ₁ = 5		12 ENTER	1.5144 5.8574	(x_Q, y_Q)
3 (Y ₁) 1 ENTER	Y ₁ = 1		13		
4 (X ₂) 1 ENTER	X ₂ = 1		14 SHIFT B	In this case, input is in the case of A , and input (L) in place of the final (l).	
5 (Y ₂) 5 ENTER	Y ₂ = 5		15		
6 (X ₃) 4 ENTER	X ₃ = 4		16		
7 (Y ₃) 10 ENTER	Y ₃ = 10		17 (L) 1.576 ENTER	L = 1.576	
8 (l) 1 ENTER	SL = 1		18	SL = 0.9997	
9	L = 1.5764		19 ENTER	S = 0.4848	
10 ENTER	S = 0.4850		20	Similarly thereafter	

– 122 –

Title INTERSECTING POINT AND PERPENDICULAR CALCULATION

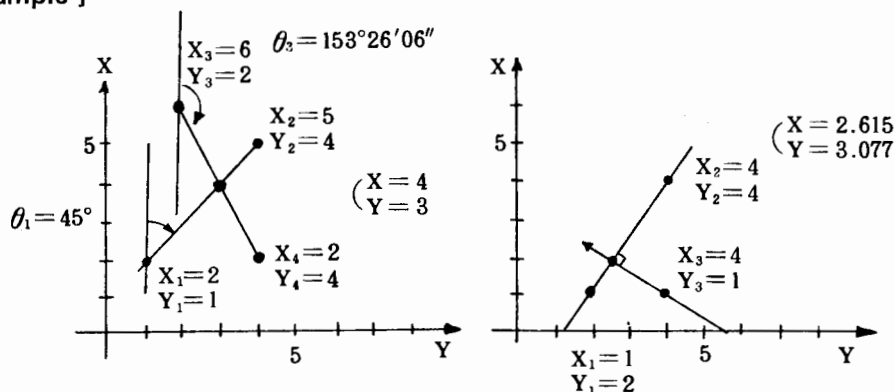
PROGRAM NO.
P 4 - C - 1 4

[Formula]



The intersecting points in the diagrams above are found by giving the coordinates and direction angle.

[Example]



[Operation]

C LOAD ▽ C 14 ▽ **ENTER**

(NOTE) Coordinates are expressed by discarding the 5th decimal.

Input	Display	Note	Input	Display	Note
1 [SHIFT] [A]			11 [SHIFT] [B]		
2 (X ₁) 2 [ENTER]	X ₁ = 2		12 (X ₁) 2 [ENTER]	X ₁ = 2	
3 (Y ₁) 1 [ENTER]	Y ₁ = 1		13 (Y ₁) 1 [ENTER]	Y ₁ = 1	
4 (X ₂) 5 [ENTER]	X ₂ = 5		14 (θ ₁) 45 [ENTER]	A ₁ = 45	
5 (Y ₂) 4 [ENTER]	Y ₂ = 4		15 (X ₃) 6 [ENTER]	X ₃ = 6	
6 (X ₃) 6 [ENTER]	X ₃ = 6		16 (Y ₃) 2 [ENTER]	Y ₃ = 2	
7 (Y ₃) 2 [ENTER]	Y ₃ = 2		17 (θ ₂) 153.2606 [ENTER]	A ₃ = 153.2606	
8 (X ₄) 2 [ENTER]	X ₄ = 2		18	3.9999 2.9999	(X _p , Y _p)
9 (Y ₄) 4 [ENTER]	Y ₄ = 4		19		
10	3.9999 2.9999	(X _p , Y _p)	20		

SHARP

Title	INTERSECTING POINT AND PERPENDICULAR CALCULATION	PROGRAM NO. P 4 - C - 1 4
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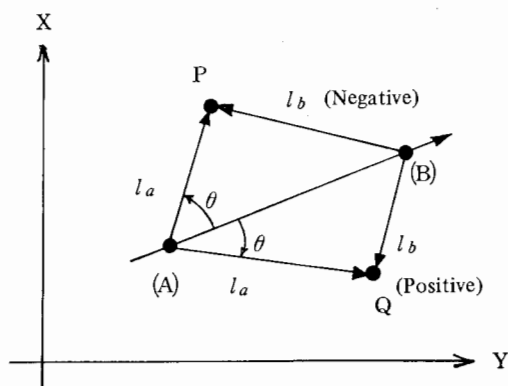
- A** program: Input of 4 points
B program: Input of 2 points and 2 direction angles
C program: Input of 3 points and 1 direction angle
D program: Perpendicular.

	Input	Display	Note		Input	Display	Note
1	SHFT C			11	SHFT D		
2	(X ₁) 2 ENTER	X ₁ = 2		12	(X ₁) 1 ENTER	X ₁ = 1	
3	(Y ₁) 1 ENTER	Y ₁ = 1		13	(Y ₁) 2 ENTER	Y ₁ = 2	
4	(X ₂) 5 ENTER	X ₂ = 5		14	(X ₂) 4 ENTER	X ₂ = 4	
5	(Y ₂) 4 ENTER	Y ₂ = 4		15	(Y ₂) 4 ENTER	Y ₂ = 4	
6	(X ₃) 6 ENTER	X ₃ = 6		16	(X ₃) 4 ENTER	X ₃ = 4	
7	(Y ₃) 2 ENTER	Y ₃ = 2		17	(Y ₃) 1 ENTER	Y ₃ = 1	
8	(θ ₃) 153.2606 ENTER	A ₃ = 153.2606		18		2.6153 3.0769	(X _p , Y _p)
9		3.9999 2.9999	(X _p , Y _p)	19			
10				20			

Title A POINT AT A CERTAIN DISTANCE FROM TWO POINTS (INTERSECTING POINTS OF TWO CIRCLES)

PROGRAM NO.
P 4- C-15

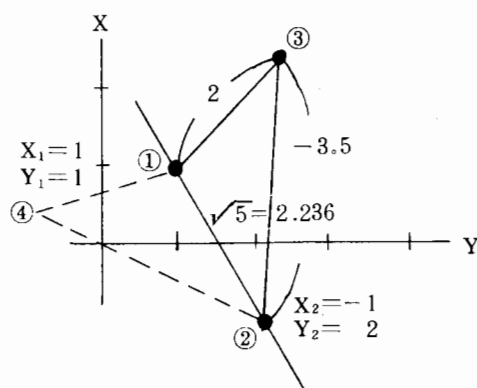
[Formula]



Given coordinates of points (A), (B), and distances l_a, l_b . This program find the coordinates of points P and Q.

Points P and Q are discriminated by changing the value of l_b to positive and negative. When l_b is positive, point Q is determined; when negative, point P is found.

[Example]



$$\textcircled{3} \begin{cases} X = 2.4832 \\ Y = 2.3415 \end{cases}$$

$$\textcircled{4} \begin{cases} X = 0.8167 \\ Y = -0.9915 \end{cases}$$

[Operation]

C LOAD ▽ C 15 ▽ ENTER

A program: For calculation of intersecting point

B program: For registration of coordinates

NOTE) Coordinates are expressed by discarding the 5th decimal. Measure points should be from No. 1 to No. 8, in principle.

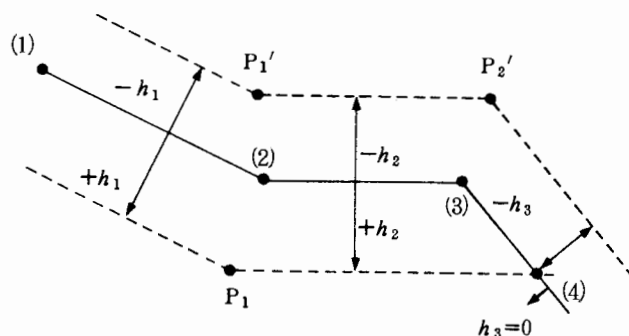
Input	Display	Note	Input	Display	Note
1 [SHIFT] [B]			11 [SHIFT] [A]		
2 Registration start No. 1 ENTER	% = 1		12 (%A) 1 ENTER	% A = 1	
3 (X1) 1 ENTER	X = 1		13 (%B) 2 ENTER	% B = 2	
4 (Y1) 1 ENTER	Y = 1		14 (lA) 2 ENTER	LA = 2	
5 (X2) -1 ENTER	X = -1		15 (lB) -3.5 ENTER	LB = -3.5	
6 (Y2) 2 ENTER	Y = 2		16 Registration No. 3 ENTER	% = 3	
7 :	:		17	2.4832 2.3415	(x_p, y_p)
8 Register necessary points, however, up to 8 points including result			18 ENTER	(NOTE) With this key, registration ends.	
9			19		
10			20		

SHARP

Title CITY BLOCK VERTEX CALCULATION

PROGRAM NO.
P 4 - C - 1 6

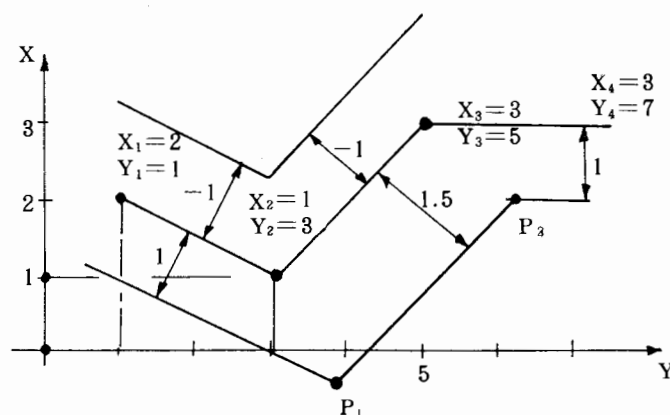
[Formula]



Given city block points (1), (2), (3), ..., and half widths of road $h_1, h_2, h_3, \dots$ as shown. The coordinates of vertex $P_1 (X_{P1}, Y_{P1})$ are determined. Depending on the sign of h , the calculation may be done on either right side or left side of the running direction.

For the intersecting point with the block line, 0 should be inputted as h at the corresponding point.

[Example]



($XP_1 = -0.4524$
 $YP_1 = 3.6688$

($XP_2 = 1.9999$
 $YP_2 = 6.1213$

[Operation]

C LOAD ▽ C 1 6 ▽ NOTE) Coordinates are expressed by discarding the 5th decimal.

Input	Display	Note	Input	Display	Note
1 SHIFT A			11	-0.4524 3.6688	(X_p, Y_p)
2 (X_1)2 ENTER	$X_1 = 2$		12 ENTER		
3 (Y_1)1 ENTER	$Y_1 = 1$		13 (X_4)3 ENTER	$X = 3$	Repeat
4 (h_1)1 ENTER	$H_1 = 1$		14 (Y_4)7 ENTER	$Y = 7$	
5 (X_2)1 ENTER	$X_2 = 1$		15 (h_4)1 ENTER	$H = 1$	
6 (Y_2)3 ENTER	$Y_2 = 3$		16	1.9999 6.1213	(X_p, Y_p)
7 (h_2)1.5 ENTER	$H_2 = 1.5$		17		
8 (X_3)3 ENTER	$X = 3$		18		
9 (Y_3)5 ENTER	$Y = 5$		19		
10 (h_3)1 ENTER	$H = 1$		20		

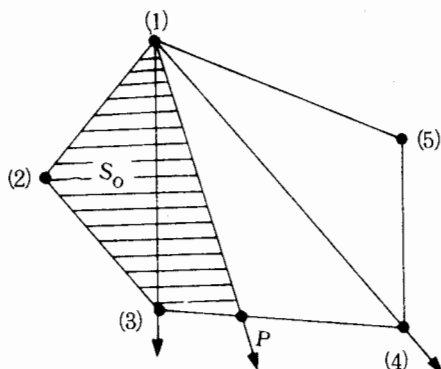
SHARP

Title

DIVISION INTO SPECIFIED AREA BY SPECIFYING
A POINT IN A POLYGON

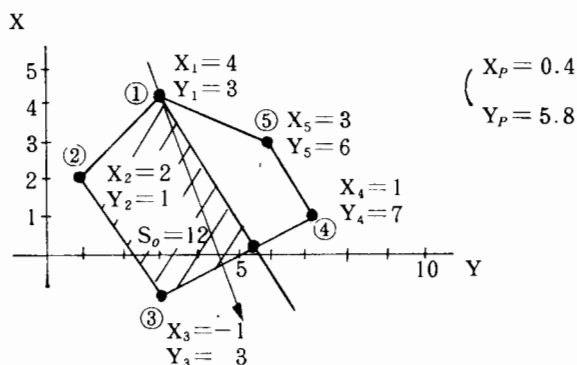
PROGRAM NO.
P4 - C - 17

[Formula]



According to the segment passing through point (1), the coordinates of point P to yield a specified area S_0 are found.
The calculation may be either clockwise or counterclockwise.

[Example]



[Operation]

C LOAD ▽ C 17 ▽ **ENTER**

(NOTE) Coordinates are expressed by discarding the 5th decimal.

	Input	Display	Note		Input	Display	Note
1	SHIFT A			11		0.4000 5.8000	(X_p, Y_p)
2	(S_0)12 ENTER	$S_0 = 12$		12			
3	(X_1)4 ENTER	$X_1 = 4$		13	Keep inputting until reaching specified area.		
4	(Y_1)3 ENTER	$Y_1 = 3$		14			
5	(X_2)2 ENTER	$X_2 = 2$		15			
6	(Y_2)1 ENTER	$Y_2 = 1$		16			
7	(X_3)-1 ENTER	$X = -1$		17			
8	(Y_3)3 ENTER	$Y = 3$		18			
9	(X_4)1 ENTER	$X = 1$		19			
10	(Y_4)7 ENTER	$Y = 7$		20			

Title			DIVISION INTO SPECIFIED AREA BY SPECIFYING A POINT IN A POLYGON	PROGRAM NO. P 4- C - 1 7
Memory content				
A	1	X_1, k		
B	2	Y_1		
C	3	X_2		
D	4	Y_2		
E	5	S_0		
F	6	ΔX_1		
G	7	ΔY_1		
H	8	ΔX_2		
I	9	ΔY_2		
J	10	ΔX_3		
K	11	ΔY_3		
L	12	$\Delta 2 S$		
M	13	$\Sigma 2 S$		
N	14			
O	15			
P	16			
Q	17			
R	18			
S	19			
T	20			
U	21			
V	22			
W	23			
X	24	X_3		
Y	25	Y_3		
Z	26			

```

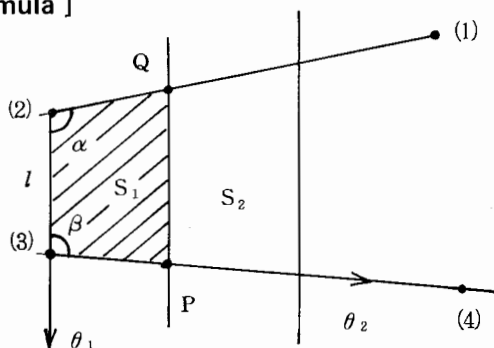
10: "A":INPUT "S0= ";E
20: INPUT "X1= ";A,"Y1= ";B
30: INPUT "X2= ";C,"Y2= ";D
40: M=0
50: INPUT "X= ";X,"Y= ";Y
60: F=C-A:G=D-B
70: H=X-C:I=Y-D
80: J=A-X:K=B-Y
90: L=G*F+(2*G+I)*H+(2*G+2*I+K)*J
100: M=M+L
110: IF ABS M/2>EGOTO 130
120: C=X:D=Y:GOTO 50
130: A=-(ABS M-2*E)/ABS L
140: X=A*H+X:Y=A*I+Y
150: PRINT USING "#####.####";X,Y
160: END
255

```

Title PARALLEL SPECIFIED AREA DIVISION

PROGRAM NO.
P 4 - C - 1 8

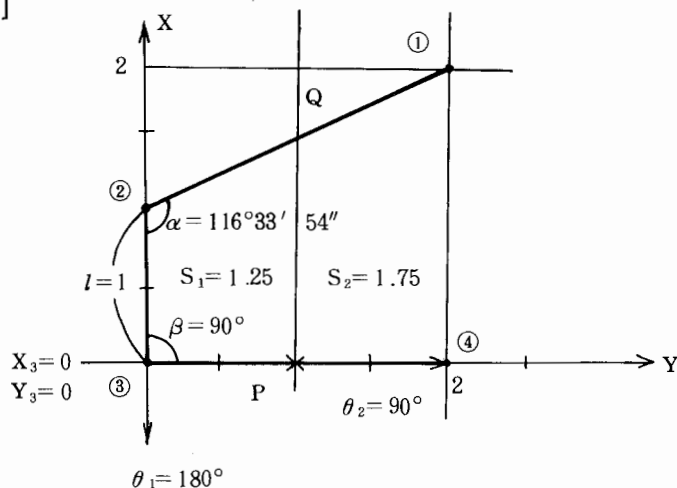
[Formula]



In a city block as shown on the left, when included angles α, β , and coordinates of (3), and $(2) \rightarrow (3) = \theta_1, (3) \rightarrow (4) = \theta_2, (2) \rightarrow (3) = l$ are given, the program find the coordinates of points P and Q that yield a specified area by the segment parallel to $(2) \rightarrow (3)$.

(NOTE) The input conditions above are obtained by the inverse calculation of P4 - C - 4.

[Example]



[Operation]

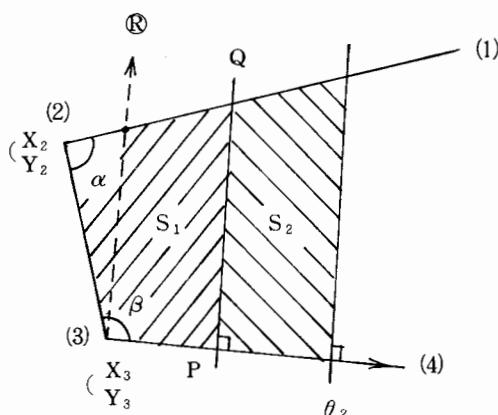
C LOAD ▽ C 1 8 ▽ NOTE) Coordinates are expressed by discarding the 5th decimal.

	Input	Display	Note		Input	Display	Note
1	[SH FT] [A]			11	[ENTER]	Q : 1.5000 0.9999	$X(x_Q, y_Q)$
2	(X_3) 0 [ENTER]	$X_3 = 0$		12	[ENTER]	Repeat from step 9 on.	
3	(Y_3) 0 [ENTER]	$Y_3 = 0$		13			
4	(α) 116.3354 [ENTER]	A = 116.3354		14			
5	(B) 90 [ENTER]	B = 90		15			
6	(θ_1) 180 [ENTER]	$\angle 1 = 180$		16			
7	(θ_2) 90 [ENTER]	$\angle 2 = 90$		17			
8	(L) 1 [ENTER]	L = 1		18			
9	(S) 1.25 [ENTER]	S = 1.25		19			
10		P : 0.0000 0.9999	$X(x_P, y_P)$	20			

Title VERTICAL SPECIFIED AREA DIVISION

PROGRAM NO.
P 4 - C - 1 9

[Formula]

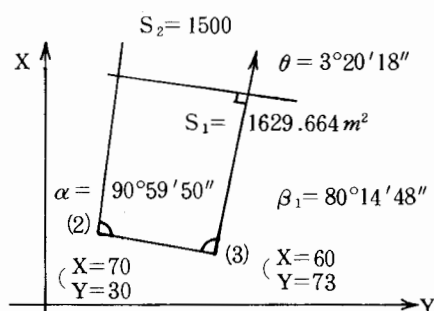


In a city block as shown on the left, when included angles α, β , and coordinates of (2), (3), and direction angle θ of (3)(4) are given, by dividing with a straight line vertical to (3)(4), the coordinates of points P and Q to yield a specified area S_0 are determined.

(NOTE) Where angles above α, β, θ are not given, they should be found from the coordinates of points (1) through (4) by the inverse calculation of P4 - C - 5.

Points P, Q should be on the right side of (3) (R).

[Example]



[Operation]

C LOAD ▽ C 1 9 ▽

(NOTE) Coordinates are expressed by discarding the 5th decimal.

	Input	Display	Note		Input	Display	Note
1	SHIFT A			11	ENTER	Q : 105.6272 37.6342	(x_Q, y_Q)
2	(X ₃) 60 ENTER	X ₃ = 60		12	ENTER	Repeat from step 9 on.	
3	(Y ₃) 73 ENTER	Y ₃ = 73		13			
4	(X ₂) 70 ENTER	X ₂ = 70		14			
5	(Y ₂) 30 ENTER	Y ₂ = 30		15			
6	(α) 90.595 ENTER	A = 90.595		16			
7	(β) 80.1448 ENTER	B = 80.1448		17			
8	(θ_2) 3.2018 ENTER	$\angle 2 = 3.2018$		18			
9	(S) 1629.664 ENTER	S = 1629.664		19			
10		P : 103.4166 75.5325	(x_P, y_P)	20			

Title LONGITUDINAL CURVE (QUADRATIC PARABOLA)

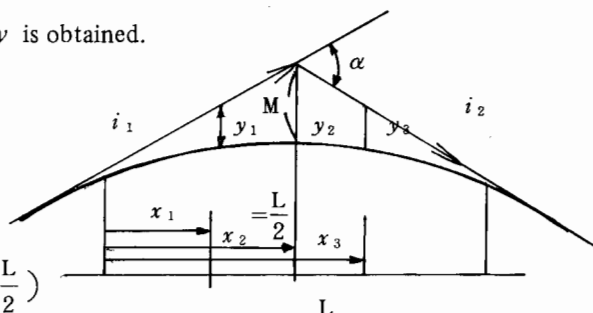
PROGRAM NO.
P 4 - C - 2 0

[Formula]

By changing the value of x , the value of y is obtained.

$$y = \frac{(i_1 \pm i_2) x^2}{200 L}$$

Meanwhile, $M = \frac{(i_1 \pm i_2) \cdot L}{800} \left(x = \frac{L}{2} \right)$



[Example]

$$i_1 = 5.5 \%$$

$$i_2 = -4.3 \%$$

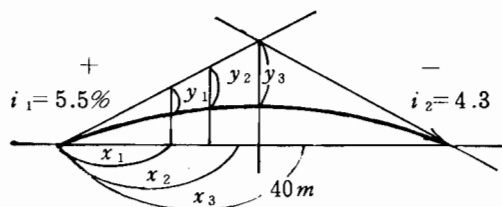
$$L = 40.0 \text{ m}$$

$$x_1 = 8 \text{ m} \quad y_1 = 0.0784$$

$$x_2 = 12 \text{ m} \quad y_2 = 0.1764$$

$$x_3 = 20 \text{ m} \quad y_3 = M = 0.49$$

Input - sign when $i_1 - i_2$.



NOTE) The value of y is expressed by discarding the 5th decimal.

[Operation] C LOAD ∇ C 2 0 ∇ **ENTER**

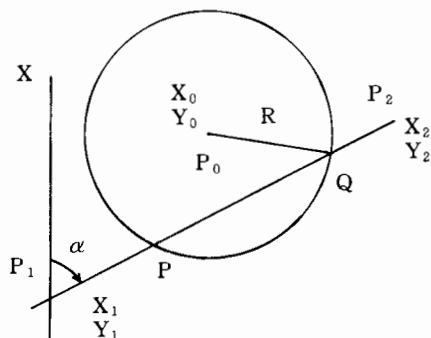
	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]			11			
2	(i_1) 5.5 [ENTER]	$I_1 = 5.5$		12			
3	$(i_2) - 4.3$ [ENTER]	$I_2 = -4.3$		13			
4	(L) 40 [ENTER]	$L = 40$		14			
5	(X) 8 [ENTER]	$X = 8$		15			
6		$Y = 0.0784$		16			
7	[ENTER]	Repeat from step 5 on.		17			
8				18			
9				19			
10				20			

Title LONGITUDINAL CURVE (QUADRATIC PARABOLA)			PROGRAM NO. P 4 - C - 2 0
Memory content			
A	1	i_1	<pre> 10: "A":INPUT "I1= ";A,"I2= ";B,"L= ";C 20: D=(A-B)/(200*C) 30: INPUT "X= ";E 40: F=E*E*D 50: PRINT USING "#####.####";"Y=";F 60: GOTO 30 104 </pre>
B	2	i_2	
C	3	L	
D	4	$\frac{i_1 + i_2}{200L}$	
E	5	x	
F	6	y	
G	7		
H	8		
I	9		
J	10		
K	11		
L	12		
M	13		
N	14		
O	15		
P	16		
Q	17		
R	18		
S	19		
T	20		
U	21		
V	22		
W	23		
X	24		
Y	25		
Z	26		

Title INTERSECTING POINTS OF CIRCLE AND LINE

PROGRAM NO.
P 4 - C - 2 1

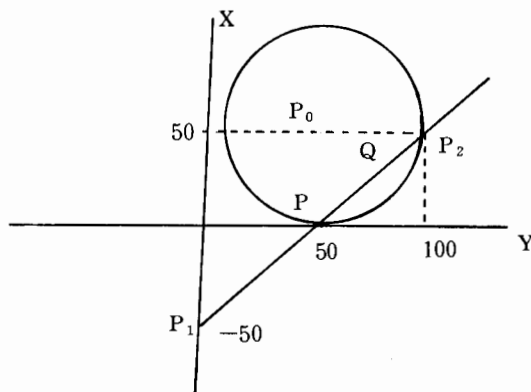
[Formula]



This program is intended to determine the intersecting points P, Q of a straight line running through points P_1, P_2 , or a line running through a point P_1 and having a direction angle of α , and a circle of which center is P_0 and radius is R .

[Example]

$X_1 = -50$
 $Y_1 = 0$
 $X_2 = 50$ $X_P = 0$
 $Y_2 = 100$ $Y_P = 50$
 $X_0 = 50$ $X_Q = 50$
 $Y_0 = 50$ $Y_Q = 100$
 $R = 50$
 $\alpha = 45^\circ$



[Operation]

C LOAD ▽ C 2 1 ▽ **ENTER**

A program: Calculation from two points

B program: Calculation from one point and one direction angle

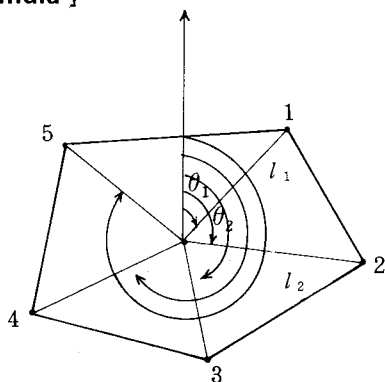
NOTE) Coordinates are expressed by discarding the 5th decimal.

Input	Display	Note	Input	Display	Note
1 SHIFT A		(In the case of 2 points, and a circle)	11 SHIFT B		(In the case of a point, a direction, and a circle)
2 (X_0) 50 ENTER	$X_0 = 50$		12 (X_0) 50 ENTER	$X_0 = 50$	
3 (Y_0) 50 ENTER	$Y_0 = 50$		13 (Y_0) 50 ENTER	$Y_0 = 50$	
4 (R) 50 ENTER	$R = 50$		14 (R) 50 ENTER	$R = 50$	
5 (X_1) -50 ENTER	$X_1 = -50$		15 (X_1) -50 ENTER	$X_1 = -50$	
6 (Y_1) 0 ENTER	$Y_1 = 0$		16 (Y_1) 0 ENTER	$Y_1 = 0$	
7 (X_2) 50 ENTER	$X_2 = 50$		17 (α) 45 ENTER	$A = 45$	
8 (Y_2) 100 ENTER	$Y_2 = 100$		18	P : 0.0000 49.9999	
9	P : 0.0000 49.9999	(x_P, y_P)	19 ENTER	Q : 50.0000 100.0000	
10 ENTER	Q : 50.0000 100.0000	(x_Q, y_Q)	20		

Title RADIAL AREA CALCULATION

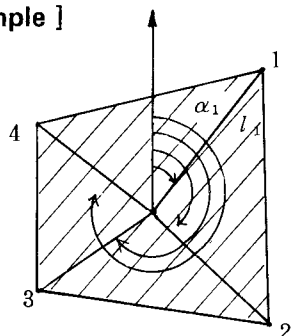
PROGRAM NO.
P 4- C - 2 2

[Formula]



- Given angle and distance. Calculate the area.
- The area is calculated by the double meridian distance method.
- When only relative coordinates are needed, the angle may be measured from any direction.

[Example]



$\alpha_1 = 37.2030$	$DX = 12.0232$
$l_1 = 15.123$	$DY = 9.1731$
$\alpha_2 = 135.4123$	$DX = -14.6376$
$l_2 = 20.456$	$DY = 14.2894$
$\alpha_3 = 232.4521$	$DX = -6.5296$
$l_3 = 10.789$	$DY = -8.5887$
$\alpha_4 = 310.1225$	$DX = 7.8272$
$l_4 = 12.125$	$DY = -9.2600$
$S = 417.965242$	

[Operation]

C LOAD ▽ C 2 2 ▽ **ENTER**

A program: For data input

B program: For area calculation

NOTE) • DX, DY are expressed by discarding the 5th decimal.

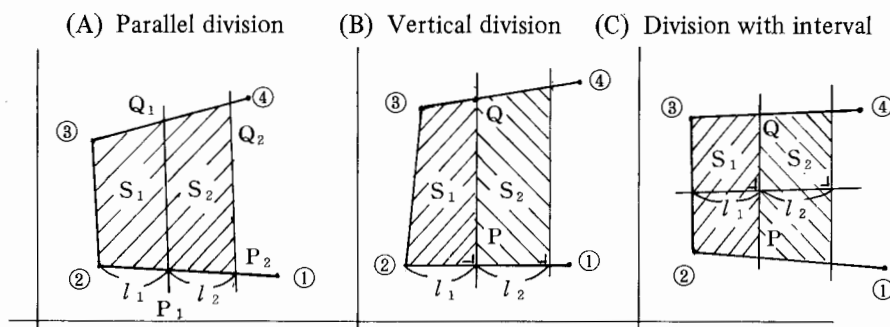
• The area is expressed by discarding the 7th decimal.

	Input	Display	Note		Input	Display	Note
1	SHIFT A			11	(A)310.1225 ENTER	A = 310.1225	
2	(A)37.2030 ENTER	A = 37.2030		12	(L)12.125 ENTER	L = 12.125	
3	(L)15.123 ENTER	L = 15.123		13	ENTER	7.8272 -9.2600	
4	ENTER	12.0232 9.1731	(DX, DY)	14	Finally		
5	(A)135.4123 ENTER	A = 135.4123		15	SHIFT B	S = 417.965242	
6	(L)20.456 ENTER	L = 20.456		16			
7	ENTER	-14.6376 14.2894		17			
8	(A)232.4521 ENTER	A = 232.4521		18			
9	(L)10.789 ENTER	L = 10.789		19			
10	ENTER	-6.5296 -8.5887		20			

Title OPENING SPECIFIED DIVISION CALCULATION

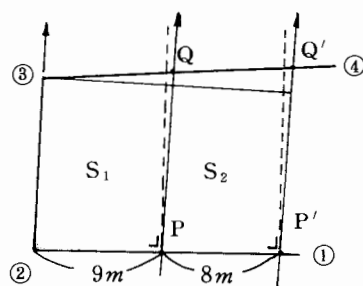
PROGRAM NO.
P 4 - C - 2 3

[Formula]



In the three cases above (A), (B), (C), points P, Q and area S are found by successively giving measure points (1) to (4) and l .

[Example]



$X_1 = 10.972$
 $Y_1 = 32.494$
 $X_2 = 11.905$
 $Y_2 = 8.863$
 $X_3 = 22.668$
 $Y_3 = 9.178$
 $X_4 = 25.182$
 $Y_4 = 33.055$
 $l_1 = 9$

[Operation]

C LOAD ▽ C 2 3 ▽ **ENTER**

- A** program: Parallel division
- B** program: Vertical division
- C** program: Division with interval

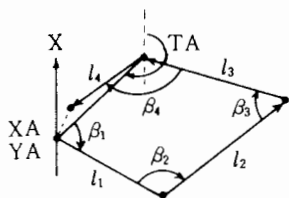
(NOTE) • Coordinates are expressed by discarding the 5th decimal.
• The area is expressed by discarding the 7th decimal.

Input	Display	Note	Input	Display	Note
1 [SHIFT] [A]	PARA		11	P : 11.5499 17.8560	
2 (X ₁)10.972 ENTER	X ₁ = 10.972		12 ENTER	Q : 23.6189 18.2092	
3 (Y ₁)32.494 ENTER	Y ₁ = 32.494		13 ENTER	S = 102.782605	
4 (X ₂)11.905 ENTER	X ₂ = 11.905		14 ENTER	Repeat from step 10 on.	
5 (Y ₂)8.863 ENTER	Y ₂ = 8.863		15		
6 (X ₃)22.668 ENTER	X ₃ = 22.668		16 [SHIFT] [B]	Same operation for vertical division	
7 (Y ₃)9.178 ENTER	Y ₃ = 9.178		17		
8 (X ₄)25.182 ENTER	X ₄ = 25.182		18 [SHIFT] [C]	Same when interval is applied	
9 (Y ₄)33.055 ENTER	Y ₄ = 33.055		19		
10 (l) 9 ENTER	L = 9		20		

Title OPENING SPECIFIED DIVISION CALCULATION			PROGRAM NO. P 4 - C - 2 3
Memory content			
A	1	✓	
B	2	✓	
C	3	✓	
D	4	J	
E	5	X_1	10: "A":PAUSE "PARA":D=0:GOTO 40
F	6	Y_1	20: "B":PAUSE "VERT":D=1:GOTO 40
G	7	X_2	30: "C":PAUSE "MOVE":D=2
H	8	Y_2	40: INPUT "X1= ";E,"Y1= ";F,"X2= ";G,"Y2= "
I	9	X_3	;H
J	10	Y_3	50: INPUT "X3= ";I,"Y3= ";J,"X4= ";K,"Y4= "
K	11	X_4	;L
L	12	Y_4	60: X=E-G:Y=F-H:GOSUB 500
M	13	l, l'	70: N=X:X=I-G:Y=J-H:GOSUB 500
N	14	θ_1	80: O=X:X=K-I:Y=L-J:GOSUB 500
O	15	θ_2, θ	90: P=X:IF D=1LET O=N-90
P	16	θ_3	100: V=O:W=O
Q	17	x_P	110: BEEP 3:INPUT "L= ";M
R	18	y_P	120: IF D=2LET M=M/COS (N-0-90)
S	19	$\sum S_i$	130: W=W+M
T	20	x_Q	140: Q=G+W*cos N:R=H+W*sin N
U	21	y_Q	150: X=TAN (O+E-4):Y=TAN (P+E-4)
V	22	$\sum S_{i-1}$	160: T=(X*Q-Y*I-R+J)/(X-Y)
W	23	$\sum l$	170: U=R+X*(T-Q)
X	24	$\Delta X, m_1$	180: X=Q:GOSUB 600
Y	25	$\Delta Y, m_2$	190: Q=X:X=R:GOSUB 600
Z	26	γ, S_i	200: R=X:X=T:GOSUB 600
			210: T=X:X=U:GOSUB 600
			220: U=X:PRINT USING "#####.####";"P:";Q;R
			230: PRINT "Q:";T;U
			240: S=(Q*(H-U)+G*(J-R)+I*(U-H)+T*(R-J))/2
			250: Z=S-V:V=V+S
			260: PRINT USING "#####.#####";"S=";Z
			270: GOTO 110
			500: Z=J(X*X+Y*Y)
			510: X=ACS (X/Z):IF Y<0LET X=360-X
			520: RETURN
			600: X=SGN X*INT ABS (X*E4+SGN X*.5)/E4:
			RETURN
			617

Title	CLOSED AND FIXED TRAVERSE (COMPASS RULE)	PROGRAM NO.
		P 4 - C - 2 4

[Formula]



After the input of initial data, entering the included angle and distance at each point, this program is intended to find the angle, error of closure in latitude and departure, sum of distance, and accuracy.

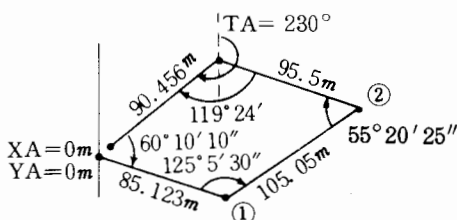
Also, using the result of calculation of the error of closure, the angle is distributed evenly and the error of coordinates are distributed according to the compass rule.

The obtained coordinates are stored in the memory.

Maximum measure points should be 12.

Error of closure in latitude	$\sum \Delta X_i = E X$
Error of closure in departure	$\sum \Delta Y_i = E Y$
Sum of distance	$\sum l_i$
Accuracy	$\sum l_i / \sqrt{(\sum \Delta X_i)^2 + (\sum \Delta Y_i)^2}$
Corrected total latitude	$X_i = X_{i-1} + \Delta X_i + \frac{l_i}{\sum l_i} E X$
Corrected total departure	$Y_i = Y_{i-1} + \Delta Y_i + \frac{l_i}{\sum l_i} E Y$

[Example]



Error of closure in angle	5"
Error of closure in latitude	5.970 m
Error of closure in departure	7.541 m
Accuracy	39

[Operation]

- NOTE) • Coordinates are expressed by discarding the 4th decimal.
 • Accuracy of ∞ results in error, but the operation can be progressed to next step by pressing **CL** key.

C LOAD ▽ C 2 4 ▽ **ENTER**

Input	Display	Note	Input	Display	Note
1 SHIFT A			11 (β) 125.053 ENTER	B = 125.053	
2 1 ENTER	C/F = 1 / 0 1	Input 1 when used, 0 when fixed.	12 (l) 105.05 ENTER	L = 105.05	
3 (TA) 230 ENTER	TA = 230		13 (β) 55.2025 ENTER	B = 55.2025	
4 (XA) 0 ENTER	XA = 0		14 (l) 95.5 ENTER	L = 95.5	
5 (YA) 0 ENTER	YA = 0		15 (β) 119.24 ENTER	B = 119.24	$l_n = 0$ when fixed. Note
6 (TB) 230 ENTER	TB = 230	Input only when fixed.	16 (l) 90.456 ENTER	L = 90.456	
7 (XB) 59.580 ENTER	XB = 59.580		17 SHIFT B	T.B = 360.0005	
8 (YB) 71.107 ENTER	YB = 71.107		18 ENTER	EB = 0.0005	
9 (β) 60.1010 ENTER	B = 60.1010		19 ENTER	TL = 376.129	
10 (l) 85.123 ENTER	L = 85.123		20 ENTER	EX=5.970 EY=7.541	

SHARP

Title CLOSED AND FIXED TRAVERSE (COMPASS RULE)

PROGRAM NO.
P 4- C - 2 4

(An example of closed traverse) input 1 when the display is C/F = 1/0.

No.	Included angle	Distance	Angle correction	Direction angle	Latitude correction	Departure correction	Total latitude	Total departure
				TA=230°			XA=0 m	YA=0 m
1	60°10'10"	85.123m	- 1"	110°10'09"	- 1.351	- 1.707	- 30.701	78.196
2	125°5'30"	105.05	- 2"	55°15'37"	- 1.667	- 2.106	27.495	162.415
3	55°20'25"	95.5	- 1"	290°36'01"	- 1.516	- 1.914	59.580	71.107
4	119°24'	90.456	- 1"	230°	- 1.436	- 1.814	0	0
			- 5"		- 5.970	- 7.541		

(An example of fixed traverse) Input 0 when the display is C/F = 1/0.

No.	Included angle	Distance	Angle correction	Direction angle	Latitude correction	Departure correction	Total latitude	Total departure
				TA= 230°			XA=0 m	YA=0m
1	60°10'10"	85.123	- 1	110.1009	- 1.351	- 1.706	- 30.701	78.197
2	125°05'30"	105.05	- 2	55.1537	- 1.667	- 2.106	27.495	162.416
3	55°20'25"	95.5	- 1	290.3601	- 1.516	- 1.915	XB=59.58	YB=71.107
4	119°24'	L _n =0	- 1	TB=230				

- A** program: For start of closed and fixed traverse
- B** program: For error calculation
- C** program: For output of results
- D** program: For correction

Input	Display	Note	Input	Display	Note
1 ENTER	ACCURACY = 39		11 Correction		
2 SHIFT C	B 60.1010 L 85.1230		12 SHIFT D	CORRECT	
3 ENTER	EB--0.0001 A=110.1009		13 (no) ENTER	NO=	
4 ENTER	C=-0.344 S=0.9386		14 (β) ENTER	B =	
5 ENTER	EX-1.351 DX-29.350		15 (L) ENTER	L =	
6 ENTER	EY-1.707 DY 79.903		16	Repeating from step 14 permissible.	
7 ENTER	X -30.701 Y 78.196 (X, Y)		17		
8	Repeat		18		
9			19		
10			20		

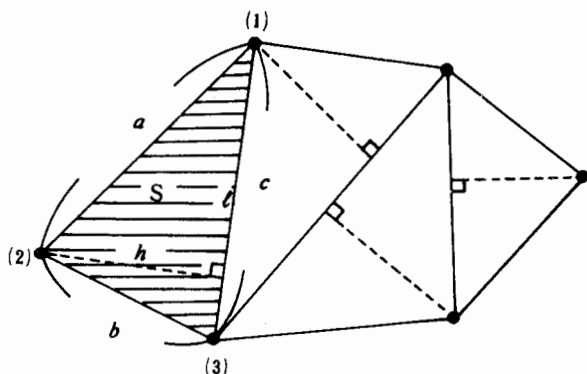
— 146 —

Title

DIAGONAL AND PERPENDICULAR AREA CALCULATION

PROGRAM NO.
P 4 - C - 2 5

[Formula]



Successively inputting the coordinates of three points or three side lengths, the area of each triangle is determined sequentially.

$$S = \sqrt{s(s-a)(s-b)(s-c)}$$

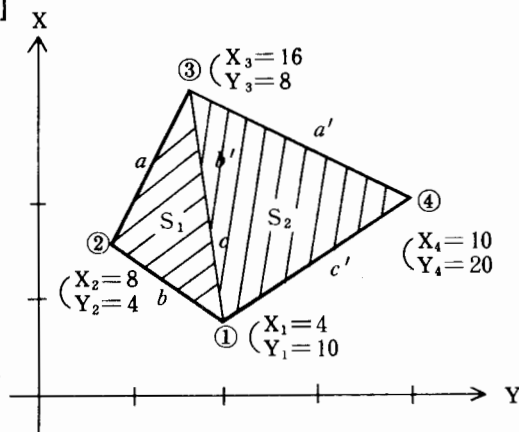
$$s = \frac{a+b+c}{2}$$

Diagonal and perpendicular method area calculation

$$S' = \frac{1}{2} hL \quad (L: \text{longest side of } a, b, c)$$

The height is expressed by discarding the 3rd decimal.

[Example]



$$\begin{aligned} a &= 7.211 & d' &= 12.166 \\ b &= 8.944 & b' &= 13.416 \\ c &= 12.166 & c' &= 11.662 \end{aligned}$$

[Operation]

C LOAD ▽ C 2 5 ▽ **ENTER**

NOTE) Side length is expressed by discarding the 4th decimal.

A program: Calculation from input of coordinates

B program: Calculation from input of side lengths

Input	Display	Note	Input	Display	Note
1 SHFT A			11 ENTER	TS=31.996580	⊗
2 (X ₁) 4 ENTER	X ₁ = 4		12 ENTER	Repeat from step 2 on.	↗
3 (Y ₁) 10 ENTER	Y ₁ = 10		13		
4 (X ₂) 8 ENTER	X ₂ = 8		14 SHFT B		
5 (Y ₂) 4 ENTER	Y ₂ = 4		15 (A)7.211 ENTER	A = 7.211	↖
6 (X ₃) 16 ENTER	X ₃ = 16		16 (B)8.944 ENTER	B = 8.944	
7 (Y ₃) 8 ENTER	Y ₃ = 8		17 (C)12.166 ENTER	C = 12.166	
8	A = 7.211 B = 8.944		18	Same as step 8 and after.	
9 ENTER	C = 12.166 H = 5.260		19		
10 ENTER	S = 31.996580	⊗	20	Repeat from step 15 on.	

SHARP

Title

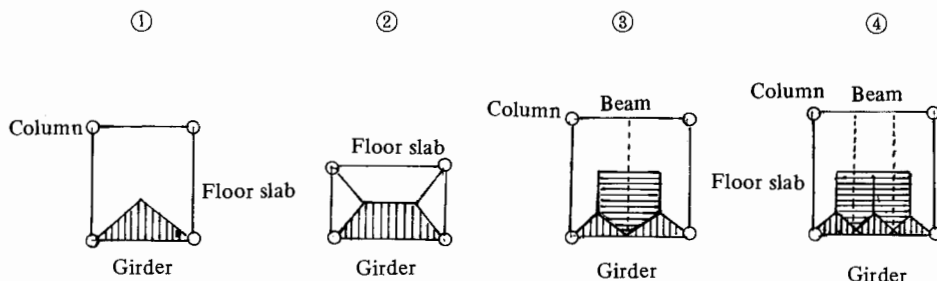
GIRDER LOAD TERMS CALCULATION PROGRAM
FOR REINFORCED CONCRETE CONSTRUCTION

PROGRAM NO.

P 4 - D - 1

[Formula]

This program calculates the load terms of tortoise-shaped girders in the preparatory stage of structural calculations of reinforced concrete construction. (See shaded parts below.)
The shape should included the four kinds shown below.



Plans of tortoise-shaped girders

Program of shape (1) is defined as **A**

Program of shape (2) is defined as **B**

Program of shape (3) is defined as **C**

Program of shape (4) is defined as **D**

Clear of cumulative memory is defined as **G**

Output of C, Mo, Q is defined as **F**

The "type" means the load shape at both sides of the girder (including the load value): input 1 when the type is the same, and 2 when different.

[Operation]

C LOAD ▽D1 ▽ **ENTER**

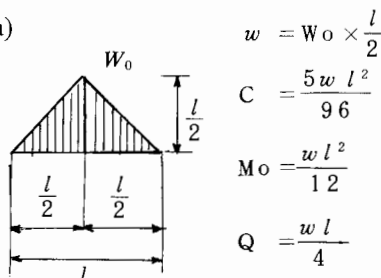
	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

SHARP

Title	GIRDER LOAD TERMS CALCULATION PROGRAM FOR REINFORCED CONCRETE CONSTRUCTION	PROGRAM NO. P 4- D - 1
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(A) Calculation formula for each shape

(a)



C: fixed end moment (t.m)

Mo: moment in the case of simple support (t.m)

Q: shearing force in the case of simple support (t)

Wo: unit weight per 1 m² of floor (t/m²)

w: unit weight per 1 m of floor (t/m)

l: span of girder to be determined (m)

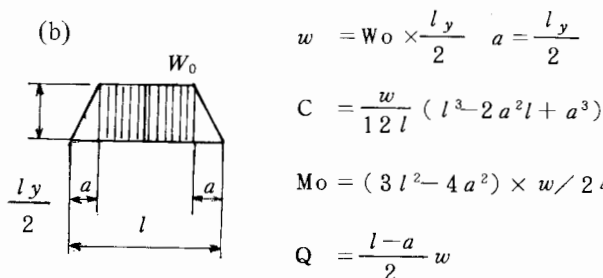
ly: slab width charged on girder to be determined (m)

Bw: unit weight of beam (t/m)

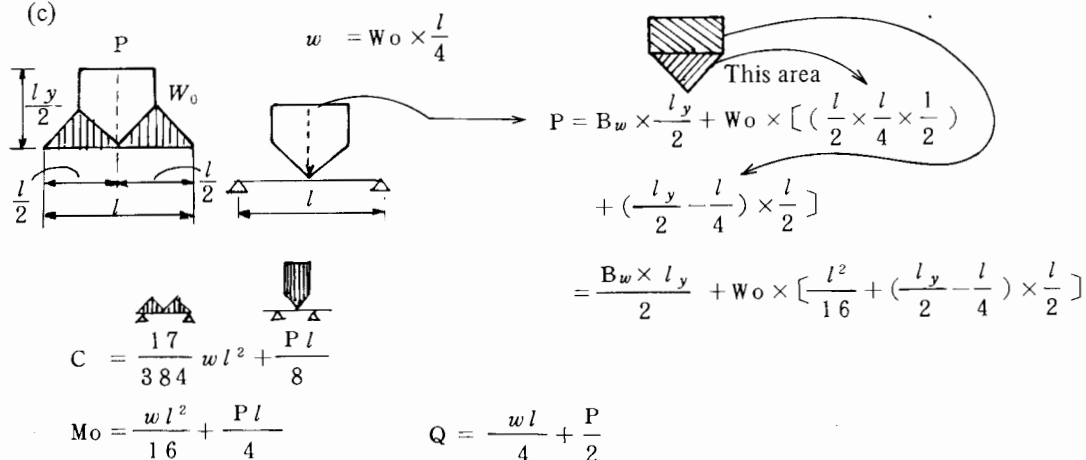
Gw: unit weight of girder (t/m)

N: number of beams

(b)



(c)



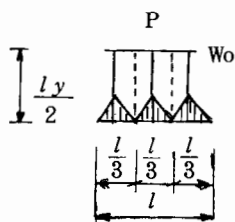
	Input	Display	Note		Input	Display	Note
1	[SHFT] [G]		Memory clear	11	[SHFT] [G]		
2	[SHFT] [A]	SPAN		12	[SHFT] [A]	SPAN	
3	(l) 6 [ENTER]	WIDTH		13	(l) 6 [ENTER]	FUTAN HABA	
4	(ly) 6 [ENTER]	SLAB W		14	(ly) 6 [ENTER]	SLAB W	
5	(Wo) 1 [ENTER]	GIRDER W		15	(Wo) 1 [ENTER]		
6	(Gw) 1 [ENTER]	TYPE		16	(Gw) 1 [ENTER]		
7	2 [ENTER]	>		17	1 [ENTER]	14.25 22.50 12.00	
8	[SHFT] [F]	8.62 13.50 7.50		18			
9				19			
10				20			

Title

GIRDER LOAD TERMS CALCULATION PROGRAM
FOR REINFORCED CONCRETE CONSTRUCTION

PROGRAM NO.
P 4 - D - 1

(d)



$$w = W_0 \times \frac{l}{6}$$

$$P = B_w \times \frac{l_y}{2} + W_0 \times \left[\left(\frac{l}{3} \times \frac{l}{6} \times \frac{1}{2} \right) + \left(\frac{l_y}{2} - \frac{l}{6} \right) \times \frac{l}{3} \right]$$

$$= \frac{B_w \times l_y}{2} + W_0 \times \left[\frac{l^2}{36} + \left(\frac{l_y}{2} - \frac{l}{6} \right) \times \frac{l}{3} \right]$$



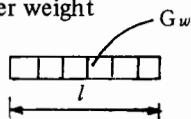
$$C = \frac{37 w l^2}{864} + \frac{2 P l}{9}$$

$$M_0 = \frac{7 w l^2}{108} + \frac{P l}{3}$$

$$Q = \frac{w l}{4} + P$$

(a) to (d) refer to the values of C, Mo, Q of the slab part.

(e) Girder weight



$$C = \frac{G_w l^2}{12}$$

$$M_0 = \frac{G_w l^2}{8}$$

$$Q = \frac{G_w l}{2}$$

Input	Display	Note	Input	Display	Note
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

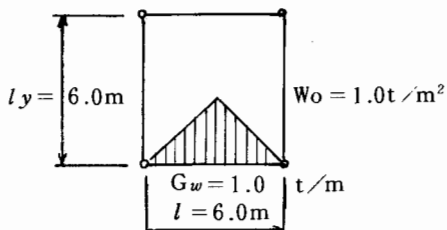
Title

GIRDER LOAD TERMS CALCULATION PROGRAM FOR REINFORCED CONCRETE CONSTRUCTION

PROGRAM NO.
P 4- D-1

☆ Use program **A**

Memory clear



SHIFT **G**

SHIFT **A**

SPAN

6 **ENTER**

WIDTH

6 **ENTER**

SLAB W

1 **ENTER**

GIRDER W

1 **ENTER**

TYPE W

2 **ENTER**

>

SHIFT **F**

8.62 13.50 7.50

↑

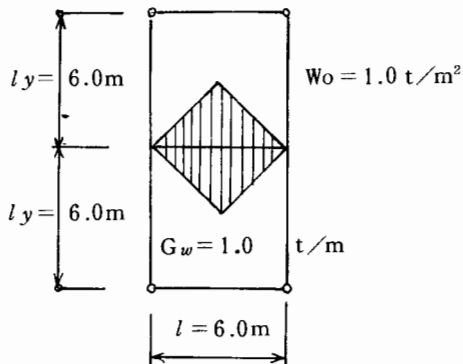
C

↑

M_o

↑

Q



SHIFT **G**

SHIFT **A**

SPAN

6 **ENTER**

WIDTH

6 **ENTER**

SLAB W

1 **ENTER**

GIRDER W

1 **ENTER**

TYPE W

1 **ENTER**

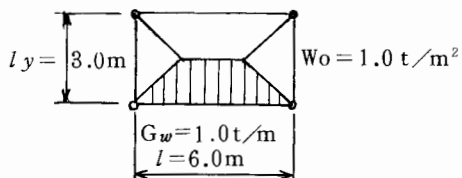
14.25 22.50 12.00

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

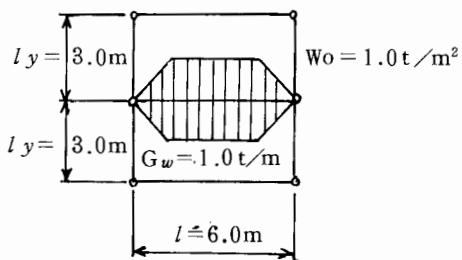
SHARP

Title	GIRDER LOAD TERMS CALCULATION PROGRAM FOR REINFORCED CONCRETE CONSTRUCTION	PROGRAM NO. P 4- D - 1
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☆ Use program **B**



SHFT **G**
 SHFT **B** SPAN
 6 **ENTER** WIDTH
 8 **ENTER** SLAB W
 1 **ENTER** GIRDER W
 1 **ENTER** TYPE
 2 **ENTER** >
 SHFT **F** 7.00 10.68 6.37



SHFT **G**
 SHFT **B** SPAN
 6 **ENTER** WIDTH
 8 **ENTER** SLAB W
 1 **ENTER** GIRDER W
 1 **ENTER** TYPE
 1 **ENTER** 11.01 16.87 9.75

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

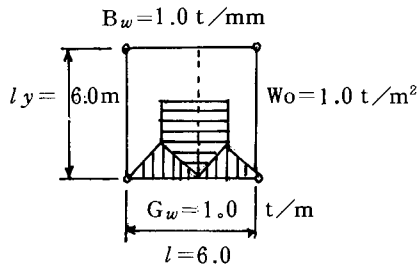
SHARP

Title

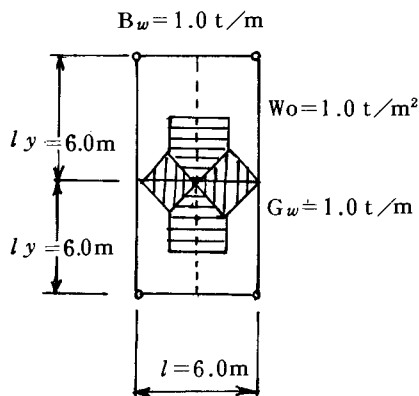
GIRDER LOAD TERMS CALCULATION PROGRAM
FOR REINFORCED CONCRETE CONSTRUCTION

PROGRAM NO.
P 4 - D - 1

☆ Use program **C**



SHFT **G**
SHFT **C** SPAN
6 **ENTER** WIDTH
6 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** TYPE
2 **ENTER** BEAM W
1 **ENTER** >
SHFT **F** 12.70 22.50 10.12



SHFT **G**
SHFT **C** SPAN
6 **ENTER** WIDTH
6 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** TYPE
1 **ENTER** BEAM W
1 **ENTER** 22.40 40.50 17.25

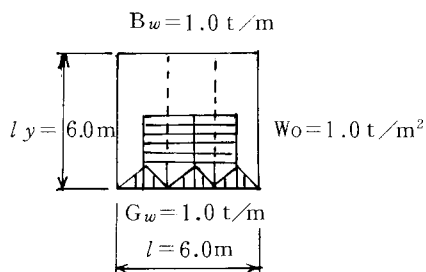
Input	Display	Note	Input	Display	Note
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

Title

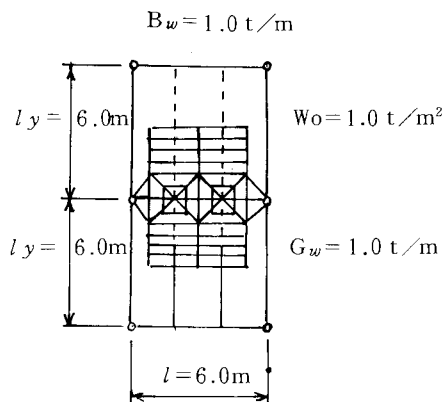
GIRDER LOAD TERMS CALCULATION PROGRAM
FOR REINFORCED CONCRETE CONSTRUCTION

PROGRAM NO.
P 4- D - 1

☆ Use program **D**



SHFT **G**
SHFT **D** SPAN
6 **ENTER** WIDTH
6 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** TYPE
2 **ENTER** BEAM W
1 **ENTER** >
SHFT **F** 15.20 22.83 12.50



SHFT **G**
SHFT **D** SPAN
6 **ENTER** WIDTH
6 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** TYPE
1 **ENTER** BEAM W
1 **ENTER** 27.41 41.16 22.00

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

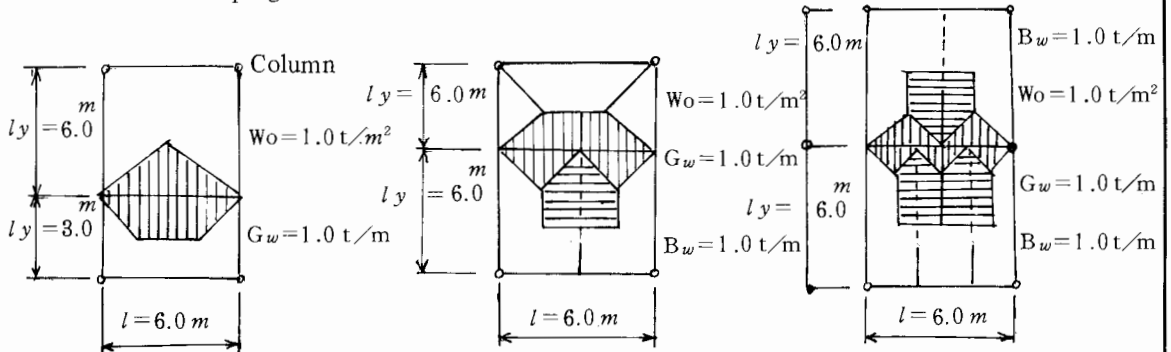
SHARP

Title

LOADS ON THE MAIN GIRDER FOR A
REINFORCED CONCRETE BUILDING

PROGRAM NO.
P 4 - D - 1

☆ Use various programs in combination.



SHFT **G**

SHFT **A** SPAN

6 **ENTER** WIDTH
6 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** TYPE
2 **ENTER** >

SHFT **G**

SHFT **B** SPAN

6 **ENTER** WIDTH
3 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** TYPE
2 **ENTER** >

SHFT **G**

SHFT **C** SPAN

6 **ENTER** WIDTH
6 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** TYPE
2 **ENTER** BEAM W
1 **ENTER** >

SHFT **B** SPAN

6 **ENTER** WIDTH
3 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** 12.63 19.68 10.87

SHFT **C** SPAN

6 **ENTER** WIDTH
6 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** BEAM W
1 **ENTER** 16.71 26.68 13.50

SHFT **D** SPAN

6 **ENTER** WIDTH
6 **ENTER** SLAB W
1 **ENTER** GIRDER W
1 **ENTER** BEAM W
1 **ENTER** 24.91 40.83 19.62

Operate programs

A and **B**.

Operate programs

B and **C**.

Operate programs

C and **D**.

Input	Display	Note	Input	Display	Note
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

Title		GIRDER LOAD TERMS CALCULATION PROGRAM FOR REINFORCED CONCRETE CONSTRUCTION	PROGRAM NO. P 4 - D - 1
Memory content			
A	1		10: "F":K=0:U=R:R=0
B	2	B _w	20: PRINT USING "#####.##";U;S;T
C	3	C	30: END
D	4		40: "G":CLEAR
E	5		50: END
F	6		60: "A":GOSUB 500
G	7	G _w	70: Z=W*L/2
H	8		80: D=5*Z*L*L
I	9	✓	90: C=D/96:Q=Z*L/4
J	10	✓	100: M=Z*L*L/12:GOSUB 600
K	11	Type	110: END
L	12	l	120: "B":GOSUB 500
M	13	m	130: A=Y/2:Z=U*A
N	14		140: C=Z/(12*L)*(L^3-2*A*A*L+A^3)
O	15		150: M=(3*L*L-4*A*A)*Z/24
P	16	P	160: Q=(L-A)/2*Z:GOSUB 600
Q	17	Q	170: END
R	18	C	180: "C":GOSUB 500
S	19	M	190: INPUT "BEAM W ";B
T	20	Q	200: Z=W*L/4
U	21		210: P=B*Y/2+W*(L*L/16+(Y/2-L/4)*L/2)
V	22		220: C=17*Z*M*L/384+P*L/8
W	23	W _o	230: M=Z*L*L/16+P*L/4
X	24		240: Q=Z*L/4+P/2:GOSUB 600
Y	25	l _y	250: END
Z	26	✓	260: "D":GOSUB 500
			270: INPUT "BEAM W ";B
			280: Z=W*L/6
			290: P=B*Y/2+W*(L*L/36+(Y/2-L/6)*L/3)
			300: C=37*Z*M*L/384+2*P*L/9
			310: M=7*Z*L*L/108+P*L/3
			320: Q=Z*L/4+P:GOSUB 600
			330: END
			500: INPUT "SPAN ";L,"WIDTH ";Y
			510: INPUT "SLAB W ";W,"GIRDER W ";G
			520: IF K<>0RETURN
			530: INPUT "TYPE ";K
			540: RETURN
			600: IF K=2GOTO 620
			610: C=C+C:M=M+M:Q=Q+Q
			620: IF R<>0LET R=R+C:S=S+M:T=T+Q:GOTO 680
			630: H=G*L*L/12
			640: I=H*1.5
			650: J=G*L/2
			660: R=C+H:S=M+I:T=Q+J
			670: IF K=2RETURN
			680: PRINT USING "#####.##";R;S;T
			690: CLEAR
			700: RETURN
			740

SHARP

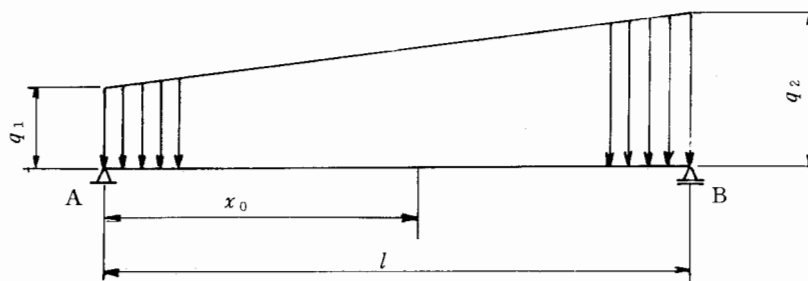
Title

FORCE OF SECTION OF SIMPLE BEAM
(UNIFORMLY VARYING LOAD, TRAPEZOIDAL)

PROGRAM NO.
P 4 - D - 2

[Formula]

This program calculates the simple beam to which a trapezoidal load as shown below exerts.



$$\text{Total load } W = \frac{q_1 + q_2}{2} \cdot l$$

$$\text{Reaction } R_A = (2q_1 + q_2) \cdot l / 6$$

$$R_B = (q_1 + 2q_2) \cdot l / 6$$

Position of x applying the maximum bending moment: x_0

$$x_0 = \frac{l}{(q_2 - q_1)} \left\{ -q_1 + \sqrt{\frac{1}{3} \times (q_1^2 + q_1 \cdot q_2 + q_2^2)} \right\}$$

Maximum bending moment

$$M_{\max} = R_A x_0 - q_1 x_0^2 / 2 - (q_2 - q_1) \cdot x_0^3 / (6l)$$

[Example] $q_1 = 1.0 \text{ t/m}$ $q_2 = 2.0 \text{ t/m}$ $l = 10 \text{ m}$

[Operation]

C LOAD ∇ D2 ∇ [ENTER]

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	Q1 =		11			
2	(q1)1 [ENTER]	Q2 =		12			
3	(q2)2 [ENTER]	L =		13			
4	(l) 10 [ENTER]	W = 15		14			
5	[ENTER]	RA = 6.666666667		15			
6	[ENTER]	RB = 8.333333333		16			
7	[ENTER]	X0 = 5.275252317		17			
8	[ENTER]	M, MAX 18.80751802		18			
9				19			
10				20			

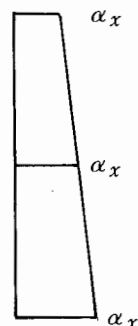
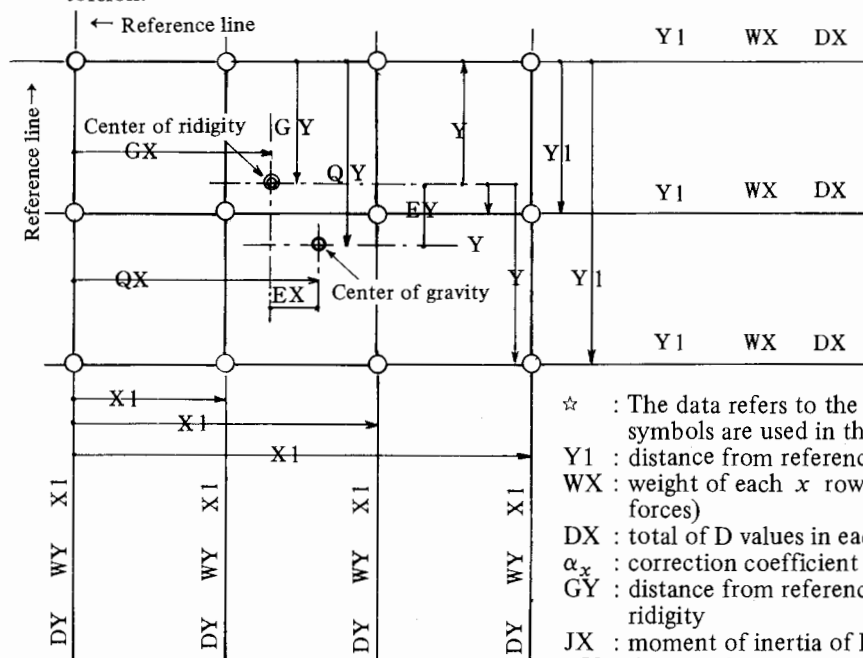
Title

**CORRECTION COEFFICIENT OF DISTRIBUTION
SHEARING FORCE DUE TO TORSION**

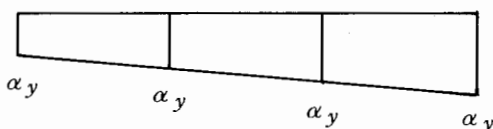
PROGRAM NO.
P 4-D-4

[Formula]

This program calculates the correction coefficient α of the distribution shearing force due to torsion.



- ☆ : The data refers to the x-direction (the same symbols are used in the y-direction).
- Y1 : distance from reference line to each x row
- WX : weight of each x row (total of column axial forces)
- DX : total of D values in each x row (incl. wall)
- α_x : correction coefficient
- GX : distance from reference line to center of rigidity
- JX : moment of inertia of D value in x-direction
- QY : distance from reference line to center of gravity
- EY : eccentric distance in x-direction
- Y : distance from center of rigidity to each x row



$$\alpha_x = 1 + \frac{\sum DX \cdot EY \cdot Y}{JX + JY}$$

$$GY = \frac{\sum (DX \cdot Y1)}{\sum DX}$$

$$JX = \sum (DX \cdot Y1^2) - \sum DX \cdot GY^2$$

$$QY = \frac{\sum (WX \cdot Y1)}{\sum WX}$$

$$EY = QY - GY$$

$$Y = Y1 - GY$$

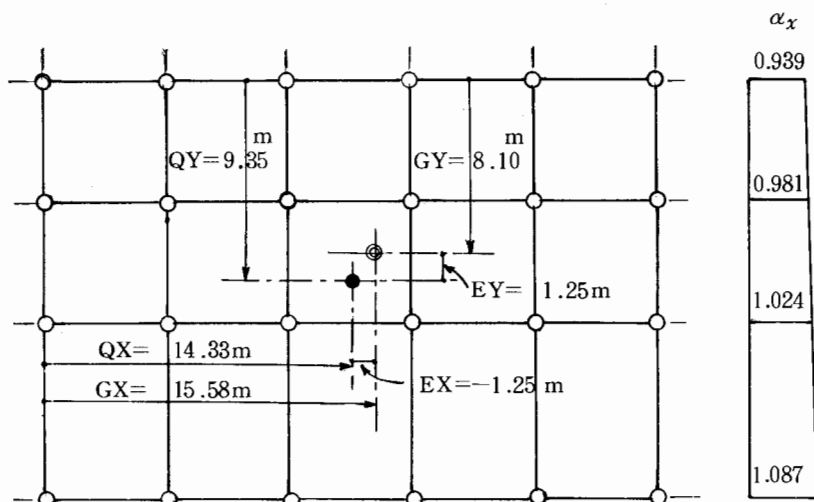
[Operation]

C LOAD ∇ D4 ∇ ENTER

Input	Display	Note	Input	Display	Note
1 SHIFT A	NX =		11 (DX) 1 ENTER	CORRECT ?	
2 (NX) 2 ENTER	NY =		12 When not correcting ENTER	WALL D	
3 (NY) 3 ENTER	Y1 =		13 3.2 ENTER	WALL D	
4 (Y1) 0 ENTER	WX =		14 Wall D input end ENTER	0.0 353.0 6.0	
5 (WX) 81 ENTER	WX =		15 : ENTER		
6 (WX) 136 ENTER	WX =		16 :		
7 (WX) 136 ENTER	CORRECT ?		17 When correcting	(Common for WX, DX)	
8 ENTER	DX =		18 No ENTER		
9 (DX) 0.8 ENTER	DX =		19 Correct value ENTER		
10 (DX) 1 ENTER	DX =		20 Let stand after correction ENTER		

Title	CORRECTION COEFFICIENT OF DISTRIBUTION SHEARING FORCE DUE TO TORSION	PROGRAM NO. P 4 - D - 4
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[Result] Output data



α_y	1.121	1.076	1.032	0.988	0.943	0.899
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JX = 2.510
JX + JY = 9.047

Cautions for correcting:

1. NX, NY, and distance cannot be corrected.
2. When correcting the wall D value, enter the wrong input with minus sign, and then feed a correct input.

Input	Display	Note	Input	Display	Note
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

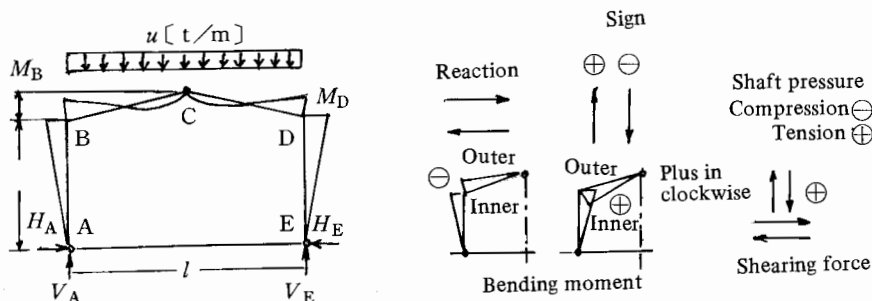
Title		CORRECTION COEFFICIENT OF DISTRIBUTION SHEARING FORCE DUE TO TORSION	PROGRAM NO. P 4 - D - 4
Memory content			
A	1	FOR text	
B	2	NX	
C	3	NY	
D	4	DX ,DY	
E	5	EX ,EY	
F	6	$\sum DX , \sum DY$	
G	7	GY ,GX	
H	8	$\sum (DX \cdot Y1) , \sum (DY \cdot X1)$	
I	9	$\sum (DX \cdot Y1^2) , \sum (DY \cdot DX^2)$	
J	10	JX , JX + JY	
K	11		
L	12	$\sum DX \cdot EY , \sum DY \cdot EX$	
M	13	$\sum (WX \cdot Y1) , \sum (WY \cdot X1)$	
N	14	GY ,GX	
O	15	$\sum DX \cdot EY , \sum DY \cdot EX$	
P	16		
Q	17	QY ,QX	
R	18		
S	19		
T	20		
U	21	α_x , α_y	
V	22	$\sum WX , \sum WY$	
W	23	WX ,WY	
X	24		
Y	25	Y1 ,X1	
Z	26		
A(27)	For jump		
A(28)	Correction address		
A(29)	~ NY pcs. W temporary store		
{		NY pcs.	W grand total
{		NX pcs.	Y 1
{		NY pcs.	X 1
{		D temporary store	
10: "A":CLEAR :INPUT "NX= ";B,"NY= ";C 20: Z=B:S=C:T=29+2*C:A(27)=0 30: GOSUB 500 40: L=0:G=N 50: F=0:H=0:I=0:M=0:V=0 60: Z=C:A(27)=1:S=B:GOSUB 500 70: "B":Z=B:A(27)=0:GOSUB 900 80: Z=C:A(27)=1:L=0:G=N 90: GOSUB 900 100: END 500: FOR X=1TO Z 510: IF A(27)=1GOTO 650 520: INPUT "Y1= ";Y 530: K=29:FOR A=1TO S 540: INPUT "WX= ";A(K) 550: K=K+1:NEXT A 560: INPUT "CORRECT ? ";P,R:GOTO 580 570: K=29:W=0:P=K+C:GOTO 590 580: A(28)=28+P:A(A(28))=R:GOTO 560 590: FOR A=1TO S 600: W=W+A(K):A(P)=A(P)+A(K) 610: P=P+1:K=K+1:NEXT A 620: K=P+C+B:FOR A=1TO C 630: INPUT "DX= ";A(K) 640: K=K+1:NEXT A:GOTO 700 650: INPUT "X1= ";Y 660: K=29+3*C+B:P=28+X+C:W=A(P) 670: FOR A=1TO S 680: INPUT "DY= ";A(K) 690: K=K+1:NEXT A 700: INPUT "CORRECT ? ";P,R:GOTO 720 710: D=0:R=29+3*C+B:GOTO 740 720: A(28)=28+3*C+B+P 730: A(A(28))=R:GOTO 700 740: FOR A=1TO S 750: D=D+A(R):R=R+1 760: NEXT A			

SHARP

Title

STRESS CALCULATION OF THREE HINGED POINT
GABLED ROOF FRAME

PROGRAM NO.
P 4 - D - 5



$$W = w l$$

$$N_{BC} = N_{DC} = -\sin \alpha V_A - \cos \alpha H_A$$

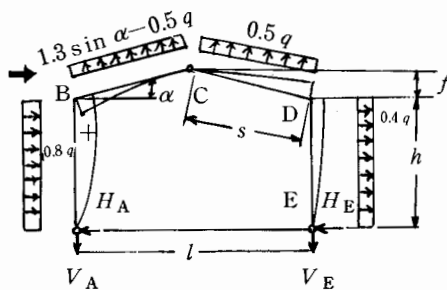
$$V_A = V_E = \frac{W}{2}$$

$$Q_{BC} = -Q_{DC} = \cos \alpha V_A - \sin \alpha H_A$$

$$H_A = -H_E = \frac{W l}{8 (h + f)}$$

$$Q_{BA} = Q_{DE} = -H_A$$

$$M_B = M_D = -H_A h$$



	Input	Display	Note		Input	Display	Note
1	[SHIFT] [M]	L =		11	[SHIFT] [A]	PERMANENT STRESS	
2	(l)10.8 [ENTER]	W =		12		VA 2.5056	
3	(w)0.464 [ENTER]	H =		13	[ENTER]	VE 2.5056	
4	(h)3.5 [ENTER]	F =		14	[ENTER]	HA 1.3213125	
5	(f)1.62 [ENTER]	S =		15	[ENTER]	HE -1.3213125	
6	(s)5.63 [ENTER]	>		16	[ENTER]	MB -4.62459375	
7				17	[ENTER]	MD -4.62459375	
8				18	[ENTER]	QBA -1.3213125	
9				19	[ENTER]	QDE -1.3213125	
10				20	[ENTER]	QBC 2.023039742	

SHARP

Title	STRESS CALCULATION OF THREE HINGED POINT GABLED ROOF FRAME	PROGRAM NO. P 4 - D - 5
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$$V_A = -q \left\{ \frac{0.6 h^2}{l} + 0.214 s + 0.0552 \left(h + \frac{f}{2} \right) \right\}$$

$$V_E = -q \left\{ -\frac{0.6 h^2}{l} + 0.39 s - 0.0552 \left(h + \frac{f}{2} \right) \right\}$$

$$H_A = -\frac{q (0.7 h^2 + 0.8 hf + 0.0754 sl + 0.053 sh + 0.0079 fs)}{h + f}$$

$$H_E = -\frac{q (0.5 h^2 + 0.4 hf - 0.0754 sl + 0.053 sh + 0.0983 fs)}{h + f}$$

$$M_B = -(H_A h + 0.4 q h^2), \quad M_D = H_E h + 0.2 q h^2$$

$$Q_{BA} = -(H_A + 0.8 qh), \quad Q_{DE} = -(H_E + 0.4 qh)$$

$$N_{BC} = -V_A \sin \alpha - (H_A + 0.8 qh) \cos \alpha$$

$$Q_{BC} = V_A \cos \alpha - (H_A + 0.8 qh) \sin \alpha$$

$$N_{DC} = -V_E \sin \alpha + (H_E + 0.4 qh) \cos \alpha$$

$$Q_{DC} = -V_E \cos \alpha - (H_E + 0.4 qh) \sin \alpha$$

M program: Input of condition

A program: Perpendicular stress

B program: Horizontal stress

[Operation]

C LOAD ▽D5 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1	ENTER	QDC -2.023039742		11	ENTER	MB 9.55175102	
2	ENTER	NBC -1.988305418		12	ENTER	MD -1.776221328	
3	ENTER	NDC -1.988305418		13	ENTER	QBA -1.04907172	
4				14	ENTER	QDE -0.332508192	
5	SHIFT B	SEISMIC STRESS		15	ENTER	QBC -2.141990617	
6		Q=		16	ENTER	QDC 1.374387738	
7	(q) 1.2 ENTER	VA -2.547945067		17	ENTER	NBC 1.739370923	
8	ENTER	VE -1.532678933		18	ENTER	NDC 7.59943E-01	
9	ENTER	HA -4.40907172		19			
10	ENTER	HE -1.347491808		20			

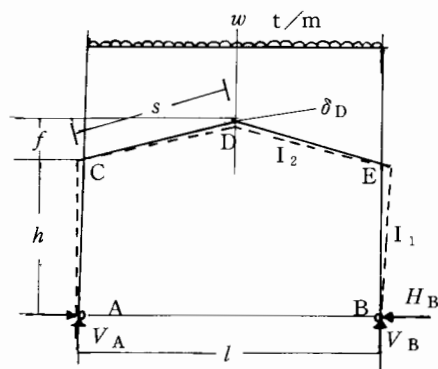
SHARP

Title

RIDGE DEFLECTION CALCULATION OF GABLED ROOF
FRAME (COLUMN BASE PIN, UNIFORM DISTRIBUTION)

PROGRAM NO.
P4-D-6

[Formula]



$$H_A = H_B = H$$

$$H = \frac{(8h+5f) \cdot w l^2}{32 \{ h^2 (k+3) + f(3h+f) \}}$$

$$k = \frac{I_2 \cdot h}{I_1 \cdot s}$$

$$I_1 = I_2 = I$$

$$\bar{H} = \frac{3h+2f}{8 \{ h^2 (k+3) + f(3h+f) \}} \bar{P} l$$

$$\delta_D = \frac{2h^3}{3EI} \cdot H\bar{H} + \frac{S}{EI} \left\{ \frac{5wl^3}{192} - \frac{wl^2}{48} (5f+8h) \bar{H} - \frac{l}{12} (2f+3h) H + \frac{2}{3} (f^2+3hf+3h^2) H\bar{H} \right\}$$

Where, $\bar{H}$ is the horizontal reaction at points A, B when virtual load $\bar{P} = 1$ is applied to ridge point D.

[Example]

$$h = 450 \text{ (cm)}$$

$$s = 940 \text{ (cm)}$$

$$f = 270 \text{ (cm)}$$

$$E = 2,100 \text{ (t/cm}^2\text{)}$$

$$w = 0.0027 \text{ (t/cm)}$$

$$I = 7,210 \text{ (cm}^4\text{)}$$

$$l = 1800 \text{ (cm)}$$

[Operation]

C LOAD ▽D6▽

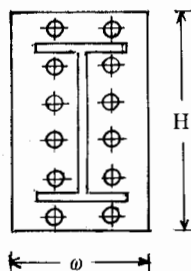
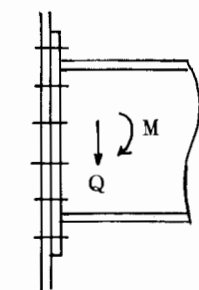
ENTER

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	H =		11			
2	(h)450 [ENTER]	F =		12			
3	(f)270 [ENTER]	W =		13			
4	(w)0.0027 [ENTER]	L =		14			
5	(l)1800 [ENTER]	S =		15			
6	(s)940 [ENTER]	E =		16			
7	(E)2100 [ENTER]	I =		17			
8	(I)7210 [ENTER]	DEFLECTION 4.599375225		18			
9				19			
10				20			

Title DESIGN OF END PLATE JOINT PART

PROGRAM NO.
P 4 - D - 7

[Formula]



$$\omega_1 = \frac{n A_b}{H}$$

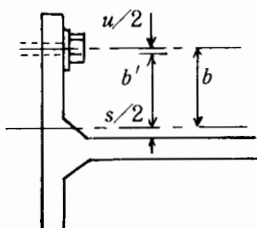
n : number of bolts

A_b : sectional area of bolt shaft (cm²)

H : height of end plate (cm)

$$w_2 = w - w_1$$

w : width of end plate



$$\gamma = \frac{x}{h} = \frac{w_1}{w_2} \left(\sqrt{\frac{w_2}{w_1}} + 1 - 1 \right)$$

r : neutral axis ratio

$$I = \frac{w_2 H^3}{3} \left\{ \frac{3}{w_2} \frac{w_1}{w_2} \left(\frac{1}{2} - r \right)^2 + r^3 + \frac{w_1}{4 w_2} \right\}$$

I : moment of second order of replacement section (cm⁴)

Z : sectional coefficient (cm³)

σ_t : bolt tensile stress (t/cm²)

$$Z = \frac{I}{(1 - \gamma)} \cdot H^{-1}$$

$$\sigma_t = M / Z$$

Investigation of $\sigma_t \leq f_t$

$$Q \leq n \cdot A_b \cdot f_s(t)$$

(Investigation into shearing force)

$$t_p \geq \sqrt{\frac{6 b' n' B T}{w \cdot f_{b1}}}$$

t_p : thickness of endplate (cm)

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	FS =		11	[ENTER]	I = 54797.60986	
2	(f _s)2.25 [ENTER]	FB1 =		12	[ENTER]	Z = 896.0846184	
3	(f _b)3.81 [ENTER]	M =		13	[ENTER]	SIGMA T=4.463864146	
4	(M)4000 [ENTER]	B ₁ =		14	[ENTER]	N*AB*FS= 98.91	
5	(b')3.4 [ENTER]	N =		15	[ENTER]	TP = 2.236800622	
6	(n)14 [ENTER]	N ₁ =		16			
7	(n')2 [ENTER]	AB =		17			
8	(A _b)3.14 [ENTER]	H =		18			
9	(H)70 [ENTER]	W =		19			
10	(w)30 [ENTER]	R = 1.26396E-01		20			

Title DESIGN OF END PLATE JOINT PART	PROGRAM NO. P 4 - D - 7
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b' : $b - u/2$ (b : distance between bolt center and fillet center, cm; u : parallel distance between bolt heads, cm)

n' : number of bolts in the outermost edge bolt row on the tension side

BT : tension acting on outermost edge bolts

$= \sigma_t \cdot A_b(t)$

f_{b_1} : allowable bending stress of plate (t/cm^2)

[Example]

f_s 2.25 t/cm^2 (temporary)	A_b 3.14 cm^2
f_{b_1} 3.81 t/cm^2 (temporary)	H 70 cm
M_0 4000 $t \cdot cm$	w_1 0.628 cm
b' 3.4 cm	w 30 cm
n' 2	

[Operation]

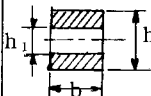
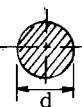
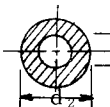
C LOAD ▽D7▽ ENTER

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title	SECTIONAL AREA A, MOMENT OF SECOND ORDER I, SECTIONAL COEFFICIENT Z (PART 1)	PROGRAM NO. P 4 - D - 8
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[Formula]

With respect to the typical sections shown below, A, I and Z are determined.

Symbol	Section	A	I	Z	
A		$b h$	$\frac{1}{12} b h^3$	$\frac{1}{6} b h^2$	... A Program
B		$b (h_2 - h_1)$	$\frac{1}{12} b (h_2^3 - h_1^3)$	$\frac{1}{6} \cdot \frac{b (h_2^3 - h_1^3)}{h_2}$	... B Program
C		$\frac{\pi}{4} d^2$	$\frac{\pi}{64} d^4$	$\frac{\pi}{32} d^3$	... C Program
D		$\frac{\pi}{4} (d_2^2 - d_1^2)$	$\frac{\pi}{64} (d_2^4 - d_1^4)$	$\frac{\pi}{32} \cdot \frac{d_2^4 - d_1^4}{d_2}$	... D Program

In the case of A, if the structure is square, the same value should be entered for the input of b and h.

[Example]

- (A)-a. In section A, the values of A, I, Z are found, provided $b = 3$ cm, $h = 5$ cm.
- (A)-b. The values of A, I, Z of a square of which one side is 4 cm are found.
- (B) The values of A, I, Z are found under the condition that a 2.5 cm hole is provided in the center of a plate measuring 1.2 cm in thickness and 10 cm in height.
- (C) The values of A, I, Z of a bar measuring 6.5 cm in diameter are found.
- (D) The values of A, I, Z of a pipe measuring 7.5 cm in outside diameter and 6.5 cm in inside diameter are found.

[Operation] C LOAD ▽ D8 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	B =		11	SHIFT C	D =	
2	(b) 3 ENTER	H =		12	(d) 6.5 ENTER	33.18 87.62 26.96	
3	(h) 5 ENTER	15.00 31.25 12.50		13			
4		↑ ↑ ↑ A I Z		14	SHIFT D	D1 =	
5	SHIFT B	B =		15	(d ₁) 6.5 ENTER	D2 =	
6	(b) 1.2 ENTER	H1 =		16	(d ₂) 7.5 ENTER	10.99 67.69 18.05	
7	(h ₁) 2.5 ENTER	H2 =		17			
8	(h ₂) 10 ENTER	9.00 98.43 19.68		18			
9				19			
10				20			

Title		SECTIONAL AREA A, MOMENT OF SECOND ORDER I, SECTIONAL COEFFICIENT Z (PART 1)	PROGRAM NO. P 4-D-8
Memory content			
A	1	bh ,	
B	2	bh ³ /12 ,	
C	3	bh ² /6 ,	
D	4		10: "A":INPUT "B= ";X,"H= ";Y
E	5		20: GOSUB 500
F	6		30: GOTO 200
G	7		40: "B":INPUT "B= ";X,"H1= ";Y
H	8		50: GOSUB 500
I	9		60: GOSUB 540
J	10		70: INPUT "H2= ";Y
K	11		80: GOSUB 500
L	12		90: GOSUB 550
M	13		100: GOTO 200
N	14		110: "C":INPUT "D= ";Y
O	15		120: GOSUB 520
P	16		130: GOTO 200
Q	17		140: "D":INPUT "D1= ";Y
R	18		150: GOSUB 520
S	19		160: GOSUB 540
T	20		170: INPUT "D2= ";Y
U	21		180: GOSUB 520
V	22		190: GOSUB 550
W	23		200: PRINT USING "#####.##";A;B;C
X	24	b	210: RETURN
Y	25	h , h ₁ ,	500: A=X*Y;B=A*Y*Y/12
Z	26		510: C=2*B/Y:RETURN
			520: A=π*Y*Y/4;B=A*Y*Y/16
			530: C=2*B/Y:RETURN
			540: D=A;E=B:RETURN
			550: A=A-D;B=B-E
			560: C=2*B/Y:RETURN
			322

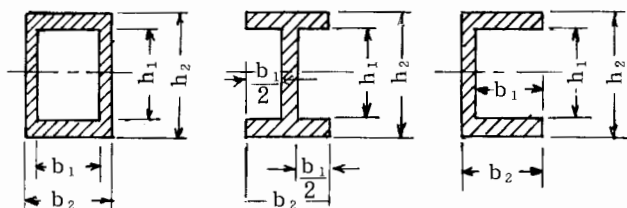
Title A, I, Z OF VARIOUS SHAPES (PART 2)

PROGRAM NO.
P 4 - D - 9

[Formula]

This program calculates the sectional area A, moment of second order I, and sectional coefficient Z of sections a) to c) shown below. However, as for case c), since the section is not symmetrical vertically with respect to the neutral axis, the sectional coefficient is delivered in two kinds: Z_1, Z_2 .

a)

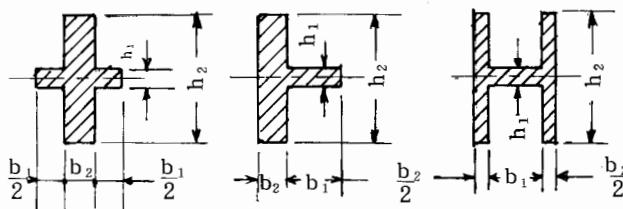


$$A = b_2 h_2 - b_1 h_1$$

$$I = \frac{1}{12} (b_2 h_2^3 - b_1 h_1^3) \quad \dots \text{Program A}$$

$$Z = \frac{2 I}{h_2}$$

b)

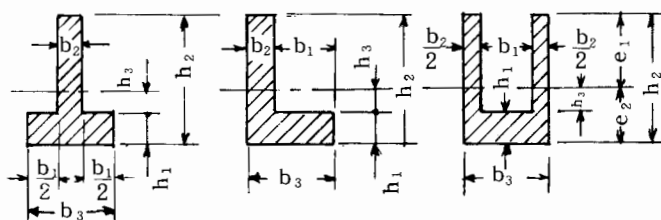


$$A = b_1 h_1 + b_2 h_2$$

$$I = \frac{1}{12} (b_1 h_1^3 + b_2 h_2^3) \quad \dots \text{Program B}$$

$$Z = \frac{2 I}{h_2}$$

c)



$$A = b_1 h_1 + b_2 h_2$$

$$b_3 = b_1 + b_2$$

$$h_3 = e_2 - h_1$$

$$e_1 = h_2 - e_2$$

$$I = \frac{1}{3} (b_3 e_2^3 - b_1 h_3^3 + b_2 e_1^3) \quad \dots \text{Program C}$$

$$e_2 = \frac{b_1 h_1^2 + b_2 h_2^2}{2 (b_1 h_1 + b_2 h_2)}$$

$$Z_1 = \frac{1}{e_1}, \quad Z_2 = \frac{1}{e_2}$$

C LOAD ▽D9 ▽ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	H1 =		11	SHIFT C	H1 =	
2	(h ₁) 10 ENTER	H2 =		12	(h ₁) 2 ENTER	H2 =	
3	(h ₂) 15 ENTER	B1 =		13	(h ₂) 10 ENTER	B1 =	
4	(b ₁) 4 ENTER	B2 =		14	(b ₁) 10 ENTER	B2 =	
5	(b ₂) 6 ENTER	A = 50		15	(b ₂) 1 ENTER	A = 30	
6	ENTER	I = 1354.166667		16	ENTER	I = 196.6666667	
7	ENTER	Z = 180.5555556		17	ENTER	Z1 = 25.65217392	
8				18	ENTER	Z2 = 84.28571431	
9				19			
10				20			

[Example]

- a) In the drawing, $h_1 = 10$ cm, $h_2 = 15$ cm, $b_1 = 4$ cm, $b_2 = 6$ cm
($A = 50$ cm², $I = 1354.16$ cm⁴, $Z = 180.55$ cm³)
- c) In the drawing, $h_1 = 2$ cm, $h_2 = 10$ cm, $b_1 = 10$ cm, $b_2 = 1$ cm
($A = 30$ cm², $I = 196.66$ cm⁴, $Z_1 = 25.65$ cm³, $Z_2 = 84.28$ cm³)

[Operation]

CLOAD ▽D9▽

Selection { In the case of drawing a)
 In the case of drawing b)
 In the case of drawing c)

(h_1)

(h_2)

(b_1)

(b_2) (A)

(I)

NOTE (Z)

NOTE) When is selected, two outputs are delivered for Z (namely, Z_1 and Z_2).

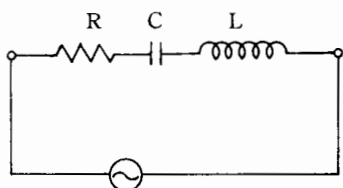
	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title IMPEDANCE IN A SERIES CIRCUIT

PROGRAM NO.
P 4 - E - 1

[Formula]

Impedance in a series circuit



$$Z = |\dot{Z}| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \quad [\Omega]$$

$$\theta = \tan^{-1} \left(\frac{\omega L - \frac{1}{\omega C}}{R} \right) \quad [^\circ]$$

$$\dot{Z} = R + j \left(\omega L - \frac{1}{\omega C} \right)$$

[Example]

$$\begin{cases} L = 25 & [\text{mH}] \\ C = 10 & [\mu\text{F}] \\ R = 5 & [\Omega] \\ f = 50 & [\text{Hz}] \end{cases}$$

$$\begin{cases} Z = 310.5 & [\Omega] \\ \theta = -89.08 & [^\circ] \\ x = 5 \\ y = -310.5 \\ \therefore \dot{Z} = 5 - 310.5j \end{cases}$$

[Operation]

C LOAD ∇ E 1 ∇ **ENTER**

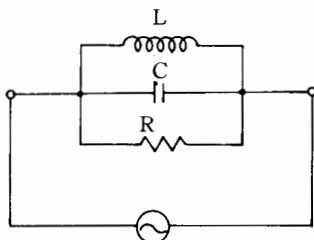
	Input	Display	Note		Input	Display	Note
1	[SHIFT] A	L =		11			
2	(L)25E-3 [ENTER]	C =		12			
3	(C)10E-6 [ENTER]	R =		13			
4	(R)5 [ENTER]	F (HZ) =		14			
5	(f)50 [ENTER]			15			
6		X 5		16			
7	[ENTER]	Y -310.455 ...		17			
8	[ENTER]	Z 310.496 ...		18			
9	[ENTER]	PHASE -89.077 ...	(θ)	19			
10				20			

Title IMPEDANCE IN A PARALLEL CIRCUIT

PROGRAM NO.
P 4 - E - 2

[Formula]

Impedance in a parallel circuit



$$Z = |Z| = \frac{1}{\sqrt{\frac{1}{R^2} + \left(\frac{1}{\omega L} - \omega C\right)^2}} \quad [\Omega]$$

$$\theta = \tan^{-1} R \left(\frac{1}{\omega L} - \omega C \right) \quad [^\circ]$$

$$\dot{Z} = \frac{1}{\frac{1}{R} - j \left(\frac{1}{\omega L} - \omega C \right)}$$

[Example]

$$\begin{cases} L = 40 & [\text{mH}] \\ C = 0.5 & [\mu\text{F}] \\ R = 8 & [\Omega] \\ f = 60 & [\text{Hz}] \end{cases}$$

$$\begin{cases} Z = 7.07 & [\Omega] \\ \theta = 27.88 & [^\circ] \\ x = 6.251 \\ y = 3.307 \\ \therefore \dot{Z} = 6.251 + 3.307 j \end{cases}$$

[Operation]

C LOAD ▽ E 2 ▽ ENTER

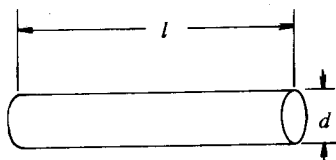
	Input	Display	Note		Input	Display	Note
1	SHIFT A	L =		11			
2	(L)40E-3 ENTER	C =		12			
3	(C)0.5E-6 ENTER	R =		13			
4	(R) 8 ENTER	F (Hz) =		14			
5	(f)60 ENTER			15			
6		X 6.2507 ...		16			
7	ENTER	Y 3.3066 ...		17			
8	ENTER	Z 7.0714 ...		18			
9	ENTER	PHASE 27.8792 ...	(θ)	19			
10				20			

Title SELF-INDUCTANCE ON A STRAIGHT LINE

PROGRAM NO.
P 4 - E - 3

[Formula]

Computing the self-inductance on lead wire or printed wire



$$L [\mu H] = 0.002 l \left(1 + \frac{4 l}{d} - 1 \right)$$

$$L_o [\mu H] = 0.002 l \left(1 + \frac{4 l}{d} - 1 + \frac{\mu_r}{4} \right)$$

Where μ : relative permeability

When the frequency is fairly high, use the upper equation, and when low, use the lower.

[Example]

$$\begin{cases} l = 8 & [\text{cm}] \\ d = 0.2 & [\text{cm}] \end{cases}$$

Answer $L = 0.07 [\mu H]$

[Operation]

C LOAD ∇ E 3 ∇ **ENTER**

* When the frequency is low and μ_r is taken into account.

SHIFT **A**

μ_r **ENTER**

l **ENTER**

d **ENTER**

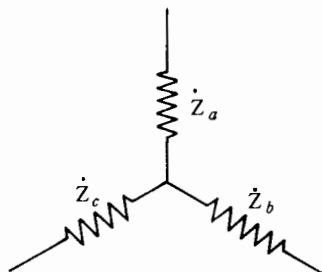
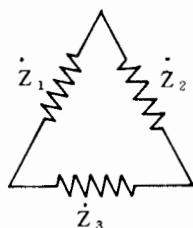
	Input	Display	Note		Input	Display	Note
1	SHIFT B	L =		11			
2	(l)8 ENTER	D =		12			
3	(d)0.2 ENTER			13			
4		L 6.52027 E-02		14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title SELF-INDUCTANCE ON A STRAIGHT LINE			PROGRAM NO: P 4- E- 3
Memory content			
A	1	l	
B	2	d	
C	3		
D	4		10: "A":INPUT "UR=";Z
E	5		20: INPUT "L=";A
F	6		30: INPUT "D=";B
G	7		40: L=.002*A*(LN (4*A/B)-1+Z/4)
H	8		50: USING :PRINT "LO",L
I	9		60: "B":INPUT "L=";A
J	10		70: INPUT "D=";B
K	11		80: L=.002*A*(LN (4*A/B)-1)
L	12	L	90: USING :PRINT "L",L
M	13		100: END
N	14		138
O	15		
P	16		
Q	17		
R	18		
S	19		
T	20		
U	21		
V	22		
W	23		
X	24		
Y	25		
Z	26	μ_r	

Title $\Delta \rightarrow Y$ TRANSLATION

PROGRAM NO.
P 4 - E - 4

[Formula]



$$\dot{Z}_a = \frac{\dot{Z}_1 \cdot \dot{Z}_2}{\Sigma} \quad [\Omega]$$

$$\Sigma = \dot{Z}_1 + \dot{Z}_2 + \dot{Z}_3$$

$$\dot{Z}_b = \frac{\dot{Z}_2 \cdot \dot{Z}_3}{\Sigma} \quad [\Omega]$$

$$\dot{Z}_i = x_i + y_i$$

$$\dot{Z}_c = \frac{\dot{Z}_3 \cdot \dot{Z}_1}{\Sigma} \quad [\Omega]$$

[Example]

$$\begin{pmatrix} R_1 = 5 \\ x_1 = 3 \end{pmatrix} \quad \begin{pmatrix} R_2 = 6 \\ x_2 = -2 \end{pmatrix} \quad \begin{pmatrix} R_3 = 9 \\ x_3 = 5 \end{pmatrix} \quad \begin{cases} \dot{Z}_a = 1.76 - 0.13 j \\ \dot{Z}_b = 3.10 - 0.33 j \\ \dot{Z}_c = 2.09 + 1.97 j \end{cases}$$

[Operation]

C LOAD ∇ E 4 ∇ ENTER

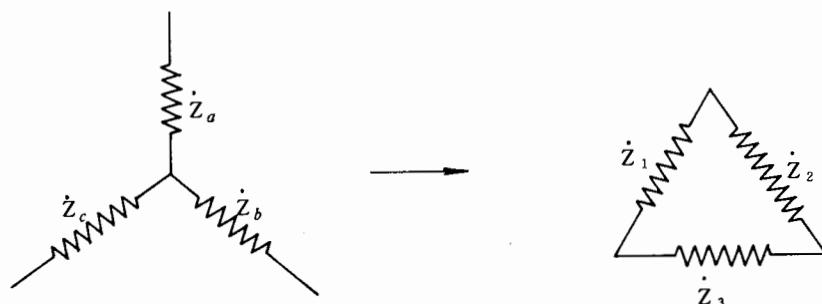
	Input	Display	Note		Input	Display	Note
1	SHIFT A	Z1 R =		11			
2	(R ₁)5 ENTER	Z1 X =		12			
3	(x ₁)3 ENTER	Z2 R =		13			
4	(R ₂)6 ENTER	Z2 X =		14			
5	(x ₂)-2 ENTER	Z3 R =		15			
6	(R ₃)9 ENTER	Z3 X =		16			
7	(x ₃)5 ENTER			17			
8		ZA1.761 ... -1.284 ...	R _a , x _a	18			
9	ENTER	ZB3.100 ... -3.302 ...	R _b , x _b	19			
10	ENTER	ZC2.091 ... 1.972 ...	R _c , x _c	20			

Title Y → Δ TRANSLATION

PROGRAM NO.
P 4 - E - 5

[Formula]

This program translates the impedance in a Y-shaped connection to its equivalent in a triangular connection.



$$\begin{aligned} \dot{Z}_1 &= \Delta / \dot{Z}_b \quad [\Omega] & \Delta &= \dot{Z}_a \dot{Z}_b + \dot{Z}_b \dot{Z}_c + \dot{Z}_c \dot{Z}_a \\ \dot{Z}_2 &= \Delta / \dot{Z}_c \quad [\Omega] & \dot{Z}_i &= x_i + y_i \\ \dot{Z}_3 &= \Delta / \dot{Z}_a \quad [\Omega] \end{aligned}$$

[Example]

$$\begin{pmatrix} R_a = 8 \\ x_a = 3 \end{pmatrix} \quad \begin{pmatrix} R_b = 9 \\ x_b = -5 \end{pmatrix} \quad \begin{pmatrix} R_c = 7 \\ x_c = 6 \end{pmatrix}$$

$$\begin{cases} \dot{Z}_1 = 14.97 + 16.65 j \\ \dot{Z}_2 = 23.25 - 9.21 j \\ \dot{Z}_3 = 26.97 - 0.74 j \end{cases}$$

[Operation] C LOAD ▽ E 5 ▽ ENTER

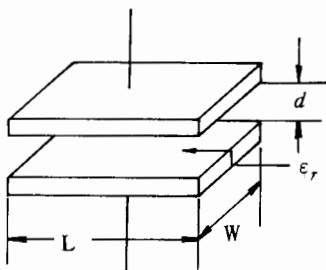
	Input	Display	Note		Input	Display	Note
1	SHIFT A	ZA R =		11			
2	(R _a)8 ENTER	ZA X =		12			
3	(x _a)3 ENTER	ZB R =		13			
4	(R _b)9 ENTER	ZB X =		14			
5	(x _b) -5 ENTER	ZC R =		15			
6	(R _c)7 ENTER	ZC X =		16			
7	(x _c)6 ENTER			17			
8		Z1 14.97 ... 16.65 ...	R ₁ , X ₁	18			
9	ENTER	Z2 23.24 ... -9.21 ...	R ₂ , X ₂	19			
10	ENTER	Z3 26.97 ... -0.73 ...	R ₃ , X ₃	20			

Title Y → Δ TRANSLATION			PROGRAM NO. P 4 - E - 5
Memory content			
A	1	✓	
B	2		
C	3	) $\dot{z}_a$	10: "A":DEGREE :INPUT "ZA R=";X
D	4		20: INPUT "ZA X=";Y
E	5	) $\dot{z}_b$	30: GOSUB 500
F	6		40: B=U:C=V
G	7	) $\dot{z}_c$	50: INPUT "ZB R=";X
H	8		60: INPUT "ZB X=";Y
I	9	) Δ	70: GOSUB 500
J	10	) $\dot{z}_3$	80: D=U:E=V
K	11		90: INPUT "ZC R=";X
L	12	) $\dot{z}_1$	100: INPUT "ZC X=";Y
M	13		110: GOSUB 500
N	14	) $\dot{z}_2$	120: F=U:G=V
O	15		130: X=0:Y=0
P	16	✓	140: FOR A=4TO 7
Q	17		150: H=B*A(A)
R	18		160: A=A+1
S	19		170: I=C+A(A)
T	20		180: X=X+H*COS I
U	21	| $\dot{z}$ |	190: Y=Y+H*SIN I
V	22	θ	200: NEXT A
W	23		210: H=D*F
X	24	✓	220: I=E+G
Y	25	✓	230: X=X+H*COS I
Z	26		240: Y=Y+H*SIN I
			250: GOSUB 500
			260: H=U:I=V:P=10
			270: FOR A=2TO 7
			280: X=H/A(A)
			290: A=A+1
			300: Y=I-A(A)
			310: A(P)=X*COS Y
			320: P=P+1
			330: A(P)=X*SIN Y
			340: P=P+1
			350: NEXT A
			360: PRINT "Z1 ";L;" ";M
			370: PRINT "Z2 ";N;" ";O
			380: PRINT "Z3 ";J;" ";K
			500: U=√(X*X+Y*Y)
			510: V=ACS (X/U)
			520: IF 0>YLET V=-V
			530: RETURN
			540: END
			452

SHARP

Title	CAPACITANCE ACROSS TWO PARALLEL ELECTRODES	PROGRAM NO. P 4 - E - 6
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[Formula]



Length L [cm]
 Width W [cm]
 Inductivity ϵ_r
 Space d [cm]
 ($\epsilon_r = 1$: air)

$$C [\text{pF}] = 0.0885419 \frac{\epsilon_r L W}{d} (1 + p)$$

Where $P = \begin{cases} 0 : (100 W > L) \\ \frac{d}{\pi W} \left(1 + \ln \frac{2 \pi W}{d} \right) : (L \geq 100 W) \end{cases}$

[Example]

1)

$$\begin{cases} \epsilon_r = 1 \\ d = 0.01 [\text{cm}] \\ L = 20 [\text{cm}] \\ W = 1 [\text{cm}] \end{cases}$$

Answer 177.08 [pF]

2)

$$\begin{cases} \epsilon_r = 1 \\ d = 0.01 [\text{cm}] \\ L = 300 [\text{cm}] \\ W = 3 \end{cases}$$

Answer 8040.99 [pF]

[Operation]

C LOAD ▽ E 6 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHFT A	L (CM) =		11			
2	(L)20 ENTER	W (CM) =		12			
3	(W)1 ENTER	D (CM) =		13			
4	(d).01 ENTER	ER =		14			
5	(ϵ_r) 1 ENTER			15			
6		C 177.0838 (PF)		16			
7				17			
8				18			
9				19			
10				20			

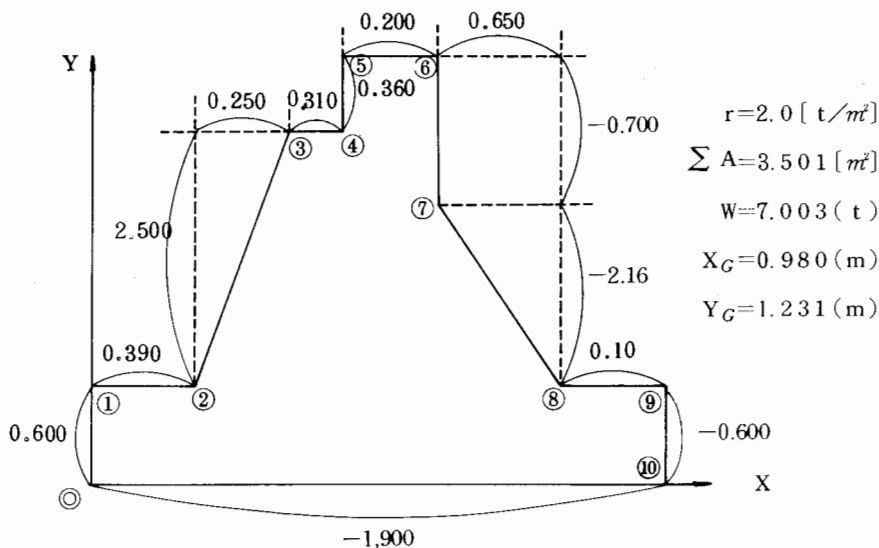
Title SECTION, DEAD LOAD AND CENTROID OF A POLYGON

PROGRAM NO.
P 4 - F - 1

[Formula]

This program finds the sectional area and centroid of a polygon from its latitude and departure.

[Example]



[Operation]

C LOAD ∇ F1 ∇

NOTE) ΔX and ΔY are, when input, accompanied by a sign respectively.

Input	Display	Note	Input	Display	Note
1 SHIFT A			11 $\vdots$		
2 (Xo) 0 ENTER	Xo=0		12 $\Delta X_{n-1.9}$ ENTER	$\Delta X = -1.9$	
3 (Yo) 0 ENTER	Yo=0		13 ΔY_n 0 ENTER	$\Delta Y = 0$	
4 (r) 2 ENTER	R = 2		14	A = 3.5015	Rechecking permissible
5 ΔX_1 0 ENTER	DX=0		15 ENTER	W = 7.0030	
6 ΔY_1 .6 ENTER	DY=.6		16 ENTER	XG = 0.9804	
7 ΔX_2 .39 ENTER	DX=.39		17 ENTER	YG = 1.2313	
8 ΔY_2 0 ENTER	DY=0		18 ENTER		
9 ΔX_3 .25 ENTER	DX=.25		19		
10 ΔY_3 2.5 ENTER	DY=2.5		20		

Title COULOMB'S COEFFICIENT OF EARTH PRESSURE

PROGRAM NO.
P 4 - F - 2

[Formula]

This program determines the coefficient of active earth pressure from coulomb's earth pressures.

In seismic case

$$K_{EA} = \frac{\cos^2(\phi - \theta_0 - \theta)}{\cos \theta_0 \cos^2 \theta \cos(\theta + \theta_0 + \delta) \left[1 + \sqrt{\frac{\sin(\phi + \delta) \cdot \sin(\phi - \alpha - \theta_0)}{\cos(\theta + \theta_0 + \delta) \cdot \cos(\theta - \alpha)}} \right]^2}$$

In permanent case

$$K_A = K_{EA} (\theta_0 = 0)$$

α : angle closed by earth surface and level surface

ϕ : internal friction angle of back-filling soil

θ : angle closed by wall back surface and horizontal surface

δ : angle closed by wall back surface normal line and earth pressure active direction

[Example]

$$\phi = 35^\circ$$

$$\theta = 21.48^\circ$$

$$\theta_0 = 11.19^\circ$$

$$\delta = 0$$

$$K_A = .4348$$

$$K_{EA} = .5858$$

$$\alpha = 0$$

[Operation]

C LOAD ∇ F2 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A			11			
2	(ϕ) 35 ENTER	PHI=35		12			
3	(α) 0 ENTER	ALPHA=0		13			
4	(θ) 21.48 ENTER	THETA=21.48		14			
5	(θ_0) 11.19 ENTER	THETA 0=11.19		15			
6	(δ) 0 ENTER	DELTA=0		16			
7		KEA=0.585886		17			
8				18			
9				19			
10				20			

Title STABILITY OF A SLOPE (METHOD OF SLICES)

PROGRAM NO.
P 4 - F - 3

[Formula]

This program computes the safety factor of a slope which possesses C_i and θ_i .

$$F_s = \frac{\sum C_i \cdot l_i + \sum W_i \cdot \cos \alpha_i \cdot \tan \phi_i}{\sum W_i \cdot \sin \alpha_i}$$

where W_i : weight of soil above sliding surface

R : radius

α_i : angle closed by divided area and vertical line

θ_i : central angle for each soil layer

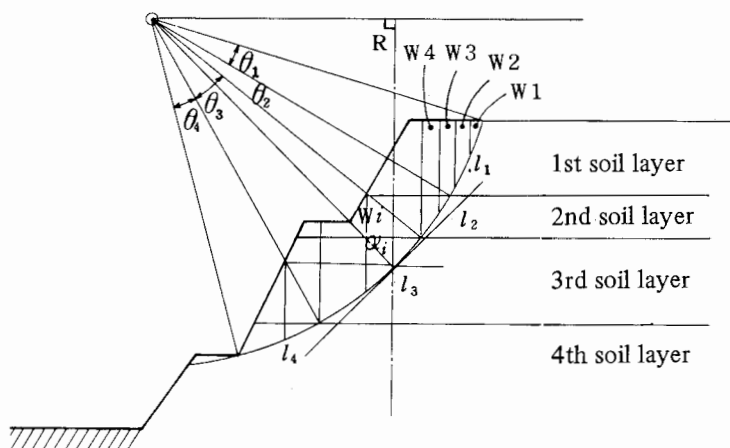
γ_i : weight per soil's unit volume

P_i : internal friction angle of soil

C_i : cohesion of soil

l_i : length of arc

See the figure below



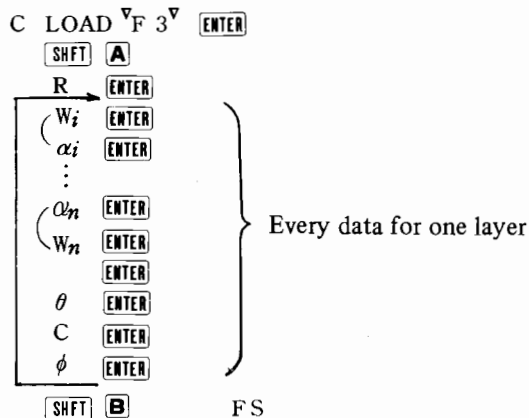
Input	Display	Note	Input	Display	Note
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

Title	STABILITY OF A SLOPE (METHOD OF SLICES)	PROGRAM NO.
		P 4 - F - 3

[Example]

	$R = 15 \text{ m}$	(t/m)	(degrees)	
1st layer	$\theta_1 = 21.8^\circ$	$W_1 = 0.578$	$\alpha_1 = 69.8$	$C_1 = 3.0 \text{ t/m}$
		$W_2 = 3.640$	$\alpha_2 = 62.4$	$\phi_1 = 18^\circ$
		$W_3 = 5.985$	$\alpha_3 = 55.0$	
2nd layer	$\theta_2 = 34.0^\circ$	$W_4 = 8.732$	$\alpha_4 = 48.3$	$C_2 = 4.0 \text{ t/m}$
		$W_5 = 9.588$	$\alpha_5 = 42.6$	$\phi_2 = 0^\circ$
		$W_6 = 10.863$	$\alpha_6 = 37.6$	
		$W_7 = 11.913$	$\alpha_7 = 33.0$	
		$W_8 = 12.813$	$\alpha_8 = 28.5$	
		$W_9 = 11.605$	$\alpha_9 = 24.0$	
		$W_{10} = 8.804$	$\alpha_{10} = 20.0$	
3rd layer	$\theta_3 = 11.2^\circ$	$W_{11} = 6.730$	$\alpha_{11} = 15.6$	$C_3 = 5.0 \text{ t/m}$
		$W_{12} = 5.183$	$\alpha_{12} = 12.0$	$\phi_3 = 23^\circ$
		$W_B = 0.805$	$\alpha_{13} = 8.1$	

[Operation]



	Input	Display	Note		Input	Display	Note
1	SHFT A			11	(C) 3 ENTER	C=3	
2	(R) 15 ENTER	R=15		12	(ϕ) 18 ENTER	PHI=18	
3	(W_1) .578 ENTER	W=.578		13	Repeat step 3 and the subsequent.		
4	(α_1) 69.8 ENTER	ALPHA=69.8		14			
5	(W_2) 3.64 ENTER	W=3.64		15	SHFT B	FS=1.439837	
6	(α_2) 62.4 ENTER	ALPHA=62.4		16			
7	(W_3) 5.985 ENTER	W=5.985		17			
8	(α_3) 55 ENTER	ALPHA=55		18			
9	ENTER			19			
10	(θ) 21.8 ENTER	THETA=21.8		20			

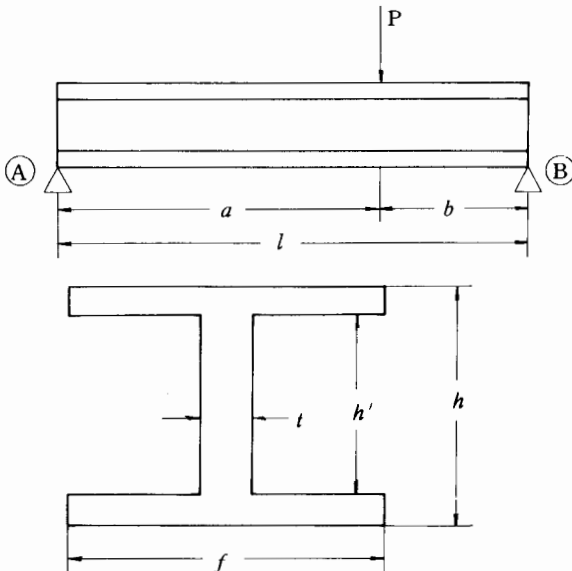
SHARP

Title BENDING STRESS OF SIMPLE GIRDER

PROGRAM NO.
P 4 - F - 4

[Formula]

When a concentrated load P acts on an simple H-shaped steel girder — see below — with span l.



Reaction force:

$$R_A = \frac{P \cdot b}{l}, \quad R_B = \frac{P \cdot a}{l}$$

Bending moment:

$$M_X = R_A \cdot a$$

Section modulus:

$$W = (f \cdot h^3 - h' \cdot t^3) / 6h$$

Stress

$$\sigma = \frac{M_X}{W}$$

[Example]

$$f = 40 \text{ (cm)}$$

$$t = 1.8 \text{ (cm)}$$

$$h = 40 \text{ (cm)}$$

$$h' = 36.4 \text{ (cm)}$$

$$P = 13000 \text{ (Kg/cm)}$$

$$l = 10000 \text{ (cm)}$$

$$a = 5000 \text{ (cm)}$$

$$b = 5000 \text{ (cm)}$$

[Operation]

C LOAD ▽ F 4 ▽ ENTER

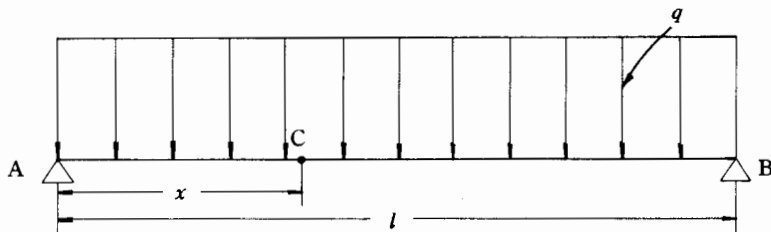
	Input	Display	Note		Input	Display	Note
1	SHIFT A			11	ENTER	RB=6500	↑
2	(f) 40 ENTER	F=40		12	ENTER	MX=32500000	
3	(t) 1.8 ENTER	T=1.8		13	ENTER	SIGMA=10868.51079	
4	(h) 40 ENTER	H=40		14	ENTER	Repeat step 6 and the subsequent.	
5	(h') 36.4 ENTER	H*=36.4		15			
6	(P) 13000 ENTER	P=13000	←	16			
7	(l) 10000 ENTER	L=10000		17			
8	(a) 5000 ENTER	A=5000		18			
9	(b) 5000 ENTER	B=5000		19			
10		RA=6500		20			

SHARP

Title	INTERNAL FORCE OF A SIMPLE GIRDER (UNIFORM LOAD)	PROGRAM NO. P 4 - F - 5
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[Formula]

This program computes the reaction force, shearing force, bending moment, and maximum bending moment of a simple girder that is subjected to a uniform load, shown below,



Total load:

$$W = q l$$

Reaction force:

$$R_{A1} = R_{A2} = \frac{W}{2}$$

Max. bending moment:

$$M_{MAX} = \frac{q \cdot l^2}{8}$$

The shearing force (S_c) and the bending moment (M_c) at point C which is X — arbitrary distance — apart from support A.

$$S_c = q \left(\frac{l}{2} - x \right)$$

$$M_c = q x \left(l - x \right) / 2$$

[Example]

$$l = 15 \text{ (m)}$$

$$q = 3 \text{ (t/m)}$$

$$x = 2, 4, 8, 12 \text{ (m)}$$

[Operation]

C LOAD ∇ F5 ∇ ENTER

Input	Display	Note	Input	Display	Note
1 SHFT A			11 ENTER	Repeat step 8 and the subsequent.	
2 (q) 3 ENTER	Q=3		12		
3 (l) 15 ENTER	L=15		13		
4	W=45		14		
5 ENTER	RA, RB=22.5		15		
6 ENTER	M-MAX=84.375		16		
7 ENTER	X=		17		
8 (x) 2 ENTER	X=2		18		
9	SC=16.5		19		
10 ENTER	MC=39		20		

SHARP

Title	INTERNAL FORCE OF A SIMPLE GIRDER (UNIFORMLY VARYING LOAD)	PROGRAM NO. P 4 - F - 6
-------	---	----------------------------

[Formula]

This program computes the internal force of a simple girder that is subjected to such a uniformly varying load as shown below.

Total load

$$W = \frac{1}{2} q \cdot l$$

Reaction force

$$R_A = \frac{W}{3} \quad R_B = \frac{2}{3} W$$

Max. bending moment

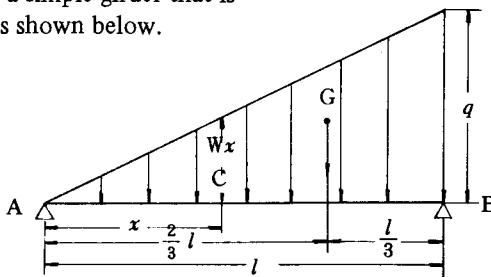
$$M_{MAX} = \frac{q \cdot l^2}{9 \cdot \sqrt{3}} \quad x = \frac{l}{\sqrt{3}}$$

The shearing force (S_c), bending moment (M_c) and load strength ($W_x = \frac{qx}{l}$) at point C located X — arbitrary — from support A are computed by the equations

$$W_x = wx \cdot \frac{x}{2}$$

$$S_c = R_A - W_x$$

$$W_c = R_A \cdot x - W_x \cdot \frac{x}{3}$$



[Example]

$$q = 7 \text{ (t / m)}$$

$$l = 15 \text{ (m)}$$

$$x = 2, 4, 8, 12, 14$$

[Operation]

C LOAD ∇ F6 ∇ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHFT A			11	ENTER	$M_c = 34.3777778$	
2	(q) 7 ENTER	$Q = 7$		12	ENTER	Repeat step 9 and the subsequent	
3	(l) 15 ENTER	$L = 15$		13			
4		$W = 52.5$		14			
5	ENTER	$R_A = 17.5$		15			
6	ENTER	$R_B = 35$		16			
7	ENTER	$M_{MAX} = 101.0362971$		17			
8	ENTER	$X =$		18			
9	(x) 2 ENTER	$X = 2$		19			
10		$S_C = 16.56666667$		20			

SHARP

Title	VELOCITY OF FLOW AND FLOW RATE (MANNING'S FORMULA AND GANGUILLET-KUTTER'S FORMULA)	PROGRAM NO. P 4 - F - 7
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[Formula]

1) Manning's formula

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I^{\frac{1}{2}}$$

where V : average velocity of flow on the whole section of flowing water (m/sec)

n : manning's coefficient of roughness

R : hydraulic mean depth (m) (= sectional area of flowing water/wetted perimeter)

I : surface slope (surface difference/waterway length (h/l))

From R, h, l and n are determined I, $C = \frac{1}{n} \cdot R^{\frac{1}{6}}$ (Chézy's coefficient) and V.

2) Ganguillet-Kutter's formula

$$V = C \sqrt{RI}$$

$$C = \frac{\frac{I}{n} + 23 + \frac{0.00155}{I}}{I + (23 + \frac{0.00155}{I}) \cdot \frac{n}{\sqrt{R}}}$$

in which V : average velocity of flow on the whole section of flowing water (m/sec)

R : hydraulic mean depth (m)

I : surface slope

C : Chézy's coefficient

n : coefficient of roughness

I, C and V are determined from R, h, l and n.

[Example]

$$(1) R = 1.25 (m)$$

$$h = 2.13 (m)$$

$$l = 10 (m)$$

$$n = 0.013$$

$$(2) R = 0.333333 (m)$$

$$h = 2.6 (m)$$

$$l = 10 (m)$$

$$n = 0.013$$

[Operation]

C LOAD ∇ F7 ∇ **ENTER**

A program: Manning's formula

B program: Ganguillet-Kutter's formula

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	MANNING		11	[SHIFT] [B]	G. KUTTER	
2	(R) 1.25 [ENTER]	R=1.25		12	(R) .333333 [ENTER]	R=.333333	
3	(h) 2.13 [ENTER]	H=2.13		13	(h) 2.6 [ENTER]	H=2.6	
4	(l) 10 [ENTER]	L=10		14	(l) 10 [ENTER]	L=10	
5	(n) .013 [ENTER]	N=.013		15	(n) .013 [ENTER]	N=.013	
6		I=0.213		16		I=0.26	
7	[ENTER]	C=79.83775504		17	[ENTER]	C=65.82863921	
8	[ENTER]	V=41.19581743		18	[ENTER]	V=19.37941697	
9				19			
10				20			

Title VELOCITY OF FLOW AND FLOW RATE	PROGRAM NO. P 4 - F - 8
---	-----------------------------------

[Formula]

- (1) Hazen-William's formula (open channel)

$$V = 0.84935 C \cdot R^{0.63} \cdot I^{0.54}$$

V : average velocity of flow (m/sec)

C : coefficient of velocity

R : hydraulic mean depth (m)

I : hydraulic gradient ($I = \frac{h}{l}$)

l : channel length (m)

h : surface difference (m)

I and V are found from R, h, l and C.

- (2) Hazen-William's formula (closed channel)

$$V = 0.35464 C \cdot D^{0.63} \cdot I^{0.54} \quad (\text{average velocity m/sec})$$

$$Q = 0.27853 C \cdot D^{2.63} \cdot I^{0.54} \quad (\text{flow rate m}^2/\text{sec})$$

$$I = \frac{h}{l} \quad (\text{hydraulic gradient})$$

D : pipe diameter

C : coefficient of velocity

h : surface difference (m)

l : channel length (m)

This program determines V and Q from
D, h, l and C.

[Example]

(1) R = 1.25 (m)

h = 2.13 (m)

l = 10 (m)

C = 100

(2) D = 0.6 (m)

h = 2.13 (m)

l = 10 (m)

C = 100

[Operation]

C LOAD ∇ F8 ∇ ENTER

A program: Open channel

B program: Closed channel

	Input	Display	Note		Input	Display	Note
1	SHIFT A	H.W 1		11	SHIFT B	H.W 2	
2	(R) 1.25 ENTER	R=1.25		12	(D).6 ENTER	D=.6	
3	(h) 2.13 ENTER	H=2.13		13	(h) 2.13 ENTER	H=2.13	
4	(l) 10 ENTER	L=10		14	(l) 10 ENTER	L=10	
5	(C) 100 ENTER	C=100		15	(C) 100 ENTER	C=100	
6		I=0.213		16		I=0.213	
7	ENTER	V=42.40967899		17	ENTER	V=11.15187754	
8				18	ENTER	Q=3.153078285	
9				19			
10				20			

Title VELOCITY OF FLOW AND FLOW RATE			PROGRAM NO. P 4 - F - 8
Memory content			
A	1		
B	2		
C	3	C	
D	4	D	
E	5		10: "A":PAUSE "H.W 1"
F	6		20: INPUT "R= ";R,"H= ";H,"L= ";L,"C= ";C
G	7		30: I=H/L
H	8	h	40: V=.84935*C*R^.63*I^.54
I	9	I	50: USING :PRINT "I=",I
J	10		60: PRINT "V=",V
K	11		70: END
L	12	l	80: "B":PAUSE "H.W 2"
M	13		90: INPUT "D= ";D,"H= ";H,"L= ";L,"C= ";C
N	14		100: I=H/L
O	15		110: V=.35464*C*D^.63*I^.54
P	16		120: Q=.27853*C*D^2.63*I^.54
Q	17	Q	130: USING :PRINT "I=",I
R	18	R	140: PRINT "V=",V
S	19		150: PRINT "Q=",Q
T	20		160: END
U	21		254
V	22	V	
W	23		
X	24		
Y	25		
Z	26		

Title CHANNEL SECTION

PROGRAM NO.
P 4 - F - 9

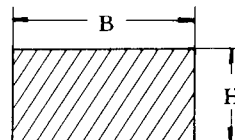
[Formula]

A) Rectangular section

Sectional area $A = B \cdot H$

Wetted perimeter $S = B + 2H$

Hydraulic mean depth $R = A / S$

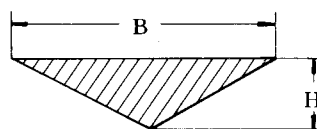


B) Triangular section

$$A = \frac{1}{2} B \cdot H$$

$$S = 2 \times \sqrt{H^2 + \frac{1}{4} B^2}$$

$$R = A / S$$

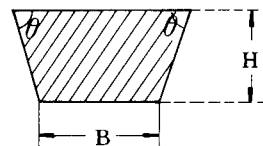


C) Trapezoidal section

$$A = B H + H^2 \times \frac{1}{\tan \theta}$$

$$S = B + 2 H \times \frac{1}{\sin \theta}$$

$$R = A / S$$



[Operation]

C LOAD $\nabla F 9 \nabla$

- program: Rectangular section
- program: Triangular section
- program: Trapezoidal section
- program: Circular section

	Input	Display	Note		Input	Display	Note
1	SHIFT A	RECTANGLE		11	SHIFT B	TRIANGLE	
2	(B) 4 ENTER	B=4		12	(B) 4 ENTER	B=4	
3	(H) 2 ENTER	H=2		13	(H) 2 ENTER	H=2	
4		A=8.0000		14		A=4.0000	
5	ENTER	S=8.0000		15	ENTER	S=5.6568	
6	ENTER	R=1.0000		16	ENTER	R=0.7071	
7				17			
8				18			
9				19			
10				20			

Title CHANNEL SECTION

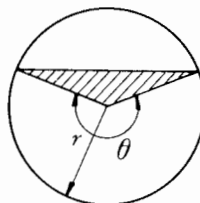
PROGRAM NO.
P 4 - F - 9

D) Circular section

$$A = r^2 \left(\frac{\theta \times \pi}{360} - \frac{1}{2} \sin \theta \right)$$

$$S = \frac{\theta}{180} \times \pi r$$

$$R = A / S$$



[Example]

A. B = 4 H = 2 → A = 8 , S = 8 , R = 1

B. B = 4 H = 2 → A = 4 , S = 5.6569 , R = 0.7071

C. $\theta = 60^\circ$ B = 4 H = 2 → A = 10.3094 , S = 8.6188 ,
R = 1.1962

D. r = 0.5 $\theta = 240$ → A = 0.6319 S = 2.0944
R = 0.3017

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [C]	TRAPEZOID		11	[SHIFT] [D]	CIRCLE	
2	(θ) 60 [ENTER]	THETA=60		12	(r) .5 [ENTER]	R=.5	
3	(B) 4 [ENTER]	B=4		13	(θ) 240 [ENTER]	THETA=240	
4	(H) 2 [ENTER]	H=2		14		A= 0.6318	
5		A=10.3094		15	[ENTER]	S= 2.0943	
6	[ENTER]	S=8.6188		16	[ENTER]	R= 0.3016	
7	[ENTER]	R=1.1961		17			
8				18			
9				19			
10				20			

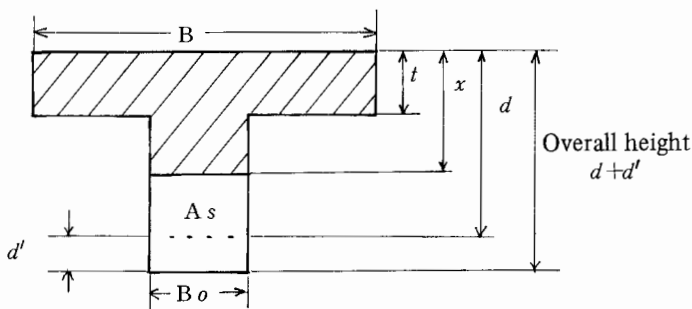
[illegible]

Title

STRESS INTENSITY OF SINGLE REINFORCE
REINFORCEMENT'S T-SHAPED SECTION

PROGRAM NO.
P 4 - F - 10

[Formula]



$$x = \frac{n d A_s + \frac{B t^2}{2}}{n A_s + B t}$$

$$P = \frac{A_s}{B d}$$

$$K = \frac{n P + \frac{1}{2} \left(\frac{t}{d} \right)^2}{n P + \left(\frac{t}{d} \right)}$$

$$j = 1 - \frac{1}{3} \left(\frac{t}{d} \right) \left[\frac{3 K - 2 \left(\frac{t}{d} \right)}{2 K - \left(\frac{t}{d} \right)} \right]$$

View of single reinforcement's
T-shaped section

B : flange width

t : flange thickness

M_o : bending moment (t · m)

S : shearing force

n : young's modulus

A_s : total sectional area of tension bar (m²)

x : neutral axis position

[Example]

$$M = 11,500,000 \text{ (Kg} \cdot \text{cm)}$$

$$S = 33,500 \text{ (cm)}$$

$$n = 15$$

$$A_s = 85 \text{ (m}^2\text{)}$$

$$B = 170 \text{ (cm)}$$

$$B_o = 55 \text{ (cm)}$$

$$d = 100 \text{ (cm)}$$

$$t = 18 \text{ (cm)}$$

○ Tensile stress intensity of reinforcement

$$\sigma_s = \frac{M}{P j B d^2} \quad (t / m^2)$$

○ Compressive stress intensity of concrete

$$\sigma_c = \frac{K}{n (1 - K)} \sigma_s \quad (t / m^2)$$

○ Shearing stress intensity

$$\tau = \frac{S}{B_o j d} \quad (t / m^2)$$

[Operation]

C LOAD $\nabla F10 \nabla$ ENTER

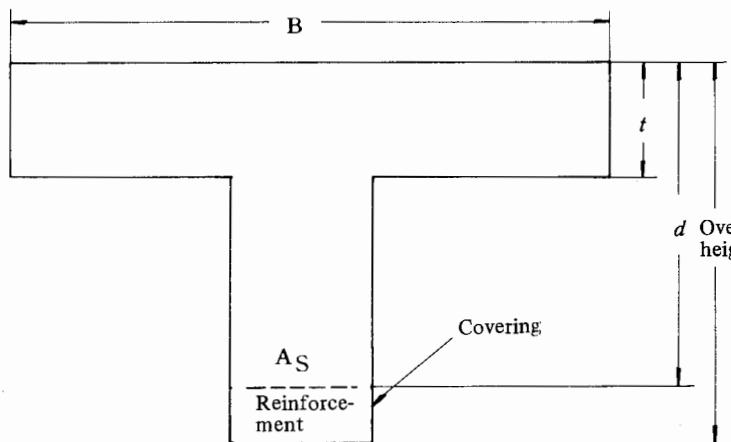
Input	Display	Note	Input	Display	Note
1 [SHIFT] [A]			11 [ENTER]	P=0.0050	
2 (M)11500000 [ENTER]	M=11500000		12 [ENTER]	K=0.3576	
3 (S)33500 [ENTER]	S=33500		13 [ENTER]	J=0.9200	
4 (n)15 [ENTER]	N=15		14 [ENTER]	SIGMA S=1470.4477	
5 (A_s)85 [ENTER]	AS=85		15 [ENTER]	SIGMA C=54.5807	
6 (B)170 [ENTER]	B=170		16 [ENTER]	TAU=6.6199	
7 (B_o)55 [ENTER]	Bo=55		17 [ENTER]	AS=	
8 (d)100 [ENTER]	D=100		18 (A_s)65 [ENTER]	AS=65	
9 (t)18 [ENTER]	T=18		19	Repeat step 10 and the subsequent	
10	X=35.7647		20		

—212—

SHARP

Title	SECTION OF SINGLE REINFORCEMENT'S T-SHAPED GIRDER	PROGRAM NO. P 4 - F - 11
-------	--	-----------------------------

[Formula]



B : flange width
 t : flange thickness
 n : ratio of moduli of elasticity
 M_0 : maximum bending moment ($t \cdot m$)
 σ_{ca} : allowable compressive stress of concrete (t/m^2)
 σ_{sa} : allowable tensile stress of reinforcement (t/m^2)
 x : neutral axis position
 As' : sectional area of tension bar
 As : sectional area of compressive reinforcement

View of T-shaped girder

$$\begin{aligned}
 W &= \frac{1}{3k} \\
 m &= \frac{1}{4} \left(1 + \frac{1}{k} \right) \\
 Z &= \frac{M}{2 \sigma_{ca} B t} + m t \\
 d' &= Z + \sqrt{Z^2 - W t^2} \\
 x &= k d' \\
 As &= \frac{\sigma_{ca} B t}{\sigma_{sa}} \left(1 - \frac{t}{2x} \right)
 \end{aligned}$$

[Example]

$M = 11,500,000 \text{ (Kg} \cdot \text{cm)}$
 $\sigma_{ca} = 55 \text{ (Kg/cm}^2\text{)}$
 $\sigma_{sa} = 1,400 \text{ (Kg/cm}^2\text{)}$
 $n = 15$
 $t = 17 \text{ (cm)}$
 $B = 170 \text{ (cm)}$
 $d = 125 \text{ (cm)}$

[Operation]

C LOAD $\nabla F11 \nabla$

Input	Display	Note	Input	Display	Note
1 SHFT A			11 ENTER	W=0.8989	
2 (M)11500000 ENTER	M=11500000		12 ENTER	Z=51.8870	
3 (n)15 ENTER	N=15		13 ENTER	D*=101.2069	
4 (σ_{ca})55 ENTER	SIGMA C=55		14 ENTER	X=37.5261	
5 (σ_{sa})1400 ENTER	SIGMA S=1400		15 ENTER	AS=87.8188	
6 (t)17 ENTER	T=17		16 ENTER	AS*=70.5088	
7 (B)170 ENTER	B=170		17		
8 (d)125 ENTER	D=125		18		
9	K=0.3707		19		
10 ENTER	SM=0.9242		20		

Title GRAPHIC CALCULATION

PROGRAM NO.
P 4 - G -

Inputting a figure

Straight line: Enter the coordinates of a point on it and an angle required.

x-coordinate, y-coordinate, angle

Enter angles in degree.

Ex. 30.5°

135.0°

The range of angles is to be within $\pm 180^\circ$.

Straight lines are made use of for discrimination with their directality considered.

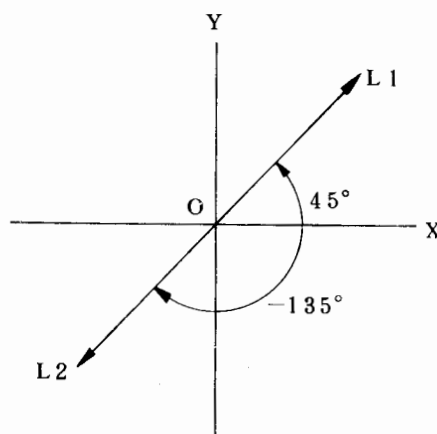


Fig. 1 Directionality of straight line

As seen from Fig. 1 above, straight lines L1 and L2 are different in direction from each other.

Circle: Enter its central coordinates and radius.

x-coordinate, y-coordinate, radius

Discrimination: When two or more answers exist in graphic calculations, required answers are found by inputting the condition of discrimination.

For discrimination, input +1 or -1.

Input nothing else than the above.

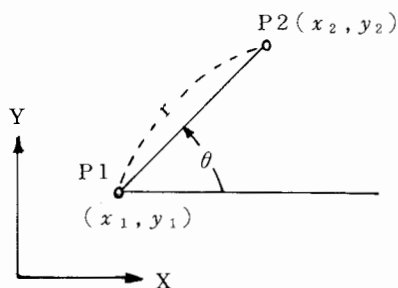
- Answers in other programs than P4-G-1 and P4-G-2 are rounded at the 3rd decimal place.

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title	DISTANCE BETWEEN TWO POINTS AND ANGLE	PROGRAM NO.
		P 4 - G - 1

[Formula]

This program determines the distance between two points and the angle closed by a line passing these points and a line parallel to the x-axis from entered values of coordinates of the points.



$$x_2 - x_1 = \Delta x$$

$$y_2 - y_1 = \Delta y$$

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

$$\theta = \text{ACS}(\Delta x / r)$$

Fig. 2 Distance between Two Points and Angle

[Example]

When $P_1(0, 0)$ and $P_2(10, 10)$,

Angle $\theta = 45^\circ$

Distance $r = 14.142$

[Operation]

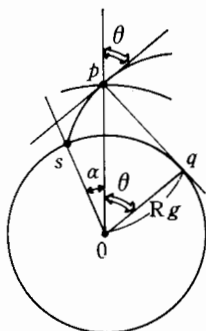
C LOAD $\nabla G1 \nabla$ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	P1 X=		11			
2	0 ENTER	P1 Y=		12			
3	0 ENTER	P2 X=		13			
4	10 ENTER	P2 Y=		14			
5	10 ENTER			15			
6		D(P1-P2) 14.142		16			
7	ENTER	ANG(DEG) 45.000		17			
8				18			
9				19			
10				20			

Title INVOLUTE, INVERSE INVOLUTE

PROGRAM NO.
P 4 - G - 2

[Formula]



This program finds the involute function essential for the design of an involute gear,

$$\text{inv } \theta = \tan \theta - \theta \text{ [RAD]}$$

and also the inverse involute function by Newton-method as shown below.

$$\begin{aligned} \theta_{i+1} &= \theta_i - \frac{f(\theta_i)}{f'(\theta_i)} \\ &= \theta_i - \frac{\tan \theta - \theta}{\tan^2 \theta} \end{aligned}$$

Fig. 3 Involute

SP : involute curve

S : starting point of involute

θ : angle of obliquity of action at point P

[Example]

θ in degree	Inv θ
14.10°	.0050912
23.00°	.0230490
25.53°	.0320358

[Operation]

C LOAD $\nabla G 2 \nabla$ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	INITIAL=	Initial value	11			
2	10 ENTER	INV A=		12			
3	.00509 ENTER	A 14.09889751		13			
4	SHIFT B	INPUT A=		14			
5	14.1 ENTER			15			
6		B 5.09121E-03		16			
7				17			
8				18			
9				19			
10				20			

Title THE POINT OF INTERSECTION OF TWO STRAIGHT LINES $P = L / L$

PROGRAM NO.
P 4 - G - 3

[Formula]

This program determines the point of intersection of given two straight lines.

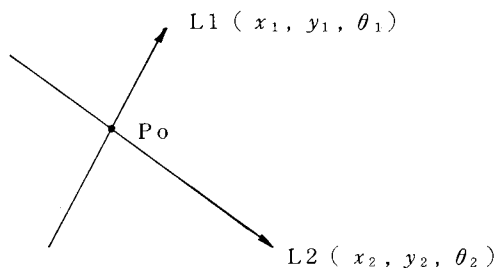
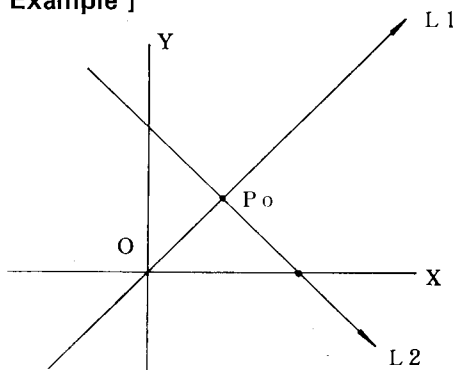


Fig. 4 The Point of Intersection of Two Straight Lines

[Example]



L1: straight line that passes point 1 (0, 0) and crosses the X-axis at 45 degrees.

L2: straight line that passes point 2 (10, 0) and crosses the X-axis at -45 degrees.

Fig. 5 Example ($P = L/L$)

[Operation]

C LOAD $\nabla G3 \nabla$ ENTER

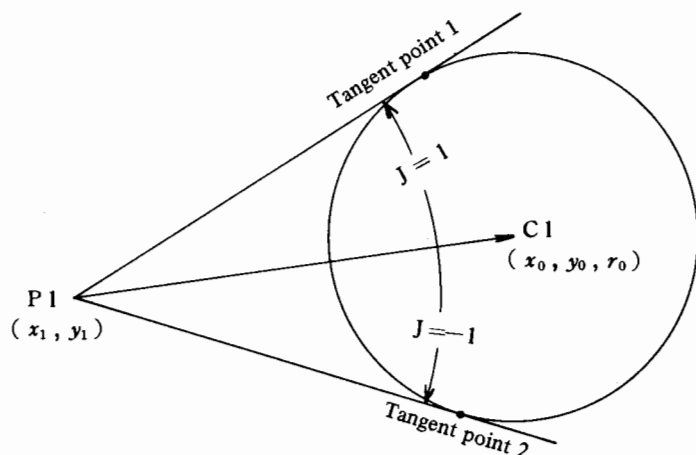
	Input	Display	Note		Input	Display	Note
1	SHIFT A	P1 X=		11			
2	0 ENTER	P1 Y=		12			
3	0 ENTER	ANGLE 1 =		13			
4	45 ENTER	P2 X=		14			
5	10 ENTER	P2 Y=		15			
6	0 ENTER	ANGLE 2 =		16			
7	-45 ENTER			17			
8		PO 5.00 5.00		18			
9				19			
10				20			

Title A TANGENT LINE FROM ONE POINT $P = P / C$

PROGRAM NO.
P 4 - G - 4

[Formula]

This program finds a tangent point from a given point $P1$ and a given circle $C1$.

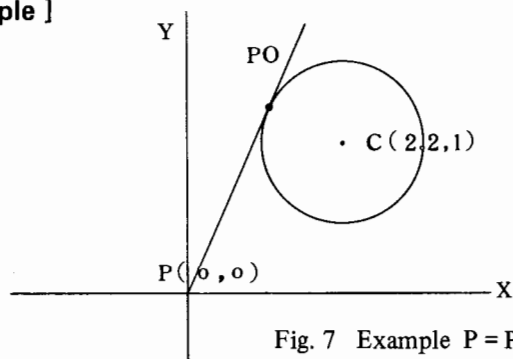


Condition of discrimination:

For discrimination, input 1 if the tangent point is located on the left of the line that passes point $P1$ and the center of circle; otherwise input -1 .

Fig. 6 Tangent Line from a Point

[Example]



C : central coordinates (2, 2) radius 1
P : point (0, 0)

Fig. 7 Example $P = P / C$

[Operation]

C LOAD ∇ G4 ∇ **ENTER**

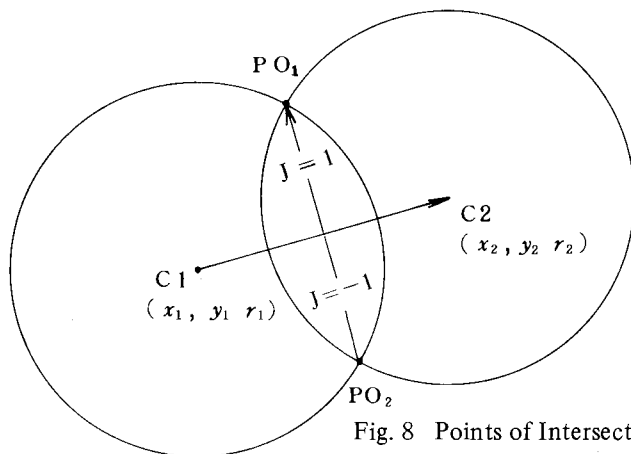
	Input	Display	Note		Input	Display	Note
1	SHIFT A	P1 X=		11			
2	0 ENTER	P1 Y=		12			
3	0 ENTER	C1 X=		13			
4	2 ENTER	C1 Y=		14			
5	2 ENTER	C1 R=		15			
6	1 ENTER	J . L (1) R (- 1) =		16			
7	1 ENTER			17			
8		PO 1.09 2.41		18			
9				19			
10				20			

—223—

Title	POINTS OF INTERSECTION OF TWO CIRCLES P = C/C	PROGRAM NO. P4 -G- 5
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[Formula]

This program finds points PO_1 and PO_2 of intersection of two given circles.

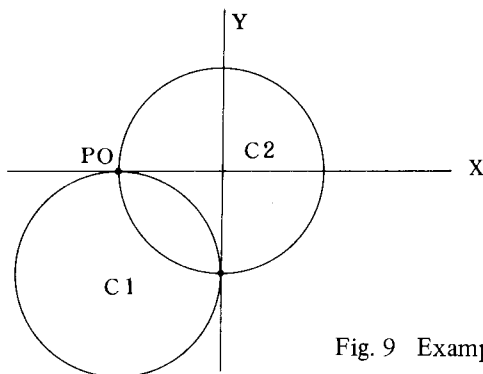


Condition of discrimination:

To find the left-hand point of intersection that is located at the left of the line passing the centers of two given circles C1 — input first — and C2 — input second — input 1; to find the right-hand point, input -1.

Fig. 8 Points of Intersection of Two Circless

[Example]



C_1 : center $(-50, -50)$, radius 50

C_2 : center $(0, 0)$, radius 50

Fig. 9 Example (P = P/C)

[Operation]

C LOAD ∇ G5 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	C1 X=		11			
2	-50 ENTER	C1 Y=		12			
3	-50 ENTER	C1 R=		13			
4	50 ENTER	C2 X=		14			
5	0 ENTER	C2 Y=		15			
6	0 ENTER	C2 R=		16			
7	50 ENTER	J.L(1) R(-1)=		17			
8	1 ENTER			18			
9		PO -50.00 0.00		19			
10				20			

Title A CIRCLE TANGENT TO TWO LINES C = L/L

PROGRAM NO.
P 4 - G - 6

[Formula]

This program finds the central coordinates of a circle tangent to given two lines $L_1 (x_1, y_1, \theta_1)$ and $L_2 (x_2, y_2, \theta_2)$ with the condition of discrimination J_1 and J_2 and radius R known.

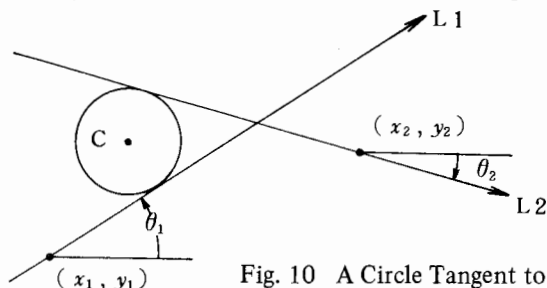


Fig. 10 A Circle Tangent to Two Lines

Condition of discrimination

J_1 : 1 when a circle is created on the left of line L_1 that is input first.

-1 when a circle is created on the right of line L_1 .

J_2 : 1 when a circle is created on the left of line L_2 that is input second.

-1 when a circle is created on the right of line L_2 .

[Example]

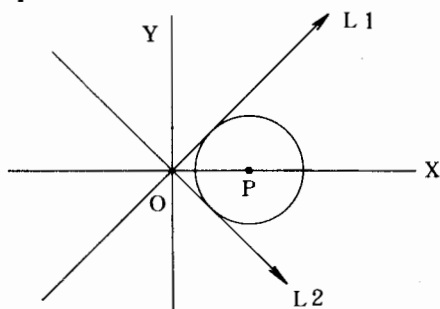


Fig. 11 Example (C = L/L)

L_1 : line that passes origin (0, 0) and crosses the x-axis at 45 degrees.

L_2 : line that passes origin (0, 0) and crosses the x-axis at -45 degrees.

$R = 20$

J_1 : -1 because the circle is on the right of L_1 .

J_2 : 1 because the circle is on the left of L_2 .

[Operation]

C LOAD ∇ G6 ∇ ENTER

Input	Display	Note	Input	Display	Note
1 [SHIFT] [A]	L1 X=		11	P0 28.28 0.00	
2 0 [ENTER]	L1 Y=		12 [ENTER]	P1 14.14 14.14	
3 0 [ENTER]	L1 A=		13 [ENTER]	P2 14.14 -14.14	
4 45 [ENTER]	L2 X=		14		
5 0 [ENTER]	L2 Y=		15		
6 0 [ENTER]	L2 A=		16		
7 -45 [ENTER]	R =		17		
8 20 [ENTER]	J.L1 L(1),R(-1)=		18		
9 -1 [ENTER]	J.L2 L(1),R(-1)=		19		
10 1 [ENTER]			20		

SHARP

Title

INTERSECTION OF A CIRCLE AND A LINE
P = L/C

PROGRAM NO.
P 4 - G - 7

[Formula]

This program finds points of intersection of line $L(x_1, y_1, \theta)$ and circle $C(x_0, y_0, r_0)$ with the condition of discrimination given.

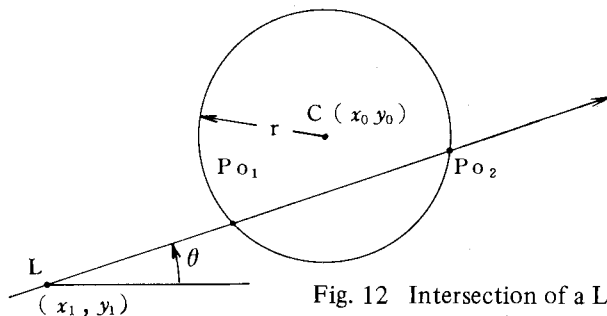


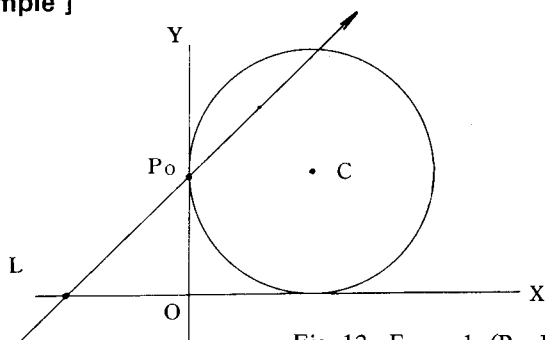
Fig. 12 Intersection of a Line and a Circle

Condition of discrimination:

A line and a circle intersect each other at two points unless they are tangent to each other. To discover the point of intersection nearer to the start point of the line, input -1; to discover another point, input 1.

In the above example, P_{01} is fixed when -1 is input and P_{02} when 1 is input.

[Example]



L: line that passes point $(-50, 0)$ and crosses the X-axis at 45 degrees.

C: center $(50, 50)$, radius 50.

Fig. 13 Example (P = L/C)

[Operation]

C LOAD ∇ G7 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	L1 X=		11			
2	-50 [ENTER]	L1 Y=		12			
3	0 [ENTER]	L1 A=		13			
4	45 [ENTER]	C1 X=		14			
5	50 [ENTER]	C1 Y=		15			
6	50 [ENTER]	C1 R=		16			
7	50 [ENTER]	NEARER (-1), FARTHER (1) =		17			
8	- 1 [ENTER]			18			
9		PO 0.00 50.00		19			
10				20			

Title A LINE TANGENT TO TWO CIRCLES

PROGRAM NO.
P 4 - G - 8

[Formula]

This program discovers two tangent points on a line tangent to two given circles $C_1(x_1, y_1, r_1)$ and $C_2(x_2, y_2, r_2)$ with the conditions of discrimination J_1 and J_2 given.

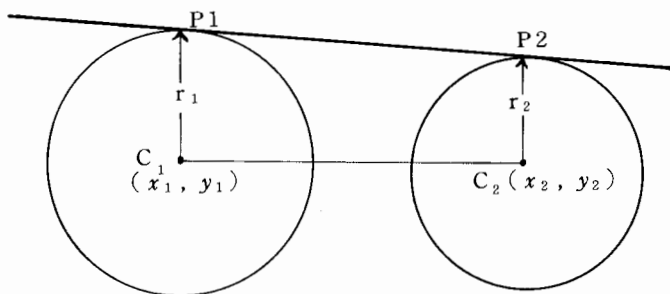


Fig. 14 A Line Tangent to Two Circles

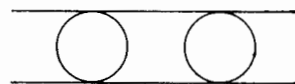


Fig. 15 Lines Tangent to Two Circles at the Same Side

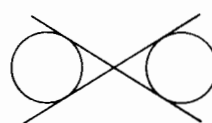
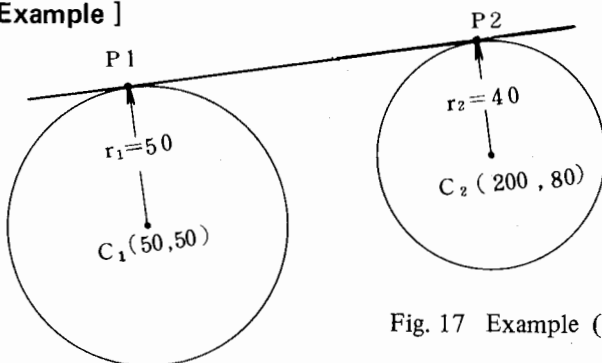


Fig. 16 Lines Tangent to Two Circles at the Sides Opposite to Each Other

Condition of discrimination

- J_1 : 1 when a line to be found out is tangent to circles C_1 and C_2 on the same side.
-1 when that line is tangent to those circles on the sides opposite to each other.
- J_2 : 1 when the tangent point of circle C_2 which is on the left side of the line connecting the centers of circles C_1 and C_2 is found.
-1 when the tangent point on the right side is found.

[Example]



C_1 : center (50, 50), radius 50
 C_2 : center (200, 80), radius 40
 J_1 : 1 because the line is tangent to C_1 and C_2 on the same side.
 J_2 : 1 because the tangent point is on the left side.

Fig. 17 Example ($L = C/C$)

[Operation] CLOAD ∇ G8 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT [A]	C1 X=		11			
2	50 ENTER	C1 Y=		12			
3	50 ENTER	C1 R=		13			
4	50 ENTER	C2 X=		14			
5	200 ENTER	C2 Y=		15			
6	80 ENTER	C2 R=		16			
7	40 ENTER	J. OUT(1), IN(-1)=		17			
8	1 ENTER	J. L(1), R(-1)=		18			
9	1 ENTER	P1 43.42 99.57		19			
10	ENTER	P2 194.74 119.65		20			

SHARP

Title

A CIRCLE TANGENT TO BOTH A CIRCLE AND
A LINE $C = L/C$

PROGRAM NO.
P4-G-9

[Formula]

This program finds the central coordinates of a circle tangent to both line $L_1(x_1, y_1, \theta_1)$ and circle $C_1(x_0, y_0, r_0)$ — both are given — with its radius R and the conditions of discrimination J_1 and J_2 input.

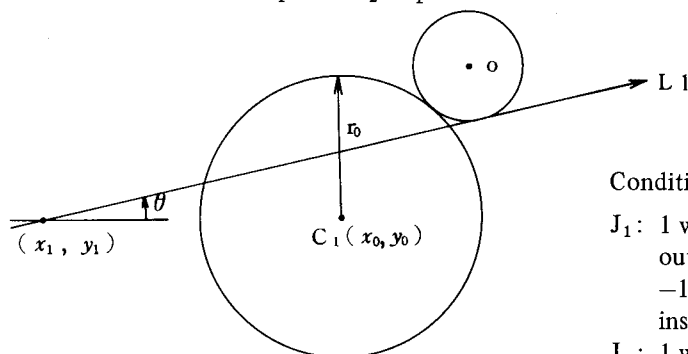


Fig. 18 A Circle Tangent to Line L_1 and Circle C_1

[Example]

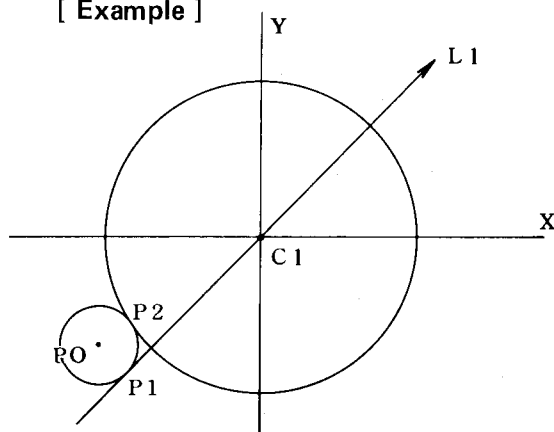


Fig. 19 Example ($C = L/C$)

Conditions of discrimination

- J_1 : 1 when a circle is tangent to circle C_1 at the outside is found.
-1 when a circle is tangent to circle C_1 at the inside is found.
- J_2 : 1 when a circle to be found is on the left side of line L_1 .
-1 when the circle stays on the right side.
- J_3 : -1 when the circle is on the nearer side.
1 when a circle to be found is on the farther side of circle C_1 in terms of the direction of line L_1 .

L_1 : line that passes original (0, 0), and crosses the X-axis at 45 degrees.

C_1 : center (0, 0), radius 40

R : 20

J_1 : 1 because the circle PO to be found is outside C_1 .

J_2 : 1 because PO is on the left side of L_1 .

J_3 : -1 because PO is on the nearer side.

[Operation]

CLOAD ∇ G9 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	L1 X=		11	-1 ENTER		
2	0 ENTER	L1 Y=		12		PO -54.14 -25.86	
3	0 ENTER	L1 A=		13	ENTER	P1 -40.00 -40.00	
4	45 ENTER	C1 X=		14	ENTER	P2 -36.09 -17.24	
5	0 ENTER	C1 Y=		15			
6	0 ENTER	C1 R=		16			
7	40 ENTER	R =		17			
8	20 ENTER	J.C OUT(1), IN(-1)=		18			
9	1 ENTER	J.L1 L(1), R(-1)=		19			
10	1 ENTER	FARTHER(1), NEARER(-1)=		20			

Title A CIRCLE TANGENT TO TWO CIRCLES C = C/C

PROGRAM NO.
P 4 - G - 10

[Formula]

This program finds the center O of a circle tangent to two given circles $C_1(x_1, y_1, r_1)$ and $C_2(x_2, y_2, r_2)$ and their tangent points P_1 and P_2 with the radius R of that circle and the conditions of discrimination J_1, J_2 and J_3 entered.

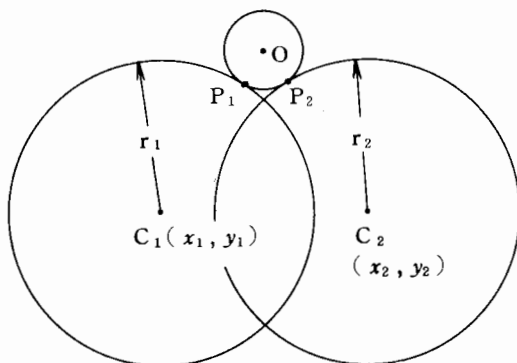


Fig. 20 A Circle Tangent to Two Circles

Conditions of discrimination

- J_1 : 1 when a circle to be found is tangent to C_1 at the outside.
-1 when that circle is tangent to C_1 at the inside.
- J_2 : 1 when a circle to be found is tangent to C_2 at the outside.
-1 when that circle is tangent to C_2 at the inside.
- J_3 : 1 when a circle is created on the left side of circle C_2 looking from circle C_1 .
-1 when a circle is created on the right side.

[Example]

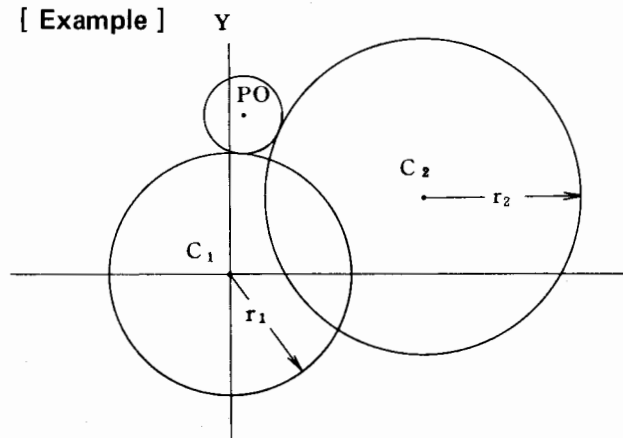


Fig. 21 Example (C = C/C)

C_1 : (0, 0, 30)

C_2 : (50, 20, 40)

$r = 10$

- J_1 : 1 because the circle to be found — namely PO — is tangent to C_1 at the outside.
- J_2 : -1 because PO is tangent to C_2 at the outside.
- J_3 : 1 because PO is on the left side of C_2 .

[Operation]

CLOAD ∇ G10 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	C1 X=		11	1 ENTER		
2	0 ENTER	C1 Y=		12		PO 4.08 39.79	
3	0 ENTER	C1 R=		13	ENTER	P1 3.06 29.84	
4	30 ENTER	C2 X=		14	ENTER	P2 13.27 35.83	
5	50 ENTER	C2 Y=		15			
6	20 ENTER	C2 R=		16			
7	40 ENTER	R =		17			
8	10 ENTER	J.C1.OUT(1), IN(-1)=		18			
9	1 ENTER	J.C2.OUT(1), IN(-1)=		19			
10	1 ENTER	J.L(1), R(-1)=		20			

Title A CIRCLE TANGENT TO TWO CIRCLES C = C/C			PROGRAM NO. P 4 - G - 10
Memory content			
A	1	x_1	
B	2	y_1	
C	3	✓	10: "A":DEGREE :INPUT "C1 X=";A
D	4	x_2	20: INPUT "C1 Y=";B
E	5	y_2	30: INPUT "C1 R=";0
F	6	✓	40: INPUT "C2 X=";D
G	7	Judge 3	50: INPUT "C2 Y=";E
H	8	P_1x	60: INPUT "C2 R=";P
I	9	P_1y	70: INPUT "R=";S
J	10	P_2x	80: INPUT "J.C1. OUT(1),IN(-1)=";Q
K	11	P_2y	90: INPUT "J.C2. OUT(1),IN(-1)=";R
L	12	✓	100: INPUT "J. L(1),R(-1)=";G
M	13	P_{ox}	110: F=P+R*S:C=0+Q*S
N	14	P_{oy}	120: H=D-A
O	15	r_1	130: I=E-B
P	16	r_2	140: J=√(H*H+I*I)
Q	17	Judge 1	150: K=ACS (H/J)
R	18	Judge 2	160: IF 0>I LET K=-K
S	19	Radius	170: L=ACS ((C*C+J*J-F*F)/2/C/J)
T	20		180: M=A+C*COS (K+G*L)
U	21		190: N=B+C*SIN (K+G*L)
V	22		200: X=Q*(A-M)
W	23	✓	210: Y=Q*(B-N)
X	24	✓	220: GOSUB 500
Y	25	✓	230: IF ((Q=-1)*(S>0))=1 LET W=W+180
Z	26		240: H=M+S*COS W
			250: I=N+S*SIN W:X=R*(D-M)
			260: Y=R*(E-N)
			270: GOSUB 500
			280: IF ((R=-1)*(S>P))=1 LET W=W+180
			290: J=M+S*COS W:K=N+S*SIN W
			300: M=M+SGN M*.005:N=N+SGN N*.005
			310: H=H+SGN H*.005:I=I+SGN I*.005
			320: J=J+SGN J*.005:K=K+SGN K*.005
			330: PRINT "P0";USING "#####.###";M;N
			340: PRINT "P1";USING "#####.###";H;I
			350: PRINT "P2";USING "#####.###";J;K
			500: Z=√(X*X+Y*Y)
			510: W=ACS (X/Z)
			520: IF 0>Y LET W=-W
			530: RETURN
			540: END
			668

SHARP

Title A CIRCLE PASSING A POINT AND TANGENT TO
A LINE C = L/P/R

PROGRAM NO.
P4 - G - 11

[Formula]

This program finds the central coordinates of a circle passing given point $P_1(x, y)$ and tangent to given line $L_1(x_1, y_1, \theta_1)$ and the coordinates of a point of their intersection with radius R and the conditions of discrimination J_1 and J_2 given.

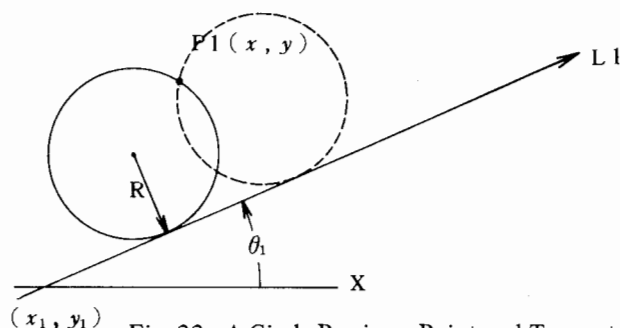


Fig. 22 A Circle Passing a Point and Tangent to a Line

Condition of discrimination

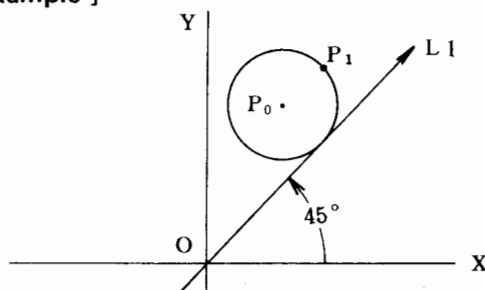
J_1 : 1 when point P_1 is on the left side of line L_1 .

-1 when P_1 is on the right side of L_1 .

J_2 : 1 when line L_1 is on the farther side of a circle to be created.

-1 when line L_1 is on the nearer side.

[Example]



L_1 : line that passes origin (0, 0) and crosses the X-axis at 45 degrees.

P_1 : (30, 50), radius 15

J_1 : 1 because P_1 is on the left side.

J_2 : -1 because L_1 is on the nearer side.

Fig. 23 Example C = L/P/R

[Operation]

CLOAD ∇ G11 ∇ ENTER

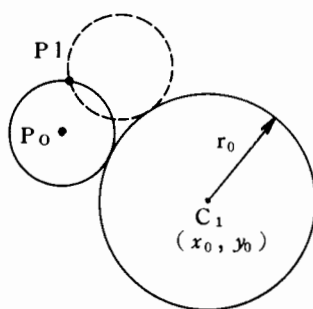
	Input	Display	Note		Input	Display	Note
1	SHIFT A	L1 X=		11	ENTER	P1 29.41 29.41	Tangent point
2	0 ENTER	L1 Y=		12			
3	0 ENTER	L1 A=		13			
4	45 ENTER	P1 X=		14			
5	30 ENTER	P1 Y=		15			
6	50 ENTER	R =		16			
7	15 ENTER	J.P.L(1),R(-1)=		17			
8	1 ENTER	FARTHER(1), NEARER(-1) =		18			
9	-1 ENTER			19			
10		PO 18.80 40.02		20			

Title A CIRCLE PASSING A POINT AND TANGENT TO A CIRCLE C = P/C/R

PROGRAM NO.
P 4 - G - 1 2

[Formula]

This program finds the central coordinates of a circle that passes given point $P_1 (x_1, y_1)$ and is tangent to given circle $C_1 (x_0, y_0, r_0)$ and the coordinates of a point where those two circles are tangent with radius R and the condition of discrimination given.



Condition of discrimination

J_1 : 1 when a circle to be found is tangent to circle C_1 at the outside.

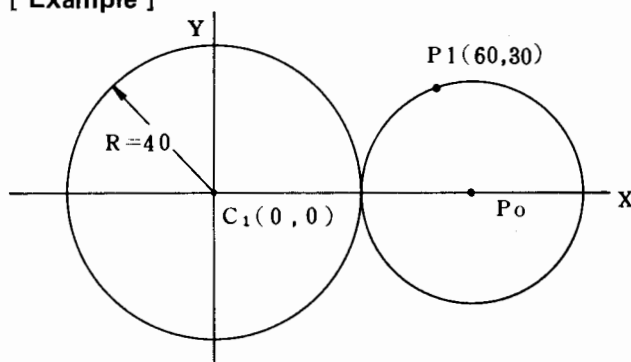
-1 when that circle is tangent to C_1 at the inside.

J_2 : 1 when a circle to be found is created on the left side looking from point P_1 .

-1 when that circle is created on the right side.

Fig. 24 A Circle Passing a Point and Tangent to a Circle

[Example]



P_1 : (60, 30)

C_1 : center (0, 0), radius 40

R : 30

J_1 : 1 because the circle to be found is tangent to C_1 at the outside.

J_2 : 1 because the circle to be found is on the left side looking from P_1 .

Fig. 25 Example (C = P/C/R)

[Operation]

CLOAD ∇ G12 ∇ [ENTER]

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	P1 X=		11	[ENTER]	P1 39.99 0.98	Tangent point
2	60 [ENTER]	P1 Y=		12			
3	30 [ENTER]	C1 X=		13			
4	0 [ENTER]	C1 Y=		14			
5	0 [ENTER]	C1 R=		15			
6	40 [ENTER]	R =		16			
7	30 [ENTER]	J.OUT(1), IN(-1)=		17			
8	1 [ENTER]	J.L(1), R(-1)=		18			
9	1 [ENTER]			19			
10		PO 69.98 1.71		20			

Title A CIRCLE PASSING A POINT AND TANGENT TO A CIRCLE C = P/C/R			PROGRAM NO. P 4 - G - 1 2
Memory content			
A	1	x_1	
B	2	y_1	
C	3	x_0	10: "A":DEGREE :INPUT "P1 X=";A
D	4	y_0	20: INPUT "P1 Y=";B
E	5	r_0	30: INPUT "C1 X=";D
F	6	✓	40: INPUT "C1 Y=";E
G	7	Judge 2	50: INPUT "C1 R=";N
H	8	✓	60: INPUT "R=";C
I	9	✓	70: INPUT "J.OUT(1),IN(-1)=";P
J	10	✓	80: INPUT "J.L(1),R(-1)=";G
K	11	✓	90: F=N+P*C
L	12	✓	100: H=D-A:I=E-B
M	13		110: J=√(H*H+I*I)
N	14		120: K=ACS (H/J)
O	15		130: IF O>I LET K=-K
P	16	Judge 1	140: L=ACS ((C*C+J*J-F*F)/2/C/J)
Q	17		150: S=A+C*COS (K+G*L)
R	18		160: T=B+C*SIN (K+G*L)
S	19	P o x	170: X=P*(D-S):Y=P*(E-T)
T	20	P o y	180: Z=√(X*X+Y*Y)
U	21	✓	190: U=ACS (X/Z)
V	22	$P_1 x$	200: IF O>Y LET U=-U
W	23	$P_1 y$	210: IF ((P=-1)*(C>N))=1 LET C=-C
X	24	✓	220: V=S+C*COS U
Y	25	✓	230: W=T+C*SIN U:S=S+SGN S*.005:T=T+SGN T*.0
Z	26	✓	05
			240: V=V+SGN V*.005:W=W+SGN W*.005
			250: PRINT "P0";USING "#####.##";S;T
			260: PRINT "P1";USING "#####.##";V;W
			270: END
			464

Title A CIRCLE PASSING TWO POINTS C = P/P	PROGRAM NO. P 4 - G - 1 3
---	--

[Formula]

This program finds a circle that passes two points $P_1(x_1, y_1)$ and $P_2(x_2, y_2)$ — both are given — with radius R and the condition of discrimination entered.

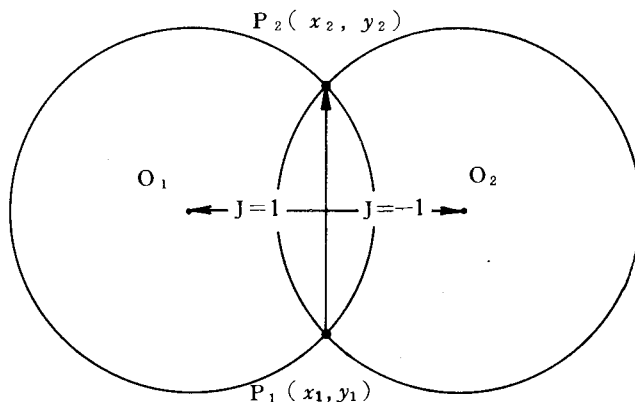


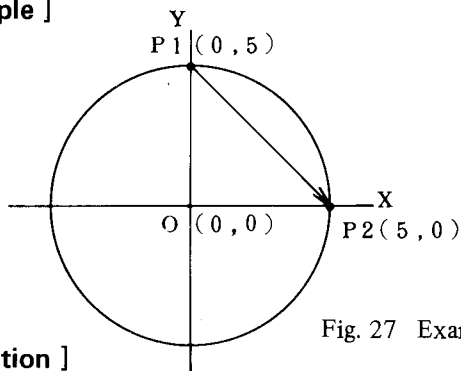
Fig. 26 A Circle Passing Two Points

Condition of discrimination

1 when the center of a circle to be created is located on the left side of a line that passes two points P_1 and P_2 .

-1 when the center is located on the right side.

[Example]



$P_1(0, 5)$ radius 5

$P_2(5, 0)$

Input for discrimination -1

Fig. 27 Example (C = P/P)

[Operation]

CLOAD ∇ G13 ∇ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	P1 X=		11			
2	0 ENTER	P1 Y=		12			
3	5 ENTER	P2 X=		13			
4	5 ENTER	P2 Y=		14			
5	0 ENTER	R =		15			
6	5 ENTER	J.L(1),R(-1)=		16			
7	-1 ENTER			17			
8		PO 0.00 0.00		18			
9				19			
10				20			

Title A CIRCLE PASSING THREE POINTS C = P/P/P

PROGRAM NO.
P 4 - G - 1 4

[Formula]

This program finds the central coordinates and radius of a circle that passes three points $P_1 (x_1, y_1)$, $P_2 (x_2, y_2)$ and $P_3 (x_3, y_3)$ — all these are given.

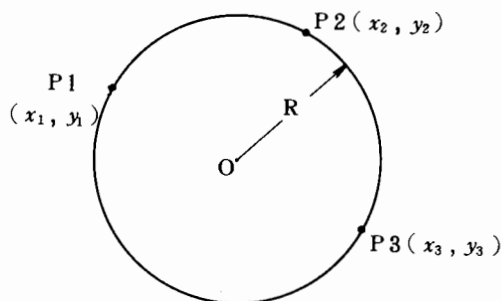


Fig. 28 A Circle Passing Three Points

[Example]

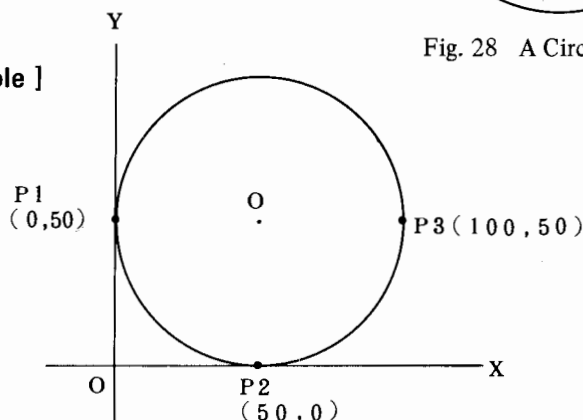


Fig. 29 Example (C = P/P/P)

[Operation]

CLOAD ∇ G14 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	P1 X=		11			
2	0 ENTER	P1 Y=		12			
3	50 ENTER	P2 X=		13			
4	50 ENTER	P2 Y=		14			
5	0 ENTER	P3 X=		15			
6	100 ENTER	P3 Y=		16			
7	50 ENTER			17			
8		PO 50.00 50.00		18			
9	ENTER	R 50.00		19			
10				20			

[illegible]

SHARP

Title	DAYS BETWEEN DATES	PROGRAM NO. P4-H-1
-------	--------------------	-----------------------

[Formula]

This program figures out the number of days between two dates by presetting reference date.
The case of a leap year is of course taken into account.
The number of days includes one-side date.

[Example]

From 10/5/1976 to 2/20/1977: 138 days

From 10/5/1976 to 11/15/1977: 406 days

[Operation]

C LOAD ▽H1 ▽

Reference year

Reference month

Reference day

Appointed year

Appointed month

Appointed day

Number of days displayed

NOTE) In the case of presetting reference date anew, start the operation from .

	Input	Display	Note		Input	Display	Note
1	SHIFT A	START YEAR=		11			
2	1976 ENTER	MONTH=		12			
3	10 ENTER	DAY=		13			
4	5 ENTER	END YEAR=		14			
5	1977 ENTER	MONTH=		15			
6	2 ENTER	DAY=		16			
7	20 ENTER			17			
8		DAYS 138		18			
9				19			
10				20			

Title	DAYS BETWEEN DATES
A	1
B	2
C	3
D	4
E	5
F	6
G	7 Month for SUB.
H	8 Year for SUB.
I	9 Day for SUB.
J	10 No. of days 1
K	11
L	12
M	13
N	14
O	15
P	16
Q	17
R	18 Start year
S	19 Start month
T	20 Start day
U	21 End year
V	22 End month
W	23 End day
X	24 No. of days wanted
Y	25
Z	26 ✓

PROGRAM NO.
P4 -H-1

```

10: "A":Y=0
20: INPUT "START YEAR=";R,"MONTH=";S,"DAY=";T
30: INPUT "END YEAR=";U,"MONTH=";V,"DAY=";W
40: IF Y=1LET H=R+1925:GOTO 60
50: H=R
60: G=S:I=T
70: GOSUB 500
80: J=I
90: IF Y=1LET H=U+1925:GOTO 110
100: H=U
110: G=V:I=W
120: GOSUB 500
130: X=I-J
140: PRINT "DAYS",X
150: GOTO 30
500: IF G-3>=0LET Z=-((G-3)*30.6-.5):GOSUB 600
    :I=I-Z:GOTO 530
510: H=H-1
520: Z=(-(G-3)-12)*30.6-.5:GOSUB 600:I=I-Z
530: Z=H*365.25:GOSUB 600:I=I+Z
540: Z=H/100:GOSUB 600:I=I-Z
550: Z=H/400:GOSUB 600:I=I+Z
560: I=I-307:RETURN
600: X=INT ABS Z:Z=SGN Z*X:RETURN
385

```

Title	CALCULATION OF PAST AND FUTURE DATES	PROGRAM NO. P 4 - H - 2
-------	--------------------------------------	----------------------------

[Formula]

This program figures out date "n" days after (or previous to) reference date. The number of days includes one-side date.

[Example]

Date 100 days after 3/10/1977: 6/18/1977

[Operation]

C LOAD ▽H2 ▽

Inputting order

Key operation

- | | | | |
|-----------------------------------|------|---|------------------------|
| 1) | | <input type="button" value="SHIFT"/> <input type="button" value="A"/> | |
| 2) Reference year: | 1977 | <input type="button" value="ENTER"/> | |
| 3) Reference month: | 3 | <input type="button" value="ENTER"/> | |
| 4) Reference day: | 10 | <input type="button" value="ENTER"/> | |
| 5) No. of days from desired date: | 100 | <input type="button" value="ENTER"/> | Desired date displayed |
| | | <input type="button" value="ENTER"/> | |

Repeat the same operation as shown above.

NOTES) 1) This program is able to calculate between 1950 and 2000.

2) To find date "n" days previous to reference date, operate the keys as -n .

	Input	Display	Note		Input	Display	Note
1	SHIFT A	START YEAR=		11			
2	1977 ENTER	MONTH=		12			
3	3 ENTER	DAY=		13			
4	10 ENTER	DAYS=		14			
5	100 ENTER			15			
6		1977. 6. 18	Calculation time: about 1 minute 40 seconds.	16			
7				17			
8				18			
9				19			
10				20			

Title CALCULATION OF INTEREST RATE ON LOAN

PROGRAM NO.
P 4 - H - 3

[Formula]

$$\text{Interest} = \text{Principal} \times \frac{\text{No. of days}}{36500} \times \text{Rate of interest}$$

(Unit of interest: 1 dollar.
Decimal fractions be reckoned as a unit.)

[Example]

Principal (dollar)	No. of days	Interest (dollar)	Amount with interest added (dollar)
58,000	60	811	58,811
45,000	45	472	45,472
Total 103,000		1,283	104,283

[Operation]

C LOAD ▽H3 ▽ ENTER

1) SHIFT A

Rate of interest ENTER

Principal ENTER

No. of days ENTER

Interest

ENTER

Amount with interest included (TOTAL)

2) To calculate total:

SHIFT B

Amount with interest included

ENTER

Total of interests

ENTER

Total amount with interests included (T.P.I)

	Input	Display	Note		Input	Display	Note
1	SHIFT A	RATE (%) =		11		RATE 472	
2	8.5 ENTER	PRINCIPAL =		12	ENTER	TOTAL 45472	
3	58000 ENTER	DAYS =		13	SHIFT B	T. PRINCIPAL 103000	
4	60 ENTER			14	ENTER	T. INTEREST 1283	
5		INTEREST 811		15	ENTER	T.P.I. 104283	
6	ENTER	TOTAL 58811		16			
7	ENTER	RATE (%) =		17			
8	8.5 ENTER	PRINCIPAL =		18			
9	45000 ENTER	DAYS =		19			
10	45 ENTER			20			

Title CALCULATION OF INTEREST ON DEPOSITES

PROGRAM NO.
P 4 - H-5

[Formula]

Is the same as that of H3, but the rate should be preset in this calculation

$$\text{Interest} = \text{Principal} \times \frac{\text{No. of days}}{36500} \times \text{Rate of interest}$$

$$\Sigma \text{ Amount interest added} = \Sigma \text{ Principal} \rightarrow \Sigma \text{ Interest}$$

[Example]

(Unit of interest: 100 dollar; any fractional sum of less than 1 dollar discarded)

Rate of interest: 7(%)

Principal (dollar)	No. of days	Interest (dollar)	Amount with interest added (dollar)
500	60	5	505
450	125	9	459
7890	175	261	8151
Total	8840	275	9115

[Operation]

C LOAD ▽H5 ▽ **ENTER**

1) Rate presetting

SHFT **C**

Rate **ENTER**

2) Calculation of interest

SHFT **A**

Principal **ENTER**

No. of days **ENTER** Interest

ENTER Amount with interest included (TOTAL)

ENTER

3) Total **SHFT** **B**

Amount with interest included

ENTER Total interest

ENTER Total amount with interest included (T.P.I.)

(NOTE) Repeat key operation in such an order as "**SHFT** **B** **ENTER** **ENTER** **ENTER**" in the first place, and check that the total memory is cleared. ("CL.OK" will be displayed if cleared.)

	Input	Display	Note		Input	Display	Note
1	SHFT C	RATE (%) =		11	SHFT B	T. PRINCIPAL 8840	
2	7 ENTER			12	ENTER	T. INTEREST 275	
3	SHFT A	PRINCIPAL =		13	ENTER	T.P.I 9115	
4	500 ENTER	DAYS =		14	ENTER	CL . OK	
5	60 ENTER	INTEREST 5		15			
6	ENTER	TOTAL 505		16			
7	ENTER			17			
8				18			
9				19			
10				20			

Title	CALCULATION OF INTEREST ON DEPOSITES
A	Principal
B	No. of days
C	Rate
D	T. Interest
E	T. Principal
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	
Q	
R	
S	
T	
U	
V	
W	
X	Interest
Y	Total
Z	

```

10: "C":INPUT "RATE(%)=";C
20: END
30: "B"
40: PRINT "T.PRINCIPAL",E
50: PRINT "T.INTEREST",D
60: PRINT "T.P.I",E+D
70: E=O:D=O:PRINT "CL.OK":END
80: "A":USING :INPUT "PRINCIPAL=";A
90: INPUT "DAYS=";B
100: X=INT (INT (A/100)*B*C/36500*100)
110: E=E+A
120: D=D+X
130: PRINT "INTEREST",X
140: PRINT "TOTAL",A+X
150: GOTO 80
160: END
    
```

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SHARP

Title	CALCULATION OF PRESENT VALUE OF COMPOUND-INTEREST ANNUITY	PROGRAM NO. P 4 - H - 7
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[Formula]

General formula: Present value of term-end payment annuity $P = R \times \frac{1 - (1+i)^{-n}}{i}$

Present value of annuity due $P' = R \times \frac{1 - (1+i)^{-n}}{i} \times (1+i)$

Payment at the end of every term $R = P \times \frac{i}{1 - (1+i)^{-n}}$

n : term (number of settlement term) i : rate of interest
 R : payment (present value)

[Example]

- 1) Find the present value of annuity which will be paid 700 dollar at the end of every half year term for 8 years, provided that the rate of compound interest is 5%.
- 2) Find the present value of annuity which will be paid 700 dollar at the top of every half year term for 8 years, provided that the rate of compound interest is 50%.
- 3) Suppose that a sum of 30000 is loaned at the rate of compound interest of 8% (a half-yearly settlement), and that it should be repaid with installments of the same sum at half-yearly compound interest for 5 years: How much is the installment paid at the end of every term? (Unit of interest: 1 dollar; less than one dollar rounded)

[Operation]

C LOAD ∇ H7 ∇ **ENTER**

- 1) Present value of term-end payment annuity (Ex. 1)

(Annuity) Amount paid at the end of term **SHFT** **A** **ENTER**
 Rate (%) **ENTER**
 Term **ENTER**
 Number of settlement term **ENTER**

Present value of
term-end pay-
ment annuity

- 2) Present value of annuity due (Ex. 2)

(Annuity) Amount paid at the top of term **SHFT** **B** **ENTER**
 Rate (%) **ENTER**
 Term **ENTER**
 Number of settlement term **ENTER**

- 3) Payment at the end of every term (Ex. 3)

(Loan) Present value of
payment at the
end of term **SHFT** **C** **ENTER**
 Rate **ENTER**
 Term **ENTER**
 Number of settle-
ment term **ENTER**

Amount paid
at the end of
every term

Present value of
annuity due

Input	Display	Note	Input	Display	Note
1 SHFT A	AMOUNT PAID =	(Ex. 1)	11 SHFT C	AMOUNT PAID =	(Ex. 3)
2 700 ENTER	RATE (%) =		12 30000 ENTER	RATE (%) =	
3 5 ENTER	TERM =		13 8 ENTER	TERM =	
4 8 ENTER	NUMBER =		14 5 ENTER	NUMBER =	
5 2 ENTER	P 9139		15 2 ENTER	R 3699	
6 SHFT B	AMOUNT PAID =	(Ex. 2)	16		
7 700 ENTER	RATE (%) =		17		
8 5 ENTER	TERM =		18		
9 8 ENTER	NUMBER =		19		
10 2 ENTER	P, 9367		20		

SHARP

Title	CALCULATION OF FUTURE & PRESENT VALUE (by compound interest)	PROGRAM NO. P 4- H-8
-------	---	-------------------------

[Formula]

Compound interest future value = Compound interest present value $\times (1 + i)^n$

Compound interest present value = Compound interest future value $\times (1 + i)^{-n}$

i : rate of interest

n : term

[Example]

- 1) Find the compound interest future value when you deposit a sum of 1500 dollar at the yearly rate of interest of 6% for 3 years.
- 2) Find the compound interest future value under the same conditions as Example 1) but compounded twice a year.
- 3) Find the principal necessary to deposit in order to obtain the future value of 5000 dollar, provided the yearly rate of interest be 6.5%.

(Unit of interest: 1 dollar;
less than 1 dollar rounded)

[Operation]

C LOAD ∇ H8 ∇ **ENTER**

- 1) Compound interest future value (Examples 1 & 2)

SHFT **A**

Principal **ENTER**

Rate of interest **ENTER**

Term **ENTER**

Number of settlement term **ENTER** Compound interest future value

- 2) Compound interest present value (Example 3)

SHFT **B**

Compound interest future value **ENTER**

Rate of interest **ENTER**

Term **ENTER**

Number of settlement term **ENTER** Compound interest present value (Principal)

	Input	Display	Note		Input	Display	Note
1	SHFT A	PRINCIPAL =	(Ex. 1)	11	SHFT B	PRINCIPAL =	(Ex. 3)
2	1500 ENTER	RATE (%) =		12	5000 ENTER	RATE (%) =	
3	6 ENTER	TERM =		13	6.5 ENTER	TERM =	
4	3 ENTER	NUMBER =		14	2 ENTER	NUMBER =	
5	1 ENTER	FUTURE VALUE 1787		15	1 ENTER	PRESENT VALUE 4408	
6	SHFT A	PRINCIPAL =	(Ex. 2)	16			
7	1500 ENTER	RATE (%) =		17			
8	6 ENTER	TERM =		18			
9	3 ENTER	NUMBER =		19			
10	2 ENTER	FUTURE VALUE 1791		20			

Title INSTALLMENT CALCULATION	PROGRAM NO. P 4- H-9
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[Formula]

General formula:
$$S = (P - R) \times \frac{i}{1 - (1 + i)^{-n}}$$

S: installment

P: price

R: deposit

n: number of times of installments

i: interest

[Example]

Suppose you pay 500 dollar down on a 3,000 dollar stereo set and pay the rest by 11 months' installments at the monthly rate of interest of 1%. So find the monthly payment.

(Unit of interest: 1 dollar;
less than 1 dollar rounded)

[Operation]

C LOAD ▽H9 ▽ **ENTER**

SHIFT

A

Price

ENTER

Deposit

ENTER

Monthly rate

ENTER

No. of times of installments

ENTER

Monthly payment

ENTER

Last payment

	Input	Display	Note		Input	Display	Note
1	SHIFT A	PRICE=		11			
2	3000 ENTER	DEPOSITE=		12			
3	500 ENTER	RATE(%) =		13			
4	1 ENTER	TERM=		14			
5	11 ENTER	M. PAYMENT 242		15			
6	ENTER	LAST PAYMENT 233		16			
7				17			
8				18			
9				19			
10				20			

SHARP

Title	CALCULATION OF DEPRECIATION	PROGRAM NO. P 4 - H - 10
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[Formula]

Depreciation amount = acquisition cost x rate of depreciation

Amount left at the term end = acquisition cost - depreciation amount

[Example] (Fixed rate method)

Note: Less than one dollar is rounded.

Ex. (1)

Depreciation rate: 3.59 (%)

	Acquisition cost	Depreciation amount	Amount left at the term end
	65,000	2,333	62,667
	55,000	1,974	53,026
Total	120,000	4,307	

Ex. (2) Schedule of depreciation

Suppose that acquisition cost of a machine is 700,000 dollar, that the durable year is 7 years and that its scrap value is 10% of the acquisition cost. So, schedule the depreciation of a half-yearly settlement for this machine.

Rate of depreciation = $1 - \left(\frac{\text{scrap value}}{\text{acquisition cost}} \right)^{\frac{1}{n}}$ n : number of settlement term

Term	Value at the beginning of term	Depreciation amount	Agregate of depreciation amount
1	700,000	106,162	106,162
2	593,838	90,061	196,223
3	503,777	76,402	272,626
...			
7	260,929	39,572	478,646
8	221,357	33,571	512,217
9	187,786	28,479	540,696
...			
13	97,264	14,751	617,490
14	82,513	12,513	630,000

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [A]	RATE(%) =	(Ex. 1)	11	[SHIFT] [C]	ACQ. COST=	(Ex. 2)
2	3.59 [ENTER]	ACQ. COST=		12	700000 [ENTER]	SCRAP VALUE=	
3	65000 [ENTER]	EVERY TERM 2333		13	10 [ENTER]	NUMBER =	
4	[ENTER]	END TERM 62667		14	14 [ENTER]	1 106162 593838	
5		)		15	[ENTER]	2 90061 503777	
6		)		16		)	
7	[SHIFT] [B]	T. ACQ. COST 120000		17		)	
8	[ENTER]	T. EVERY TERM 4307		18	[ENTER]	14 12513 70000	
9				19	[ENTER]	TOTAL 630000	
10				20			

SHARP

Title	CALCULATION OF DEPRECIATION	PROGRAM NO. P4 - H - 10
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[Operation]

C LOAD ▽H10 ▽

(Ex. 1)

Depreciation rate

Acquisition cost Depreciation amount

Amount at the term end

Totalization

Total acquisition cost

Total depreciation amount

(Ex. 2)

Acquisition cost

Scrap value

(n) number of settlement term

Depreciation amount of 1st term
Value at the beginning of 2nd term

Depreciation amount of 2nd term
Value at the beginning of 3rd term

⋮

n th term
Scrap value

Total amount of depreciation

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

SHARP

Title CATEGORIZED TOTALIZATION [I]

PROGRAM NO.
P 4 - H - 14

[Formula]

Horizontal Vertical data data	1	2		m	Total
1					
2					
⋮					
n					
Total					Grand total
Ratio	%				

This program calculates the horizontal and vertical totals and the ratio and grand total of the grand total.

[Example]

Results of sales

	Area (1)	Area (2)	Area (3)	Area (4)	Area (5)	Total
Article (A)	1000	200	500	800	700	3200
Article (B)	100	50	60	70	60	340
Article (C)	500	300	200	100	200	1300
Article (D)	300	100	50	200	100	750
Total	1900	650	810	1170	1060	5590
Ratio	33.99	11.63	14.49	20.93	18.96	100

To classify the sales of 4 kinds of articles by 5 areas, and analyze the component ratio of each area:

[Operation]

C LOAD ▽H14 ▽

1) Memory clear

After clearing memory, input the number of horizontal and vertical data.

2) Preset of the number of vertical and horizontal data

V. No.

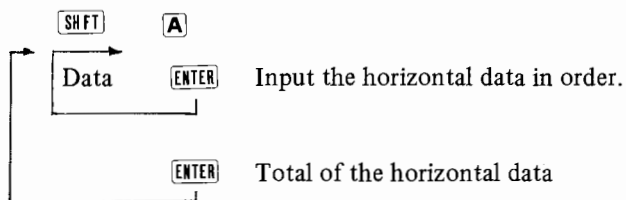
H. No. (Up to 145)

	Input	Display	Note		Input	Display	Note
1	SHIFT D			11		)	
2	SHIFT C	V. N. =		12		)	
3	4 ENTER	H. N. =		13	1060 ENTER	1 1900 33.99	
4	5 ENTER			14	ENTER	2 650 11.63	
5	SHIFT A	DATA =		15		)	
6	1000 ENTER			16		)	
7	200 ENTER			17	ENTER	5 1060 18.96	
8	500 ENTER			18	ENTER	TOTAL 5590	
9	800 ENTER			19			
10	700 ENTER	1 3200		20			

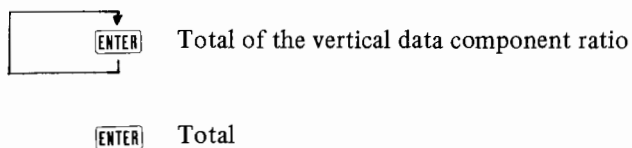
Title CATEGORIZED TOTALIZATION [I]

PROGRAM NO.
P4 - H - 14

3) Data input



After inputting "m x n" times:



4) Data correction

To correct the date input immediately before:

SHFT B

Wrongly input data ENTER , then input a right data and continue inputting operation.

	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title CATEGORIZED TOTALIZATION [II]

PROGRAM NO.
P 4-H-15

[Formula]

This program totals the slips used for business calculation.

When the code and quantity (amount) are input at random, an amount of each code number is aggregated.

[Example]

Input data

Code No.	Amount	Unit price
3	10	220
8	15	200
4	22	255
5	12	850
1	22	150
3	10	220
2	11	120
6	24	2500
4	52	255

Output amount

CodeNo.	Amount	Comp. ratio(%)
1	3300	3.26
2	1320	1.31
3	4400	4.35
4	18870	18.67
5	10200	10.09
6	60000	59.35
7	0	0.00
8	3000	2.97
9	0	0.00
10	0	0.00

[Operation]

CLOAD ∇ H15 ∇ **ENTER**

1) Code No. presetting (Must be operated at the start of calculation)

SHFT **B** (Memory clear)

Code No. **ENTER** (Up to 166 possible)

3) Total

SHFT **C**



Amount & component ratio (%)

2) Data input

SHFT **A**

Code **ENTER**
Data **ENTER**

((To find an amount from quantity and unit price, operate in such an order as quantity $\times$ and unit price **ENTER** .))

ENTER Total

	Input	Display	Note		Input	Display	Note
1	SHFT B	MAX =		11	SHFT C	1 3300 3.26%	
2	10 ENTER			12	ENTER	2 1320 1.31%	
3	SHFT A	CODE.NO. =		13			
4	3 ENTER	DATA =		14			
5	10 $\times$ 220 ENTER			15			
6	)			16	ENTER	10 0 0%	
7	)			17	ENTER	TOTAL 101090	
8	4 ENTER			18			
9	52 $\times$ 255 ENTER			19			
10				20			

Title	RANKING DECISION	PROGRAM NO. P4 -H-16
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[Formula]

This program decides rankings of some data and outputs them in the order from the highest to the lowest, regardless of whether data are zero, minus or plus.

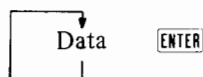
[Example]

When these numbers "123, 23, -45, 0, 45, 854, 51, -564, -0.025, 0, -56, 456, 23" are put from the highest to the lowest, the result is "854, 456, 123, 51, 45, 23, 23, 0, 0, -0.025, -45, -56, -564".

[Operation]

CLOAD ▽H16 ▽ **ENTER**

1) Data input

SHFT **B**
 **ENTER**

(The computation takes about 5 minutes because of rearrangement of 35 data.)

2) To start calculation

SHFT **A**
 **ENTER** data are displayed in the order from the highest to the lowest.

	Input	Display	Note		Input	Display	Note
1	SHFT B	DATA=		11			
2	123 ENTER	DATA=		12			
3	23 ENTER			13			
4				14			
5				15			
6	SHFT A	1 854.0000		16			
7	ENTER	2 456.0000		17			
8	ENTER			18			
9	ENTER			19			
10		13 -564.0000		20			

SHARP

Title CHANGING OF ORDER

PROGRAM NO.
P 4 - H - 17

[Formula]

This program changes places of some pairs of data and outputs them in the order from highest to the lowest, or vise versa. A datum must be a positive number of 5 digits, and no figures below the decimal point can be input.

A pair of data mean such things as an examinee's number and his marks. Either of the examinee's number and his marks. Either of the examinee's number and the marks can be used as the standard for this program.

[Example]

Data 1	Data 2
Examinee's number	Marks
4	90
3	95
1	100
5	80
2	60

Notes: No. of data is possible up to 150.

(Ex. 1)

To put the data shown in the table left in order of the examinee's number:

(Ex. 2)

To put them in order from the highest marks to the lowest.

(Ex. 1)

Data 1	Data 2
Examinee's number	Marks
1	100
2	60
3	95
4	90
5	80

(Ex. 2)

Data 1	Data 2
Examinee's number	Marks
1	100
3	95
4	90
5	80
2	60

	Input	Display	Note		Input	Display	Note
1	[SHIFT] [C]	DATA 1 =	(Ex. 1)	11	[ENTER]	4 4 90	
2	4 [ENTER]	DATA 2 =		12	[ENTER]	5 5 80	
3	90 [ENTER]	DATA 1 =		13			
4		)		14			
5				15			
6	60 [ENTER]			16			
7	[SHIFT] [F]			17			
8	[SHIFT] [B]	1 1 100		18			
9	[ENTER]	2 2 60		19			
10	[ENTER]	3 3 95		20			

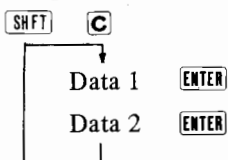
Title CHANGING OF ORDER

PROGRAM NO.
P 4 - H - 17

[Operation]

CLOAD ▽H17 ▽ ENTER

1) Data input



2) Output from the highest to the lowest or from the lowest to the highest:

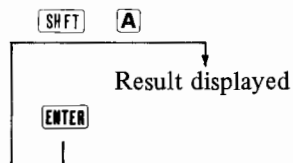
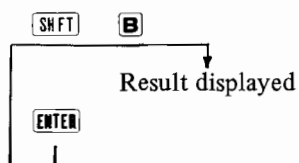
In order from the highest SHFT D

In order from the lowest SHFT F

3) Changing of the order of data 1 or data 2

Data 1

Data 2



	Input	Display	Note		Input	Display	Note
1	SHFT D		(Ex. 2)	11			
2	SHFT A	1 1 100		12			
3	ENTER	2 3 95		13			
4	ENTER	3 4 90		14			
5	ENTER	4 5 80		15			
6	ENTER	5 2 60		16			
7				17			
8				18			
9				19			
10				20			

SHARP

Title	BIORHYTHM	PROGRAM NO. P4 - I - 1
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[Formula]

The idea of biorhythm is that each of man's physical, sentiment and Intelligent has a rhythm from the very day of his birth.

Physical (P): a cycle of 23 days

Sentiment (S): a cycle of 28 days

Intelligent (I): a cycle of 33 days

The result of calculation with respect to date on which his condition becomes the worst is as follows:

P: 0, 11 or 12

S: 0, 14

I: 0, 16 or 17

Calculation can be made, however, only for the person whose date of birth is on or after 1st of March in 1900.

[Example]

To find the biorhythm on 3rd of March, 1977 for one whose date of birth is 4th of February, 1954:

[Operation]

C LOAD ∇ I I ∇

Display: P: AFTER 1.5 (Means the date 1.5 days after the target date is the worst day in respect to the constitution.)

S: TODAY (Means the target date is the worst day in respect to the sentiment.)

I: AFTER 3.5 (Means the date 3.5 days after the target date is the worst with respect to the mentality.)

	Input	Display	Note		Input	Display	Note
1	SHIFT A	BIRTHDAY?		11			
2	1954 ENTER	?		12			
3	2 ENTER	?		13			
4	4 ENTER	TARGET ?		14			
5	1977 ENTER	?		15			
6	3 ENTER	?		16			
7	3 ENTER	P AFTER 1.5		17			
8	ENTER	S TODAY		18			
9	ENTER	I AFTER 3.5		19			
10	SHIFT B			20			

SHARP

Title

CALCULATION OF VISCOSITY INDEX OF
PETROLEUM PRODUCTS

PROGRAM NO.
P 4 - I - 2

[Formula]

This program calculates the viscosity index of petroleum products by the kinematic viscosity at temperatures of 37.78°C and 98.98°C.

* In the case of viscosity index between 0 and 100 (100 not included)

$$VI = \frac{L - U}{L - H} \times 100 \quad \text{---(1)}$$

* In the case of viscosity index over 100 (100 included)

$$VI_E = \frac{10^N - 1}{0.0075} + 100 \quad \text{---(2)}$$

$$V^N = \frac{H}{U} \quad \text{---(3)}$$

In the case of oils having viscosity index of less than 100, use the formula (1) for calculation; and 100 or over, the formulas (2) and (3).

Notes: U: kinematic viscosity of sample oil at 37.78°C
V: kinematic viscosity of sample oil at 98.98°C
H: kinematic viscosity of oil of viscosity index 100 having the same viscosity as sample oil at 98.98°C
L: kinematic viscosity of oil of viscosity index 0 having the same viscosity as sample oil at 98.98°C

* Unit of kinematic viscosity: cSt

[Example]

U	V	L	H	VI / VI _E
82.5	9.1	138.18	77.74	VI = 92.12
24.71	5.15	45.66	31.69	VI _E = 155.79

[Operation]

CLOAD ▽ I2 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	U =		11	SHIFT A	U =	
2	82.5 ENTER	V =		12	24.71 ENTER	V =	
3	9.1 ENTER	L =		13	5.15 ENTER	L =	
4	138.18 ENTER	H =		14	45.66 ENTER	H =	
5	77.74 ENTER	VI=92.12442091		15	31.69 ENTER	VI _E =155.7854833	
6				16			
7				17			
8				18			
9				19			
10				20			

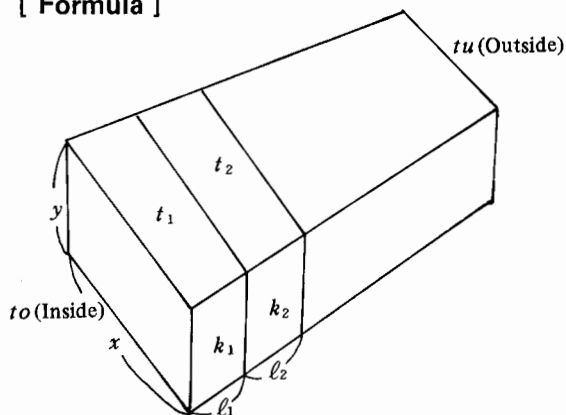
Title			PROGRAM NO.
CALCULATION OF VISCOSITY INDEX OF PETROLEUM PRODUCTS			P 4-I-2
Memory content			
A	1	U	
B	2	V	
C	3	L	
D	4	H	
E	5		10: "A":INPUT "U=";A
F	6		20: INPUT "V=";B
G	7		30: INPUT "L=";C
H	8		40: INPUT "H=";D
I	9		50: X=(C-A)/(C-D)*E2
J	10		60: IF X>=E2GOTO 90
K	11		70: BEEP 2:PRINT "VI=",X
L	12		80: END
M	13		90: Y=(10^((LOG D-LOG A)/LOG B)-1)/.0075+E2
N	14		100: BEEP 2:PRINT "VIE=";Y
O	15		140
P	16		
Q	17		
R	18		
S	19		
T	20		
U	21		
V	22		
W	23		
X	24	✓	
Y	25	✓	
Z	26		

SHARP

Title HEAT CONDUCTION OF HETEROSOLID-STRATUM

PROGRAM NO.
P4 - I - 3

[Formula]



$$A = x \times y$$

$$\text{Heat loss } q = \frac{t_o - t_u}{\frac{l_1}{k_1 A} + \frac{l_2}{k_2 A} + \dots} \text{ [Kcal/h]}$$

k = heat conduction ratio [Kcal/m·h·deg]

$$t_1 = t_o - \frac{q l_1}{k_1 A}$$

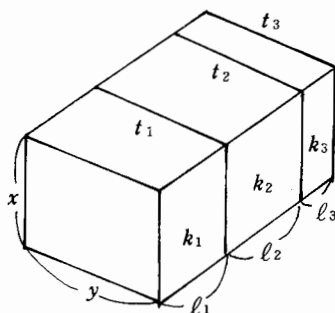
$$t_2 = t_1 - \frac{q l_2}{k_2 A}$$

⋮

$$t_n = t_{n-1} - \frac{q l_n}{k_n A}$$

(Input up to 10 strata is possible.)

[Example]



$$x = 1 \text{ [m]}, \quad y = 1 \text{ [m]}$$

$$l_1 = 0.25 \text{ [m]}, \quad k_1 = 1.2 \text{ [Kcal/m·h·deg]}$$

$$l_2 = 0.12 \text{ "}, \quad k_2 = 0.25 \text{ "}$$

$$l_3 = 0.15 \text{ "}, \quad k_3 = 0.75 \text{ "}$$

Find t_1 and t_2 , provided t_o is 900°C and t_u is 100°C .

[Operation]

CLOAD ▽ I 3 ▽

	Input	Display	Note		Input	Display	Note
1	SHIFT A	INPUT X,Y		11	900 ENTER	?	
2	1 ENTER	?		12	100 ENTER	Q = 900.5628	
3	1 ENTER	INPUT L,K		13	ENTER	T1 = 712.38273	
4	0.25 ENTER	?		14	ENTER	T2 = 280.11257	
5	1.2 ENTER	INPUT L,K		15	ENTER	T3 = 99.9999	
6	0.12 ENTER	?		16			
7	0.25 ENTER	INPUT L,K		17			
8	0.15 ENTER	?		18			
9	0.75 ENTER	INPUT L,K		19			
10	ENTER	INPUT TO,TU		20			

SHARP

Title	VAN DER WAALS' EQUATION	PROGRAM NO. P 4 - I - 4
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[Formula]

This program finds out temperature (T) by the van den Waals' equation.

$$\left(P + \frac{a n^2}{V^2} \right) (V - n b) = n R T$$

n : loschmidt number (No. of mols) a, b : van der Waals' constants
 V : volume (ℓ) R : constant of atmospheric pressure
 T : absolute temperature (°K)
 P : atmospheric pressure

[Example]

Find the absolute temperature T of 10-ℓ oxygen of 3 mols and 4.3 atmospheric pressure, provided a is 1.36 (ℓ² · atom/mol²) and b is 0.0318 (ℓ/mol).

Answer is 177.84 (°K)

[Operation]

CLOAD ▽ I 4 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	N =		11			
2	3 ENTER	P =		12			
3	4.3 ENTER	V =		13			
4	10 ENTER	A =		14			
5	1.36 ENTER	B =		15			
6	0.0318 ENTER	T(K)= 177.8404508		16			
7				17			
8				18			
9				19			
10				20			

SHARP

Title	BOILING POINT OF COMPOUND (3 COMPONENTS)	PROGRAM NO. P 4 - I - 5
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[Formula]

The boiling point of pure matters can be found using the Antoine's equation.

$$\log P \text{ (mmHg)} = A - \frac{B}{C + t \text{ (}^\circ\text{C)}}$$

A, B and C in the above equation are constants.

If the mol percentage of three components is a, b and c ($a + b + c = 1$) and their steam pressure is Pa, Pb and Pc, the total pressure is represented as " $a \cdot Pa + b \cdot Pb + c \cdot Pc$ ".

In order to find the boiling point at the atmospheric pressure, increase "t" by 1°C at a time till the total pressure becomes 740 mmHg; thereafter, increase "t" by 0.1°C at a time; and stop it when the total pressure exceeds 760 mmHg.

[Example]

Suppose you have a compound of benzine of 50 mol%, toluene of 25 mol% and O-xylene of 25 mol%, find the boiling point and equilibrium vapor composition of this liquid.

[Operation]

CLOAD ▽ I 5 ▽

	Input	Display	Note		Input	Display	Note
1	SHIFT A	No-1 A, B, C		11	80.1 ENTER	1 760.0001552	} Check that P reaches 760 mmHg
2	6.90565 ENTER	?		12	ENTER	No-2 BOILING	
3	1211.033 ENTER	?		13	110.6 ENTER	2 759.4529038	
4	220.79 ENTER	No-2 A, B, C		14	ENTER	No-3 BOILING	
5	6.95464 ENTER	?		15	144.4 ENTER	3 759.773621	
6	1344.8 ENTER	?		16	ENTER	No-1,2 MOL RATE ?	
7	219.482 ENTER	No-3 A, B, C		17	0.5 ENTER	?	
8	6.99891 ENTER	?		18	0.25 ENTER	LOWEST BOILING	
9	1474.679 ENTER	?		19	80.1 ENTER	BOILING 95.5	
10	213.686 ENTER	No-1 BOILING		20	ENTER	No-1 596.6929	

SHARP

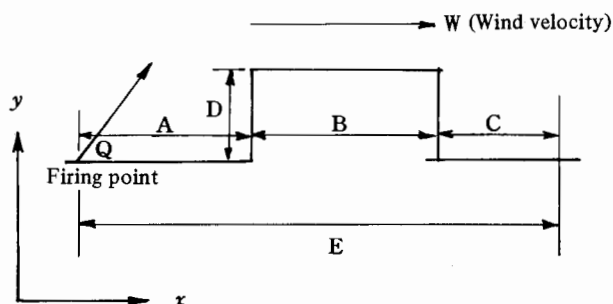
Title BOILING POINT OF COMPOUND (3 COMPONENTS)				PROGRAM NO. P 4 - I - 5			

	Input	Display	Note		Input	Display	Note
1	ENTER	No-2 121.0959701		11			
2	ENTER	No-3 42.39328333		12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Title CANNON SHOT GAME

PROGRAM NO.
P 4 - X - 1

[Formula]



To get over the barrier, the equations mentioned below should be considered first.

"Acceleration of gravity" $g = 9.8 \text{ [m/sec}^2\text{]}$

$$x = (V_0 \cos Q + W) t = V_x t$$

$$y = V_0 \sin Q \cdot t - 4.9 t^2 = V_y t - 4.9 t^2$$

Then, the following formulae should be satisfied.

$$\textcircled{1} \frac{V_y}{V_x} A - \frac{4.9}{V_x^2} A^2 > D$$

$$\textcircled{2} \frac{V_y}{V_x} (A + B) - \frac{4.9}{V_x^2} (A + B)^2 > D$$

So that target $x = \frac{V_x V_y}{4.9}$ can be aimed at.

[Outline of the game]

This program shows a game in which shells are fired on at the target.

Ones who take part in this game are let know only the distance "E" between the firing point and target, and the value of wind velocity "W".

Input an initial value not exceeding 8 digits in the first place. A radius of the target is 1.

When a fired shell crashes into a barrier, ∇ BARRIER ∇ is displayed.

When the shell gets over the barrier, the distance between the place the shell has attacked and the target is displayed. When the shell hits the target, ∇ HIT! ∇ is displayed.

Take the wind velocity into consideration when you make a challenge.

[Operation]

CLOAD ∇ X1 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	INITIAL =		11			
2	1 2 3 4 5 6 ENTER	5 5 7 4 1 0		12			
3		V, Q?	Wind velocity W	13			
4	2 0 0 0 ENTER	?	Distance "E"	14			
5	8 0 ENTER	TARGET E 1308045.682		15			
6		5 5 7 4 1 0		16			
7		V, Q?		17			
8	1 0 0 0 ENTER	?		18			
9	6 0 ENTER	TARGET E 84563.33795		19			
10				20			

[illegible]

SHARP

Title BALL ROLLING GAME

PROGRAM NO.
P 4 - X - 2

[Formula]

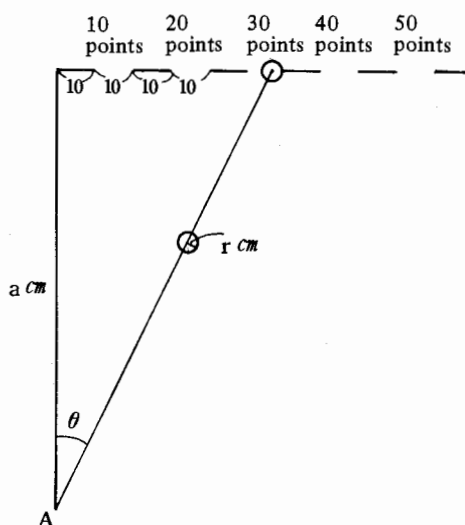
This program is a game where a ball is rolled to run through between walls as shown in the figure right. Walls of 10-cm width are standing at 10-cm intervals. The openings between walls are given points: the extreme left is 10 points, the next to it is 20 points, etc., up to 100 points which are given to the extreme right. Every time the ball is rolled through an opening, points the opening has are added to your score.

No points are made if the ball runs through the opening the ball has been previously rolled through. You can roll the ball ten times in one game.

When the last throw is over, your score is displayed.

Competition is made by points players has gained.

Input the distance "a" and a radius of the ball "r" in the first place. Then input the angle "θ" to determine the direction the ball takes.



[Example]

$a = 100 \text{ cm}$, $r = 2 \text{ cm}$

[Operation]

CLOAD ▽X2 ▽ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	DISTANCE RADIUS		11	50 ENTER	30 6	Missed
2	100 ENTER	?		12		ANGLE =	
3	2 ENTER	0 10	Point, No. of times left	13	29 ENTER	60 5	Run through 30-point opening
4		ANGLE =		14		ANGLE =	
5	10 ENTER	10 9	Run through 10-point opening	15	37 ENTER	100 4	Run through 40-point opening
6		ANGLE =		16		ANGLE =	
7	20 ENTER	30 8	Run through 20-point opening	17	8 ENTER	100 3	Missed
8		ANGLE =		18		ANGLE =	
9	40 ENTER	30 7	Missed	19	⋮	⋮	
10		ANGLE =		20		SCORE = 100	

SHARP

Title	REVERSE GAME	PROGRAM NO. P 4 - X - 3
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[Formula]

This program performs a game in which figures from 0 to 9 are put at random into a ten-figure number with each figure used once, and the figures are changed in their places to make the number as "1 2 3 8 9 0" by REVERSE.

REVERSE is performed, for example, as follows:

- 6-digit REVERSE: 3456102987 → 3456789201
- 3-digit REVERSE: 3456789201 → 3456789102
- 2-digit REVERSE: 3456689201 → 3456789210

Note that if zero (0) takes the extremely-left position of a number it is not displayed.

The number of trials is displayed. When a game is over, you can have a choice whether you will have another game with the same number or other.

The less the number of trials becomes, the better.

Input a number of 8 digits or more as an initial value.

When a game is over, the display turns out to be ∇ SAME - 1 DIF - 2 ∇ . Input "1" if you have another game with the same number as before, or "2" if with a different number.

[Operation]

CLOAD ∇ X3 ∇ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	INITIAL =		11	ENTER	NUMBER =	
2	123456789 ENTER	1 2 3 8 6 7 9 0 4 5		12	5 ENTER	TRY = 5	No. of times
3	ENTER	NUMBER =		13	ENTER	SAME-1 DIF-2	
4	2 ENTER	1 2 3 8 6 7 9 0 5 4		14		Reverse is performed with the same number if "1 ENTER ", or with a Different number if "2 ENTER "	
5	ENTER	NUMBER =		15			
6	7 ENTER	1 2 3 4 5 0 9 7 6 8		16			
7	ENTER	NUMBER =		17			
8	3 ENTER	1 2 3 4 5 0 9 8 6 7		18			
9	ENTER	NUMBER =		19			
10	2 ENTER	1 2 3 4 5 0 9 8 7 6		20			

Title		REVERSE GAME	PROGRAM NO. P 4 - X - 3
Memory content			
A	1	No. of digits	
B	2	1 2 3 4 5 6 7 8 9 0	
C	3	✓	10: "A":CLEAR :INPUT "INITIAL=";K
D	4	1 0	20: L=E8+1
E	5	Count	30: C=E11/81-11:B=C
F	6	Count of No. of digits	40: D=10:E=D
G	7	✓	50: K=K*23:X=K/L
H	8	✓	60: K=K-INT X*L
I	9		70: X=K/D/D:X=X-INT X
J	10		80: X=X*D+1:X=INT X
K	11	For random digits	90: GOSUB 520
L	12	For random digits	100: E=E-1:X=E
M	13		110: IF X<>0GOTO 50
N	14		120: X=C:H=X
O	15		130: X=2:GOSUB 500
P	16		140: PRINT C:INPUT "NUMBER=";X:GOSUB 520
Q	17		150: E=E+1:X=C
R	18		160: IF X=BGOTO 180
S	19		170: GOTO 130
T	20		180: X=D:GOSUB 500
U	21		190: PRINT "TRY=";E
V	22		200: INPUT "SAME-1 DIF-2",Z
W	23		210: IF Z=2GOTO 30
X	24		220: C=H:E=0:GOTO 130
Y	25		500: BEEP 1:X=X-1:IF X<>0GOTO 500
Z	26		510: RETURN
			520: A=X:F=X:G=0
			530: C=C/D:G=G+C-INT C:G=G*D
			540: C=INT C:F=F-1:X=F
			550: IF X<>0GOTO 530
			560: C=10^A*C+G:RETURN
			393

SHARP

Title MEMORY TEST

PROGRAM NO.
P 4 - X - 4

[Formula]

How many digits indicated at random can you keep in mind temporarily though securely? The percentage of right answers necessary for passing this test is 80% after challenging the test 10 times. In addition, if you answer wrongly three times the display tells you that you are not competent for the number of digits you have been trying to remember.
No. of digits you succeed in remembering

9 or more Genius
8 Bright
7 Good
6 Mediocre
5 Aging
4 or less Idiotic

Input the number of digits you will challenge to remember in the first place. Then a question No. 1 is displayed for about a second. Remember it, then input an answer. Repeat this performance ten times. When your answer is correct, a sound is heard three times, but if wrong no sound is heard. Now challenge a genius for memory!

[Operation]

CLOAD ▽X4 ▽

	Input	Display	Note		Input	Display	Note
1	SHIFT A	DIGITS =		11		ANSWER =	
2	6 ENTER	101004		12	775362 ENTER	934328	
3		ANSWER =		13		ANSWER =	
4	101004 ENTER	424092		14	934328 ENTER	590543	
5		ANSWER =		15	:	:	A total of ten questions given
6	424092 ENTER	855107		16	:	991716	
7		ANSWER =		17	:	ANSWER =	
8	855107 ENTER	768451		18	991716 ENTER	MEDIOCRE	
9		ANSWER =		19			
10	768451	775362		20			

Title	ROCKCLIMBING GAME	PROGRAM NO. P 4 - X - 5
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[Formula]

This is a game played by 2 persons who emulate each other in attaining the summit of a 100-meter-high rockwall.

One of two players has the right of attacking, and can choose either of the followings.

1. Continuation of attacking the rockclimbing.

The sum of pips on two dice is given the player as a distance he has gained. However, if one of or both of the cast dice show one pip, he is to miss his footing and fall onto the footing which he has previously secured. As far as he evades falling, he can keep the attacking right. But if he falls, the attacking right is transferred to his competitor, which is told by peeping sound.

2. To stop there for securing the footing.

In this case, the attacking right is transferred to his competitor.

[Operation]

CLOAD ▽X5 ▽ **ENTER**

	Input	Display	Note		Input	Display	Note
1	SHIFT A	1 ST	Attack of 1st mover	11	1 ENTER	1ST=9 2ND=0	
2		ATTACK-1 DEFEND-2		12		DICE 5 4	
3	1 ENTER	1 ST=0 2ND=0	Height of 1st & 2nd movers	13		2ND	
4		DICE 5 4	Pips of dice	14		ATTACK-1 DEFEND-2	
5		1 ST	Attack of 1st mover	15	1 ENTER	1ST=9 2ND=9	
6		ATTACK-1 DEFEND-2		16		DICE 2 1	
7	2 ENTER	1 ST=9 2ND=0		17		1 ST	
8		DICE 5 1		18		ATTACK-1 DEFEND-2	Peep sound, fall
9		2 ND	Attack of 2nd mover	19	1 ENTER	1ST=9 2ND=0	
10		ATTACK-1 DEFEND-2		20			

SHARP

Title	GUESS-NUMBER GAME	PROGRAM NO. P 4 - X - 6
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[Formula]

This is a game to guess a three-figure number by the computer.

Every time a trial is made, the number of trials and your input value are displayed for a second. Then a comment is displayed for a second.

For example, if the display shows:

COMMENT 1 1,

the left figure tells that one of the three figures you have just input coincides with one of the computer-chosen three figures and its place is also correct.

The right figure tells that one of the rest (2 figures) coincides with one of the rest of the computer-chosen ones but its place is wrong.

Therefore, if commented as follows:

COMMENT 3 0,

all the three figures you have input are correct in places as well as figures themselves. So VERY GOOD and the number of your trials are displayed.

[Operation]

CLOAD ▽X6 ▽ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	INITIAL =		11	3 7 6 ENTER	4 3 7 6	
2	1 2 3 4 5 6 ENTER	X =		12		COMMENT 1 0	
3	1 2 3 ENTER	1 1 2 3		13		X =	
4		COMMENT 0 1		14	3 8 5 ENTER	5 3 8 5	
5		X =		15		COMMENT 2 0	
6	1 4 5 ENTER	2 1 4 5		16		X =	
7		COMMENT 1 0		17	3 0 5 ENTER	6 3 0 5	
8		X =		18		COMMENT 3 0	
9	2 4 6 ENTER	3 2 4 6		19		VERY GOOD 6	
10		COMMENT 0 0		20			

Title		GUESS-NUMBER GAME	PROGRAM NO. P 4 - X - 6
Memory content			
A	1		
B	2	✓	
C	3	Three-figure number	10: "A":INPUT "INITIAL=";K
D	4		20: L=L+K
E	5		30: K=7+L*L*23
F	6		40: K=INT (K/E2):L=K-INT (K/E3)*E3:X=L
G	7		50: FOR A=2TO 4
H	8		60: GOSUB 500
I	9		70: NEXT A
J	10	Comment	80: IF (B=C)+(B=D)+(C=D)<>0GOTO 30
K	11	For random digits	90: Y=1
L	12		100: BEEP 1:INPUT "X=";X
M	13		110: PAUSE Y,X
N	14		120: FOR A=6TO 8
O	15		130: GOSUB 500
P	16	Coment	140: NEXT A
Q	17		150: J=0:L=6:P=0
R	18		160: FOR A=2TO 4
S	19		170: IF A(A)=A(L)LET J=J+1
T	20		180: GOSUB 510
U	21		190: GOSUB 510
V	22		200: M=F:F=G:G=H:H=M
W	23		210: L=L-2
X	24	Tried number	220: NEXT A
Y	25	No. of times	230: Y=Y+1
Z	26		240: PAUSE "COMMENT ";USING "####";J;P
			250: IF J<>3GOTO 100
			260: Y=Y-1:BEEP 2:PRINT "VERY GOOD",Y
			270: END
			500: A(A)=X-INT (X/10)*10:X=INT (X/10):
			RETURN
			510: L=L+1:IF A(A)=A(L)LET P=P+1
			520: RETURN
			391

Title DRIFTING-AND-SURVIVING GAME

PROGRAM NO.
P 4 - X - 7

[Formula]

This is a game to steer a drifted small dinghy to get an island of safety in storm.

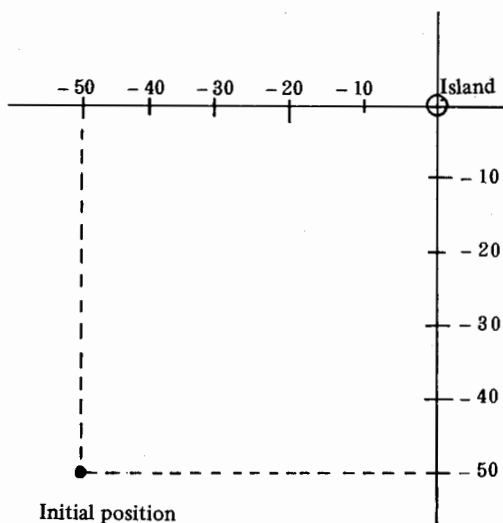
The initial drifting location is at $(-50, -50)$. Input a distance you desire to gain in each of the x and y directions, though the dinghy does not move on as you wish due to the wind. The wind blows with the velocity of between -5 and 5 in the x and y directions. The wind velocity changes at every input. A present location is displayed as a comment by the x - y coordinates, each in sign.

For example, if displayed as follows:

SGN X = 1 SGN Y = -1

the x coordinate is positive and the y coordinate is negative.

The radius of the island is 1. When you succeed in arriving the island, a landing point and the number of trials are displayed.



[Operation]

CLOAD ▽X7▽ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	INITIAL =		11			
2	1 2 3 4 5 6 7 ENTER	X =		12		Repeat	
3	5 0 ENTER	Y =		13			
4	5 0 ENTER	SGN X=1 SGN Y = 1		14			
5		X =		15			
6	0 ENTER	Y =		16			
7	0 ENTER	SGN X=-1 SGN Y=1		17			
8		X =		18			
9	2 ENTER	Y =		19			
10	- 2 ENTER	SGN X=1 SGN Y=-1		20			

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Title	SOFT-LANDING GAME	PROGRAM NO. P 4 - X - 8
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[Formula]

How can a rocket having a strictly limited quantity of fuel be soft-landed?

The rocket falls down freely unless the rocket engine be ignited to slow down its descent. If ignited too early or if too much fuel is consumed for serving the engine up, the rocket will go up to become nothing but dust in the space. But if the engine is ignited too late, the rocket will crash into the planetary surface.

The object of this game is to soft-land the rocket with minimum downward velocity by controlling the time of ignition and fuel consumption.

Gravity of the planet is $S \text{ m/s}^2$.

Fuel consumption of 5 units during a unit time will cancel the gravity.

Equations:

$$H = H_0 + V_0 t + \frac{1}{2} a t^2$$

$$V = V_0 + a t$$

$$V^2 = V_0^2 + 2 a H$$

$$H_0 = 500, \quad V_0 = -50, \quad F_0 = 120$$

H : height

V : velocity

a : acceleration of gravity

t : time

V_0 : initial velocity

H_0 : initial height

F_0 : initial fuel

F : fuel consumed

F' : remaining fuel

[Operation]

CLOAD ▽X8 ▽ ENTER

	Input	Display	Note		Input	Display	Note
1	SHIFT A	H = 500		11			
2		V = -50		12			
3		FUEL = 120		13			
4		WASTED F =		14			
5	10 ENTER	H = 452.5		15			
6		V = -45		16			
7		FUEL = 110		17			
8				18			
9	Repeat			19			
10				20			

SHARP

Title	CALENDER CALCULATION	PROGRAM NO. P 4 - X - 9
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[Formula]

This program figures out an unknown day of the week in respect to a known date.

[Example]

February 4, 1954

February 4, 1978

[Operation]

CLOAD ▽X9 ▽

	Input	Display	Note		Input	Display	Note
1	SHFT ☒	YEAR MONTH DAY ?		11	SHFT ☒	YEAR MONTH DAY ?	
2	1 9 5 4 ENTER	?		12	1 9 7 8 ENTER	?	
3	2 ENTER	?		13	2 ENTER	?	
4	4 ENTER	THURSDAY		14	4 ENTER	SATURDAY	
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

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Title TREASURE-HUNTING GAME

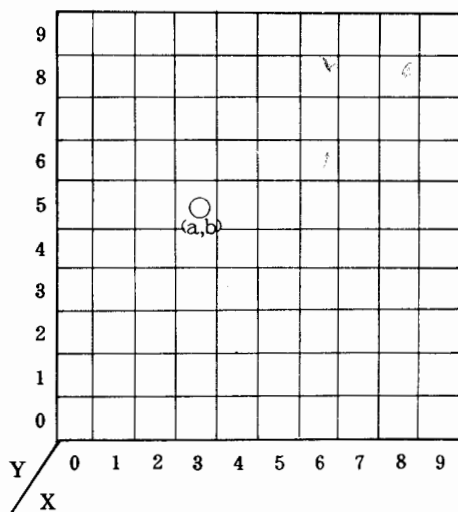
PROGRAM NO.
P 4 - X - 11

[Formula]

This is a game in which the location of treasure is decided by random numbers and a player hunts out the treasure.

Your initial position is at (0, 0). Input a distance you want to cover in each of the x and y directions. If you get out of the matrix shown on the right, the error indication appears, so try again.

A distance between you and the treasure is indicated as a hint by the value of " $ABS(x-a) + ABS(y-b)$ ". You are allowed an energy of 60 at the start of treasure hunt. The energy decreases by a sum of distances in the x and y directions which you make. And when you locate the treasure, ∇_{HIT} is displayed and the energy increases by 5. Every time you input, the following indication appears:



Example:

4	5	4	51
x coordinate of present position	y coordinate of present position	Distance bet. you and treasure (Hint)	Remaining energy

Every time the treasure is hunted out, a new location of the treasure is fixed by random numbers. You continue to hunt the treasure until the energy you have exhausts. The number of hunted treasures is displayed at the end of the game.

[Operation]

CLOAD ∇ X11 ∇

	Input	Display	Note		Input	Display	Note
1	SHIFT A	INITIAL =		11	- 4 ENTER	HIT	
2	2345781 ENTER	0 0 9 60		12		6 3 6 44	
3		DX DY ?		13		:	
4	4 ENTER			14		:	
5	5 ENTER	4 5 4 51		15		Continue fill energy exhausts	
6		DX DY ?		16			
7	- 2 ENTER	?		17			
8	2 ENTER	2 7 8 47		18			
9		DX DY ?		19			
10	4 ENTER	?		20			

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YOUR OWN PROGRAM

Title				PROGRAM NO. P —			
	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

[illegible]

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YOUR OWN PROGRAM

Title				PROGRAM NO. P —			
	Input	Display	Note		Input	Display	Note
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

[illegible]

— MEMO —

SHARP CORPORATION

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