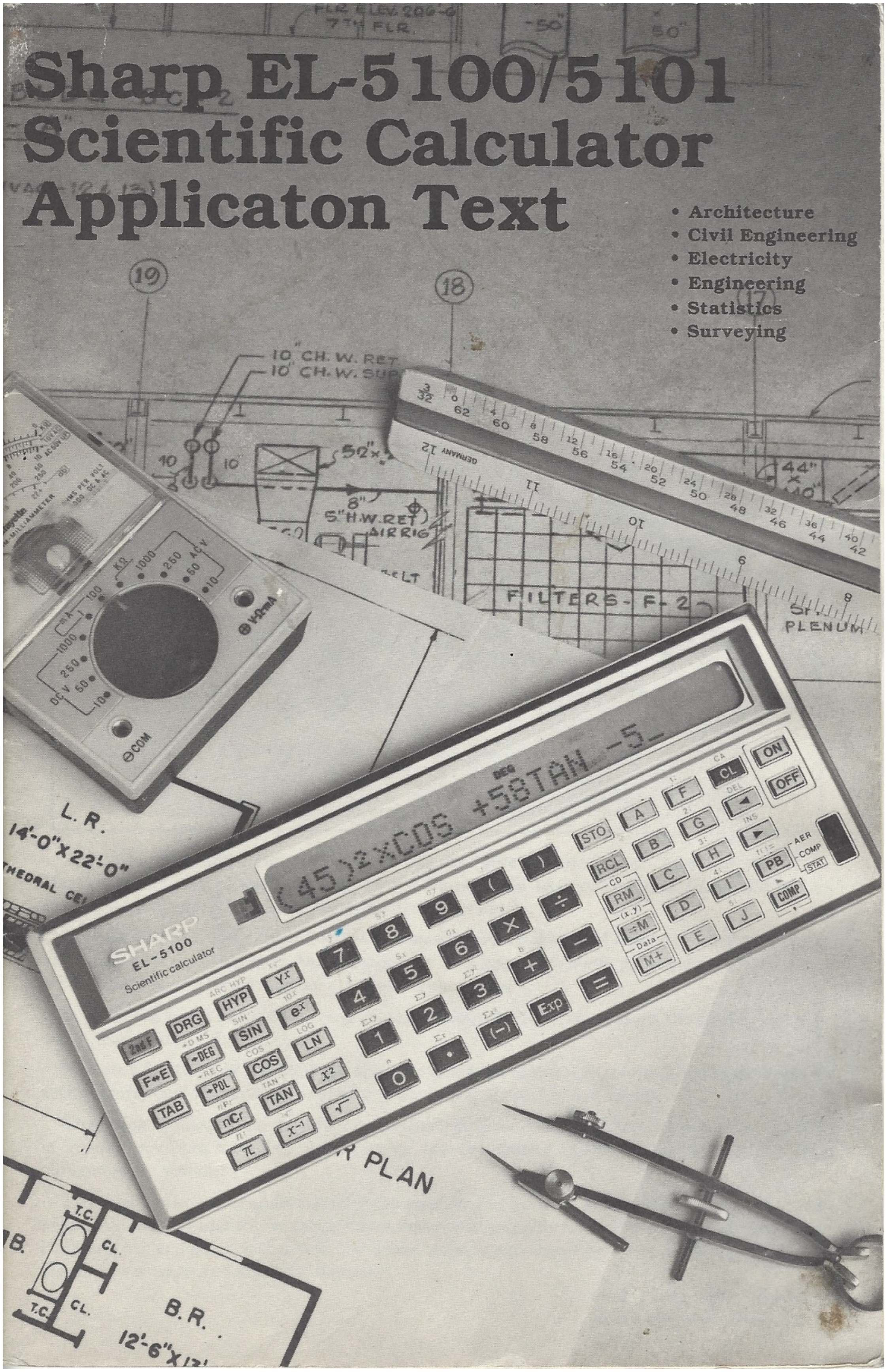
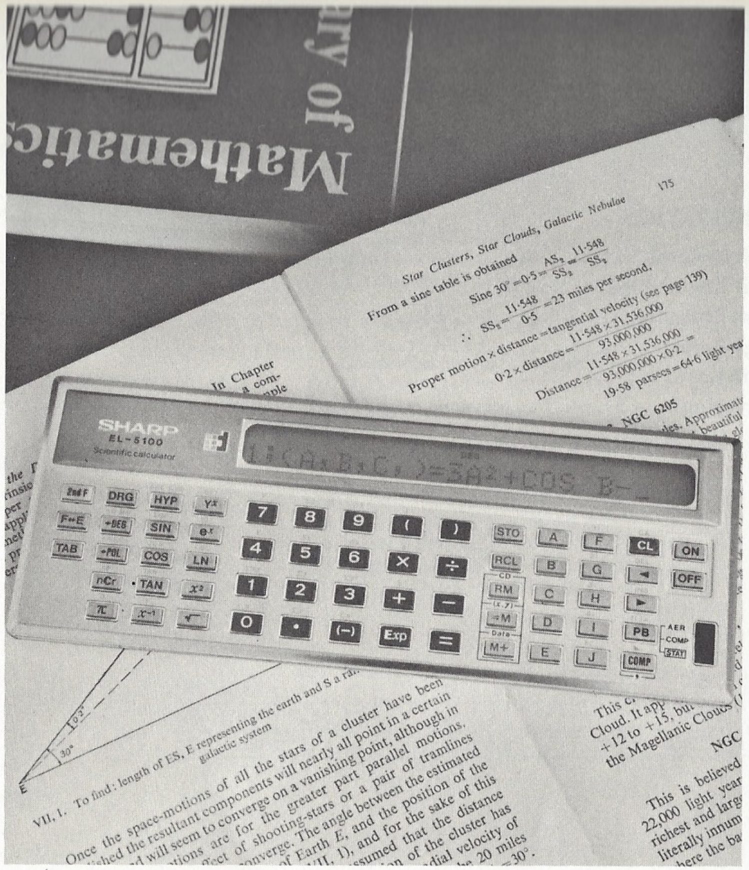
Sharp EL-5100/5101 Scientific Calculator Applicaton Text

- Architecture
- Civil Engineering
- Electricity
- Engineering
- Statistics
- Surveying





The "Sharp" brand name is derived from the "Ever Sharp Pencil" invented by Mr. T. Hayakawa, founder of the company. Sharp Corporation has continuously been devoted to developing advanced technology and innovative products.

In 1964, Sharp created the industry when we introduced the world's first all transistor-diode, electronic desktop calculator. And ever since, Sharp has consistently played the leading role in innovative discoveries of unusual electronic calculators.

In 1979, the world's first direct formula entry scientific line of calculators, the EL-5100 series, was introduced by Sharp.

Models EL-5100 and EL-5101 are specially designed to simplify computation in the areas of architecture, civil engineering, electricity, statistics, surveying and more.

The unique rolling writer feature and playback in direct formula entry, add many advantages in solving complex formulas. Additionally, the dot matrix liquid crystal display provides alphanumeric readout.

To assist you in better understanding the many functions of the Sharp EL-5100 and EL-5101 programmable calculators, we recommend that you thoroughly review this book of applications. Problems are explained with actual key stroke sequence to show how to solve these problems in the most accurate and efficient manner.

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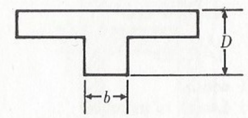
ARCHITECTURE

No. 1 — **ITEM:** Hardness ratio of sections supposed

FORMULA:

Relative stiffness ratios of pillar and beam are determined by the following equation.



b : Width
D : Height
l : Lenght of member
ϕ : 1.5 in case of single-side slab, 2 in case of both-side slab
K_0 : Standard stiffness

$$I_0 = \frac{b\,D^3}{12} \quad I = \phi\, I_0 \quad K = I/l \quad k = K/K_0$$

I : Geometrical moment of inertia
K : Stiffness
k : Relative stiffness ratio

Note: I_0 and K are displayed in $(\times 10^4)$ and $(\times 10^2)$ respectively,

EXAMPLE:

b = 30cm
D = 60cm
ϕ = 2
l = 600cm
K_0 = 1000cm^3

→

$I_0 = 5.40 \times 10^5$ (cm^4) k = 1.80
$I = 1.08 \times 10^6$ (cm^4)
$K = 1.80 \times 10^3$ (cm^3)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	$\overset{b}{\to I_0}$	$\overset{D}{\to I}$	$\overset{l}{\to K}$	ϕ	K_0					
EL−5101	$\overset{b}{\to I_0}$	$\overset{D}{\to I}$	$\overset{l}{\to K}$	ϕ	K_0					

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [E] [2ndF] [f()=] [A] [B] [Y^x] [3] [÷] [1] [2] [STO] [A]
[,] [A] [D] [STO] [B] [,] [B] [÷] [C] [STO] [C] [,] [C] [÷] [E]

〔AER〕→〔COMP〕

Decimal position : 2   [CL] [TAB] [2]

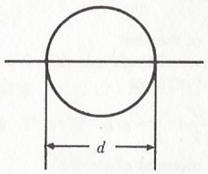
[COMP] [3] [0] [COMP] [6] [0] [COMP] [6] [0] [0] [COMP] [2] [COMP]
[1] [0] [0] [0] [COMP] → 540000.00
[F↔E] → 5.40 E 05 (5.40×10^5)(I_0)
[COMP] [F↔E] → 1.08 E 06 (1.08×10^6)(I)
[COMP] [F↔E] → 1.80 E 03 (1.80×10^3)(K)
[COMP] [F↔E] → 1.80 E 00 (1.80)(k)

ARCHITECTURE

No. 2	ITEM: Hardness ratio of a column

FORMULA:

Relative stiffness ratio of a circular pillar can be obtained by employing the following equation.



$$I_0 = \frac{\pi d^4}{64} \ (\mathrm{cm}^4)$$

$$K = I_0/h \ (\mathrm{cm}^3)$$

$$k = K/K_0$$

d : width
h : Length of member
I_0 : Geometrical moment of inertia
K : Stiffness
k : Relative stiffness ratio

EXAMPLE:

d = 30cm
h = 400cm
K_0 = 1000cm^3

→

$I_0 = 3.98 \times 10^4$ (cm^4)
$K = 9.94 \times 10$ (cm^3)
k = 0.10

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	$d \to I_0$	$h \to K$	K_0							
EL−5101	$d \to I_0$	$h \to K$	K_0							

OPERATION:

Angular mode : DEG

→ [AER]

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [2ndF] [f()=] [π] [A] [Y^x] [4] [÷] [6] [4] [STO] [A] [,]

[A] [÷] [B] [STO] [B] [,] [B] [÷] [C]

[AER]→[COMP]

Decimal position: 2 [CL] [TAB] [2]

[COMP] [3] [0] [COMP] [4] [0] [0] [COMP]

[1] [0] [0] [0] [COMP] → 39760.78

[F↔E] → 3.98 E 04 (3.98×10^4) (I_0)

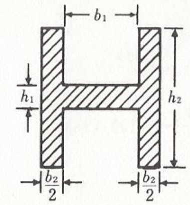
[COMP] [F↔E] → 9.94 E 01 (9.94×10) (K)

[COMP] → 0.10

ARCHITECTURE

No. 3	ITEM: Main inertia moment and section coefficient of H-shaped steel, etc.

FORMULA:



For H-iron as shown in the figure hereof, I_z and Z are computed by the following equations.

$$\begin{cases} I_z = \dfrac{1}{12}\left(b_1 h_1^3 + b_2 h_2^3\right) \\ Z = \dfrac{1}{6} \dfrac{b_1 h_1^3 + b_2 h_2^3}{h_2} \end{cases}$$

EXAMPLE:

h_1 = 6cm
b_1 = 84cm
h_2 = 100cm
b_2 = 16cm

→

$I_z = 1.33 \times 10^6$ (cm^4)
$z = 2.67 \times 10^4$ (cm^3)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	h_1	h_2	b_1	b_2						
EL−5101	h_1	h_2	b_1	b_2						

OPERATION:

→ [AER]

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [2ndF] [f()=] [C] [A] [Y^x] [3] [+] [D] [B] [Y^x] [3]

[STO] [A] [÷] [12] [,] [A] [B] [x^-1] [÷] [6]

[AER]→[COMP]

Decimal position: 2 [CL] [TAB] [2]

[COMP] [6] [COMP] [1] [0] [0] [COMP] [8] [4] [COMP]

[1] [6] [COMP] → 1334845.33

[F↔E] → 1.33 E 06 (1.33×10^6)(I_z)

[COMP] [F↔E] → 2.67 E 04 (2.67×10^4) (Z)

CIVIL ENGINEERING

No. 1	**ITEM:** Density of the ground

FORMULA:

Volume of sampling ground: V (cm^3)
Weight of sampling ground : W (g)
Weight after being dried. : W_s (g)

Water contents in percent of dry weight : $w=\dfrac{W-W_S}{W_S}\times 100$ (%)

Wet density : $\gamma_t=\dfrac{W}{V}$ (g/cm^3)

Dry density : $\gamma_d=\dfrac{W_S}{V}$ (g/cm^3)

EXAMPLE:

V = 680cm^3
W = 1163g → w = 30.381 (%)
W_S = 892g

γ_t = 1.710 (g/cm^3)
γ_d = 1.312 (g/cm^3)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	V	W	W_S							
EL−5101	V	W	W_S							

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [2ndF] [f()=] [(] [B] [−] [C] [)] [÷] [C]
[×] [Exp] [2] [,] [B] [÷] [A] [,] [C] [÷] [A]

〔AER〕→〔COMP〕

Decimal position: [CL] [TAB] [3]

[COMP] [6] [8] [0] [COMP] [1] [1] [6] [3] [COMP]
[8] [9] [2] [COMP] → 30.381 (w)
[COMP] → 1.710 (γ_t)
[COMP] → 1.312 (γ_d)

CIVIL ENGINEERING

No. 2	**ITEM:** Stability of the slope

FORMULA:

$$Hc=\frac{4C}{\gamma}\tan\left(45+\frac{\phi}{2}\right)$$

Hc : Limit height
C : Cohesion (t/m^2)
γ : Unit weight of ground (t/m^2)
ϕ : Angle of internal friction of ground

EXAMPLE:

C = 2 t/m^2
γ = 1.6 t/m^2 → Hc = 5.95877
ϕ = 10°

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	C	γ	ϕ							
EL−5101	C	γ	ϕ							

OPERATION:

Angle mode : DEG
→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [2ndF] [f()=] [4] [A] [B] [x^{-1}] [×] [TAN] [(]
[4] [5] [+] [C] [÷] [2] [)]

〔AER〕→〔COMP〕

Decimal position: 5 [CL] [TAB] [5]

[COMP] [2] [COMP] [1] [•] [6] [COMP] [1] [0] [COMP] → 5.95877 (m)

CIVIL ENGINEERING

No. 3 — **ITEM:** Flux of a pipe

FORMULA:

$$V = 0.84935CR^{0.63}\ I^{\ 0.54}$$
$$Q = AV$$

V : Mean velocity (m/sec)
C : Coefficient of velocity
R : Hydraulic mean depth = $\frac{D}{4}$ (m)
I : Hydraulic gradient = $\frac{h}{L}$
Q : Discharge (m^3/sec)
A : Sectional area of pipe = Cross-sectional area of stream (m^2)

EXAMPLE:

$C = 100$
$R = 0.0125$ (m)
$I = 0.0018$
$A = 0.0019625$ (m^2)

→ $V = 0.17701$ (m/sec)
$Q = 3.47374 \times 10^{-4}$ (m^3/sec)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	C	R	I	A						
EL−5101	C	R	I	A						

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [2ndF] [f()=] [•] [8] [4] [9] [3] [5] [A] [B] [Yˣ]
[•] [6] [3] [X] [C] [Yˣ] [•] [5] [4] [STO] [E] [,] [E] [D]

〔AER〕→〔COMP〕

Decimal position: 5 [CL] [TAB] [5]

[COMP] [1] [0] [0] [COMP] [•] [0] [1] [2] [5] [COMP]

[•] [0] [0] [1] [8] [COMP] [•] [0] [0] [1] [9] [6] [2] [5] [COMP] → 0.17701
[COMP] → 0.00035
[F↔E] → 3.47374 E −04
(3.47374×10^{-4})

CIVIL ENGINEERING

No. 4 — **ITEM:** Head lost by friction in a water pipe

FORMULA:

$$H = \left(0.0126 + \frac{0.01739 - 0.1087d}{\sqrt{V}}\right) \frac{L}{d} \cdot \frac{V^2}{2g}$$

H : Loss of head due to friction (m)
V : Velocity inside the pipe (m/sec)
L : Length of the pipe (m)
g : Gravity acceleration (9.8m/sec^2)
d : Inner diameter of the pipe (m)

EXAMPLE:

$V = 0.5$ m
$L = 5$ m
$d = 0.01$ m

→ $H = 0.22740$ (m)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	V	L	d							
EL−5101	V	L	d							

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [2ndF] [f()=] [(] [•] [0] [1] [2] [6] [+] [(] [•] [0] [1] [7]
[3] [9] [−] [•] [1] [0] [8] [7] [C] [)] [÷] [√] [A] [)] [X] [B] [A] [x²] [÷] [C]
[÷] [1] [9] [•] [6]

〔AER〕→〔COMP〕

Decimal position : 5 [CL] [TAB] [5]

[COMP] [•] [5] [COMP] [5] [COMP] [•] [0] [1] [COMP] → 0.22740

No. 5 | **ITEM:** Head lost by friction

FORMULA:

$$h_f = \frac{n^2 V^2}{R^{4/3}} L$$

h_f : Loss of head due to friction
n : Roughness coefficient
V : Mean velocity
R : Hydraulic radius
L : Length of channel

EXAMPLE:

$n = 0.015$
$V = 1.42$ (m/sec)
$L = 1000$ (m)
$R = 0.555$ (m)
→ $h_f = 0.99472$(m)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	n	V	R	L						
EL−5101	n	V	R	L						

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [2ndF] [f()=] [D] [A] [x^2] [×] [B] [x^2]
[÷] [C] [Y^x] [(] [4] [÷] [3] [)]

〔AER〕→〔COMP〕

Decimal position : 5 [CL] [TAB] [5]

[COMP] [•] [0] [1] [5] [COMP] [1] [•] [4] [2] [COMP]
[•] [5] [5] [5] [COMP] [1] [0] [0] [0] [COMP] → 0.99472

No. 6 | **ITEM:** Head lost by inflow

FORMULA:

$$h_i = f_i \frac{V_2^2}{2g}$$

h_i = Head of entrance loss (m)
V_2 = Velocity after the entrance (m/sec)
f_i = Coefficient of entrance loss
g = Gravity acceleration (9.8m/sec^2)

EXAMPLE:

$f_i = 0.2$
$V_2 = 1.4$ m/sec
→ $h_i = 0.02$ (m)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	f_i	V_2								
EL−5101	f_i	V_2								

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [2ndF] [f()=] [A] [B] [x^2] [÷] [1] [9] [•] [6]

〔AER〕→〔COMP〕

Decimal position: 2 [CL] [TAB] [2]

[COMP] [•] [2] [COMP] [1] [•] [4] [COMP] → 0.02

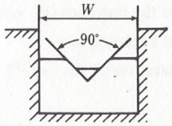
CIVIL ENGINEERING

No. 7	ITEM: Measurement of discharge by Weir, etc.

FORMULA:

$$Q=60\left(1.334+\frac{0.0205}{\sqrt{H}}\right)H^{\frac{5}{2}}$$

In which, $\theta=90^\circ$ $H > 50\text{mm}$, $W > 7H$, $d > 3H$

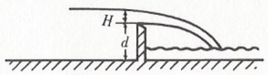


Q : Discharge (m^3/min)

H : Depth of water flowing over the weir (m)

W : Width of channel (m)

d : Height of crest above the bottom of channel (m)



EXAMPLE:

$H = 0.05\,\text{m}$ → $Q = 0.048$ (m^3/min)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	H									
EL−5101	H									

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [2ndF] [f()=] [6] [0] [×] [(] [1] [•] [3] [3] [4] [+] [•] [0] [2]
[0] [5] [÷] [√] [A] [)] [×] [A] [y^x] [2] [•] [5]

〔AER〕→〔COMP〕

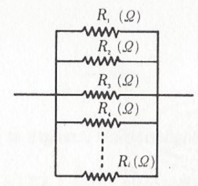
Decimal position : 3 [CL] [TAB] [3]

[COMP] [•] [0] [5] [COMP] → 0.048

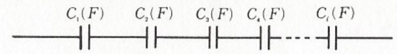
ELECTRICITY

No. 1	ITEM: Calculation of parallel resistance & series capacitance

FORMULA:



$$R_0=\frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}+\cdots\cdots+\frac{1}{R_i}} \quad (\Omega)$$



$$C_0=\frac{1}{\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}+\frac{1}{C_4}+\cdots\cdots+\frac{1}{C_i}} \quad (F)$$

EXAMPLE:

$R_1 = 1$ (Ω)
$R_2 = 2$ (Ω)
$R_3 = 3$ (Ω)
$R_4 = 4$ (Ω)
→ $R_0 = 0.48$ (Ω)

$C_1 = 1$ (F)
$C_2 = 2$ (F)
$C_3 = 3$ (F)
$C_4 = 4$ (F)
→ $C_0 = 0.48$ (F)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	R_i or C_i	$\sum_{x=1}^{i} R_x^{-1}$ or $\sum_{x=1}^{i} C_x^{-1}$								
EL−5101	R_i or C_i	$\sum_{x=1}^{i} R_x^{-1}$ or $\sum_{x=1}^{i} C_x^{-1}$								

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [2ndF] [f()=]
[B] [+] [A] [x^{-1}] [STO] [B] [x^{-1}]

〔AER〕→〔COMP〕

Decimal position: 2 [CL] [TAB] [2]

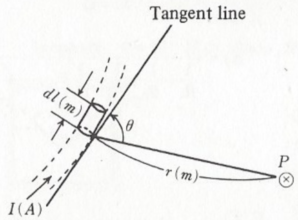
[0] [STO] [B]

[COMP] 1 [COMP] [COMP] 2 [COMP] [COMP] 3 [COMP] [COMP] 4 [COMP] → 0.48

ELECTRICITY

No. 2	ITEM: Vio Savare's method

FORMULA:



Magnetic field strength at the point P:

$$dH=\frac{I\cdot dl\cdot \sin\theta}{4\pi r^2}\ \text{[AT/m]}$$

EXAMPLE:

$\theta=30^\circ$
$I=5\text{A}$
$dl=1\text{mm}=1\times10^{-3}\text{m}$
$r=1\text{m}$

$\rightarrow dH=1.98944\times10^{-4}\,\text{[AT/m]}$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	I	dl	r	θ						
EL−5101	I	dl	r	θ						

OPERATION:

Angular mode : DEG
→ [AER]

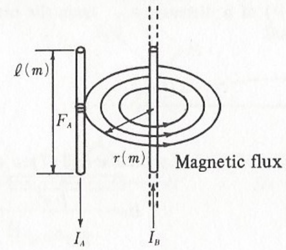
[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [2ndF] [f()=]
[A] [B] [×] [SIN] [D] [÷] [4] [π] [C] [x^2]

[AER]→[COMP]
Decimal position: 5 [CL] [TAB] [5]
[COMP] [5] [COMP] [1] [Exp] [(−)] [3] [COMP]
1 [COMP] [3] [0] [COMP] → 0.00020
[F↔E] → 1.98944 E −04
(1.98944×10^{-4})

ELECTRICITY

No. 3	ITEM: Power acting between electric current

FORMULA:



When currents I_A (A) and I_B (A) run through conductors A and B which are r meters apart from each other, force F (N) acting on each conductor ℓ (m) is computed by applying the equation;

$$F=\mu_0\frac{I_A I_B l}{2\pi r}\ \text{[N]}$$

$$\mu_0=1.25664\times10^{-6}\ H\cdot m^{-1}$$

EXAMPLE:

I_A (Current) = 2A
I_B (Current) = 4A
μ_0 (Magnetic permiability) = 1.25664 x 10^{-6} H/m → $F=1.60000\times10^{-5}$
l (Length of conductor) = 1m
r (Distance between A and B) = 0.1m

Enter μ_0 in the COMP mode.

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	μ_0	I_A	I_B	l	r					
EL−5101	μ_0	I_A	I_B	l	r					

OPERATION:

→ [AER]

[2ndF] [CA] [2ndF] [f()=] [B] [C] [D] [E] [2ndF] [f()=]
[A] [B] [C] [D] [÷] [2] [π] [E]

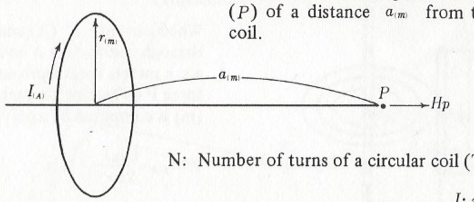
[AER]→[COMP]
Decimal position: 5 [CL] [TAB] [5]
[1] [•] [2] [5] [6] [6] [4] [Exp] [(−)] [6] [STO] [A]
[COMP] [2] [COMP] [4] [COMP] [1] [COMP] [•] [1] [COMP] → 0.00002
[F↔E] → 1.60000 E -05
(1.60000×10^{-5})

ELECTRICITY

No. 4	ITEM: Magnetic field strength on the central axis of a circular coil

FORMULA:

To calculate the magnetic field strength (Hp) at a point (P) of a distance $a_{(m)}$ from the central axis of a circular coil.



N: Number of turns of a circular coil (T)

$$H_P = \frac{I \cdot r^2}{2(r^2+a^2)^{\frac{3}{2}}} \cdot N \quad (A/m)$$

EXAMPLE:

$I = 2A$
$r = 5cm = 5\times10^{-2}m$
$a = 0.05m$
$N = 20$

$\rightarrow H_P = 1.41421\times10^2 \ (A/m)$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	I	r	a	N						
EL−5101	I	r	a	N						

OPERATION:

→〔AER〕

2ndF CA 2ndF f()= A B C D 2ndF f()=

D A B x² ÷ 2 ÷ (B x² + C x²)

Yˣ 1 • 5

〔AER〕→〔COMP〕

Decimal position: 5 CL TAB 5

COMP 2 COMP 5 Exp (−) 2 COMP

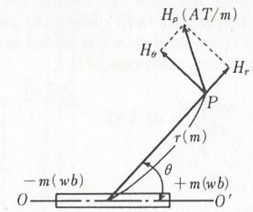
• 0 5 COMP 2 0 COMP → 141.42136

F↔E → 1.41421 E 02
(1.41421×10^2)

ELECTRICITY

No. 5	ITEM: Magnetic field strength by a micro magnet

FORMULA:



When a very small magnet with the intensity of magnet pole of $m\,(wb)$ is put in the medium whose magnetic permeability is $\mu\,(=\mu_S\,\mu_0)$, the intensity of magnetic field H_p at a point $P \cdot r$ meters away from the axis 00' with the angle of θ to this axis is determined in the following equation;

$$H_P = \sqrt{H_r^2 + H_\theta^2} = \frac{1}{4\pi\mu_S\,\mu_0} \cdot \frac{m}{r^3}\sqrt{1+3\cos^2\theta}$$

$$\mu_S = 1 + \frac{x}{\mu_0}$$

$$\mu_0 = 1.25664\times10^{-6} \ (H\cdot m^{-1})$$

$\frac{x}{\mu_0}$ = : Specific permiability

EXAMPLE:

$\theta = 60°$
$m = 5wb$
$\frac{x}{\mu_0} = 3.65\times10^{-7}$
$r = 2m$

$\rightarrow H_P = 5.23574\times10^4$

↓Enter μ_0 in the COMP mode

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	μ_0	$\frac{x}{\mu_0}$	r	m	θ					
EL−5101	μ_0	$\frac{x}{\mu_0}$	r	m	θ					

OPERATION:

Angular mode : DEG
→〔AER〕

2ndF CA 2ndF f()= B C D E 2ndF f()=

D ÷ 4 π A C Yˣ 3 ÷ (1 + B)

× √ (1 + 3 × (cos E) x²)

〔AER〕→〔COMP〕

Decimal position: 5 CL TAB 5

1 • 2 5 6 6 4 Exp (−) 6 STO A

COMP 3 • 6 5 Exp (−) 7 COMP 2

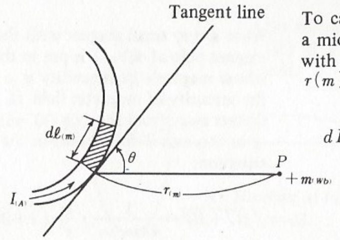
COMP 5 COMP 6 0 COMP → 52357.40815

F↔E → 5.23574 E 04
(5.23574×10^4)

ELECTRICITY

No. 6	ITEM: Electromagnetic power

FORMULA:



To calculate the force (dF) which the conductor receive at a microscopic part (dl), when the positive magnetic pole with the strength of $m(wb)$ is placed at a point P of distance $r(m)$ from the conductor (dl).

$$dF=\frac{mI\sin\theta}{4\pi r^2}\ dl\ (N)$$

EXAMPLE:

$\theta=30°$
$dl=1\text{mm}=1\times10^{-3}\text{m}$
$m=5\text{wb}$ → $dF=9.94718\times10^{-4}\ (N)$
$I=5\text{A}$
$r=1\text{m}$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	θ	m	I	r	dl					
EL−5101	θ	m	I	r	dl					

OPERATION:

Angular mode : DEG
→〔AER〕

2ndF CA 2ndF f()= A B C D E 2ndF f()=
B C E × SIN A ÷ 4 π D x²

〔AER〕→〔COMP〕

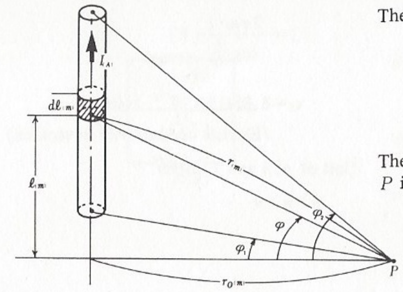
Decimal position: 5 CL TAB 5

COMP 3 0 COMP 5 COMP 5 COMP
1 COMP 1 Exp (−) 3 COMP → 0.00099
F↔E → 9.94718 E −04
(9.94718×10⁻⁴)

ELECTRICITY

No. 7	ITEM: Compound magnetic field by a direct electric current

FORMULA:



The intensity of a magnetic field formed at the point P is,

$$\therefore dH=\frac{I\cos\varphi}{4\pi r^2}\ dl\,[\text{A/m}]$$

$$l=r_0\tan\varphi$$

$$dl=r_0\sec^2\varphi\cdot d\varphi$$

The intensity of the resultant magnetic field at the point P is,

$$\therefore H=\frac{I}{4\pi r_0}\int_{\varphi_1}^{\varphi_2}\cos\varphi\cdot d\varphi$$

$$=\frac{I}{4\pi r_0}(\sin\varphi_2-\sin\varphi_1)\,[\text{A/m}]$$

EXAMPLE:

$\varphi_1=27°$
$\varphi_2=75°$
$r_0=4\text{m}$
$I=2\text{A}$

To calculate a composite magnetic field (H) at a point P.

→ $H=2.03693\times10^{-2}\ (\text{AT/m})$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	I	r_0	φ_1	φ_2						
EL−5101	I	r_0	φ_1	φ_2						

OPERATION:

Angular mode : DEG
→〔AER〕

2ndF CA 2ndF f()= A B C D 2ndF f()=
A × (SIN D − SIN C) ÷ 4 π B

〔AER〕→〔COMP〕

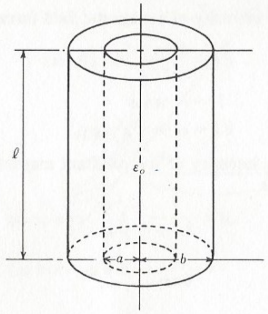
Decimal position: 5 CL TAB 5

COMP 2 COMP 4 COMP 2 7 COMP 7 5 COMP → 0.02037
F↔E → 2.03693 E −02
(2.03693×10⁻²)

ELECTRICITY

No. 8 **ITEM:** Capacity of static electricity concentric cylinder

FORMULA:



$$C=\frac{2\pi\varepsilon_0\cdot l}{\log\frac{b}{a}}\ (F)$$

$\varepsilon_0=8.85419\times10^{-12}$ F/m

(Electric conductivity in vacuum)

Unit of a, b and l :meter

$b>a>0$

EXAMPLE:

$a=1\text{mm}=1\times10^{-3}\text{m}$
$b=2\text{mm}=2\times10^{-3}\text{m}$
$\varepsilon_0=8.85419\times10^{-12}\text{F/m}$
$l=10\text{cm}=0.1\text{m}$

$\rightarrow C=1.848\times10^{-11}\ (F)$

Enter ε_0 in COMP mode

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	a	b	l	ε_0						
EL−5101	a	b	l	ε_0						

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [2ndF] [f()=]

[2] [π] [D] [C] [÷] [2ndF] [LOG] [(] [B] [÷] [A] [)]

〔AER〕→〔COMP〕

Decimal position: 3 [CL] [TAB] [3]

[8] [•] [8] [5] [4] [1] [9] [Exp] [(−)] [1] [2] [STO] [D]

[COMP] [1] [Exp] [(−)] [3] [COMP] [2] [Exp] [(−)] [3]

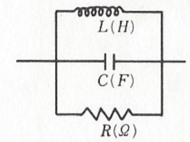
[COMP] [•] [1] [COMP] → 0.000

[F↔E] → 1.848 E −11
(1.848×10^{-11})

ELECTRICITY

No. 9 **ITEM:** Impedance (RLC parallel circuit)

FORMULA:



$$Z=\frac{1}{\sqrt{\frac{1}{R^2}+\left(\frac{1}{\omega L}-\omega C\right)^2}}$$

$$\theta=\tan^{-1}R\left(\frac{1}{\omega L}-\omega C\right)$$

$$\omega=2\pi f$$

EXAMPLE:

$R=100\Omega$
$L=5\text{H}$
$C=3\text{PF}=3\times10^{-12}F$
$f=50\text{Hz}$

$\rightarrow Z=9.97980\times10^{-1}$
$\theta=3.64264$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	$f\rightarrow2\pi f$	R	C	L						
EL−5101	$f\rightarrow2\pi f$	R	C	L						

OPERATION:

Angular mode : DEG

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [2ndF] [f()=] [2] [π] [A] [STO] [A]

[B] [x^{-1}] [→POL] [(] [1] [÷] [A] [D] [−] [A] [C] [)] [=] [x^{-1}] [,]

[J] ([E] for EL-5101)

〔AER〕→〔COMP〕

Decimal position: 5 [CL] [TAB] [5]

[COMP] [5] [0] [COMP] [1] [0] [0] [COMP] [3] [Exp] [(−)] [1] [2]

[COMP] 5 [COMP] → 99.79797

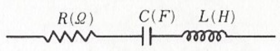
[F↔E] → 9.97980 E 01(Z)

[COMP] → 3.64264 (θ)

ELECTRICITY

No. 10 | **ITEM:** Impedance (RLC series circuit)

FORMULA:



$$Z=\sqrt{R^2+(\omega L-\frac{1}{\omega C})^2}$$

$$\theta=\tan^{-1}\left(\frac{\omega L-\frac{1}{\omega C}}{R}\right)$$

$$\omega=2\pi f$$

EXAMPLE:

$R=100\Omega$
$L=5\text{H}$
$G=3\mu F=3\times10^{-6}F$
$f=50\text{Hz}$

$\rightarrow$ $Z=519.47925$, $\theta=78.90126$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	$f\to2\pi f$	R	C	L						
EL−5101	$f\to2\pi f$	R	C	L		╳	╳	╳	╳	╳

OPERATION:

Angular mode : DEG
→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [2ndF] [f()=] [2] [π] [A] [STO] [A]

[B] [→POL] [(] [A] [D] [−] [1] [÷] [A] [C] [)] [,] [J] ([E] for EL-5101)

〔AER〕→〔COMP〕
Decimal position: 5 [CL] [TAB] [5]

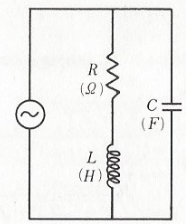
[COMP] [5] [0] [COMP] [1] [0] [0] [COMP] [3] [Exp] [(−)] [6]

[COMP] [5] [COMP] → 519.47925 (Z)
[COMP] → 78.90126 (θ)

ELECTRICITY

No. 11 | **ITEM:** Resonance frequency in a resonance parallel circuit

FORMULA:



Resonance frequency:

$$f_r=\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\frac{R^2}{L^2}} \quad (\text{Hz})$$

EXAMPLE:

$R=3\Omega$
$C=2\mu F=2\times10^{-6}F$ $\rightarrow$ $f_r=5.03291\times10^{1}$ (Hz)
$L=5\text{H}$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	R	C	L							
EL−5101	R	C	L			╳	╳	╳	╳	╳

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [2ndF] [f()=]

[√] [(] [1] [÷] [B] [C] [−] [A] [x²] [÷] [C] [x²] [)] [÷] [2] [π]

〔AER〕→〔COMP〕
Decimal position: 5 [CL] [TAB] [5]

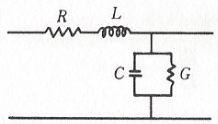
[COMP] [3] [COMP] [2] [EXP] [(−)] [6]

[COMP] [5] [COMP] → 50.32912
[F↔E] → 5.03291 E 01
(5.03291×10^{1})

ELECTRICITY

No. 12	ITEM: Constant distribution circuit –5100 only

FORMULA:



Series impedance $\dot{Z}=\sqrt{R^2+(\omega L)^2}\cdot\epsilon^{j\theta Z}$, $\theta z=\tan^{-1}\frac{\omega L}{R}$

Parallel admittance $\dot{Y}=\sqrt{G^2+(\omega C)^2}\cdot\epsilon^{j\theta Y}$, $\theta y=\tan^{-1}\frac{\omega C}{G}$

where, $\omega=2\pi f$

① Characteristic impedance

$$\dot{Z}_0=\sqrt{\frac{\dot{Z}}{\dot{Y}}}=Z_0\cdot\epsilon^{j\theta 0}$$

$$Z_0=\sqrt{\frac{\sqrt{R^2+(\omega L)^2}}{\sqrt{G^2+(\omega C)^2}}}\ (\Omega)$$

$$\theta_0=\frac{1}{2}(\tan^{-1}\frac{\omega L}{R}-\tan^{-1}\frac{\omega C}{G})\ (\mathrm{rad/Km})$$

② Propagation constant

$$r=\sqrt{\dot{Z}\dot{Y}}$$

$$=\sqrt[4]{(R^2+(\omega L)^2)\cdot(G^2+(\omega C)^2)}\ \epsilon j\ \frac{\theta_z+\theta_y}{2}$$

$$=\alpha+j\beta$$

$$\alpha=\sqrt{\sqrt{R^2+(\omega L)^2}\cdot\sqrt{G^2+(\omega C)^2}}\cdot\cos\ (\frac{\theta_z+\theta_y}{2})\ (Np/Km)$$

$$\beta=\sqrt{\sqrt{R^2+(\omega L)^2}\cdot\sqrt{G^2+(\omega C)^2}}\cdot\sin\ (\frac{\theta_z+\theta_y}{2})\ (rad/Km)$$

R: Resistance per unit line (Ω/Km)
L: Inductance per unit line (H/Km)
C: Capacitance per unit line (F/Km)
G: Leakage conductance per unit line (Ω/Km)

EXAMPLE:

$f=60$Hz
$R=1.25\Omega$/Km
$L=2.86$mH/Km
$G=0$
$C=0.075\mu F$

→

$Z_0=241.63\Omega$/Km
$\theta_0=-0.43$rad/Km
$\alpha=2.85\times10^{-3}$Np/Km
$\beta=6.21\times10^{-3}$rad/Km

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	$f\to 2\pi f$	$R\to\sqrt{R^2+(\omega L)^2}$	$L\to\theta_z$	$G\to\sqrt{G^2+(\omega C)^2}$	$C\to\theta_Y$					
EL−5101										

OPERATION:

Angular mode: RAD

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [E] [2ndF] [f()=] [2] [π] [A] [STO] [A]

[B] [→POL] [A] [C] [STO] [B] [J] [STO] [C]

[D] [→POL] [A] [E] [STO] [D] [J] [STO] [E]

[√] [B] [D] [x⁻¹] [,] [(] [C] [−] [E] [)] [÷] [2] [,]

[(] [√] [B] [D] [)] [2ndF] [→REC] [(] [(] [C] [+] [E] [)] [÷] [2] [)] [,] [J]

〔AER〕→〔COMP〕

Decimal position: 2 [CL] [TAB] [2]

[COMP] [6] [0] [COMP] [1] [•] [2] [5] [COMP]

[2] [•] [8] [6] [EXP] [(−)] [3] [COMP] [0] [COMP]

[•] [0] [7] [5] [EXP] [(−)] [6] [COMP] → 241.63 (Z_0)

[COMP] → −0.43 (θ_0)

[COMP] [F↔E] → 2.85E −03(2.85×10^{-3}) (α)

[COMP] [F↔E] → 6.21E −03(6.21×10^{-3}) (β)

ELECTRICITY

No. 13	ITEM: The 3/2 power rule (Triode)

FORMULA:

Ip : Anode current of the triode in space charge area.

$$Ip=K(Eg+\frac{Ep}{\mu})^{\frac{3}{2}}\ (A)$$

Eg : Grid voltage (V)
Ep : Anode voltage (V)
μ : Amplification degree
K : Perveance

EXAMPLE:

$\mu=10$
$Ep=100$V
$Eg=-5$V
$K=2\times10^{-3}$

→ $Ip=2.236\times10^{-2}\ (A)$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	K	Eg	Ep	μ						
EL−5101	K	Eg	Ep	μ						

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [2ndF] [f()=]

[A] [×] [(] [B] [+] [C] [÷] [D] [)] [yˣ] [1] [•] [5]

〔AER〕→〔COMP〕

Decimal position: 3 [CL] [TAB] [3]

[COMP] [2] [EXP] [(−)] [3] [COMP] [(−)] [5] [COMP]

[1] [0] [0] [COMP] [1] [0] [COMP] → 0.022

[F↔E] → 2.236E −02
(2.236×10^{-2})

ELECTRICITY

No. 14 | **ITEM:** Equivalent resistance of noise (Pentode)

FORMULA:

$$Req=\frac{2.5}{g_m}\,\frac{Ip}{Ip+Ig_2}\,(1+\frac{8Ig_2}{g_m})\quad(\Omega)$$

Ip : Anode current (A)
Ig_2 : Screen-grid current (A)
g_m : Mutual conductance

EXAMPLE:

$Ip=9.5\text{mA}=9.5\times10^{-3}\ (A)$
$Ig_2=2.8\text{mA}=2.8\times10^{-3}\ (A)\quad\rightarrow\ Req=1.43662\times10^{3}\ (\Omega)$
$g_m=6.2\text{mV}=6.2\times10^{-3}\ (V)$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	g_m	Ip	Ig_2							
EL−5101	g_m	Ip	Ig_2							

OPERATION:

→ [AER]

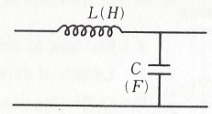
[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [2ndF] [f()=]
[2] [•] [5] [B] [×] [(] [1] [+] [8] [C] [÷] [A] [)]
[÷] [A] [÷] [(] [B] [+] [C] [)]

[AER]→[COMP]
Decimal position: 5 [CL] [TAB] [5]
[COMP] [6] [•] [2] [Exp] [(−)] [3]
[COMP] [9] [•] [5] [Exp] [(−)] [3]
[COMP] [2] [•] [8] [Exp] [(−)] [3] [COMP] → 1436.61751
[F↔E] → 1.43662 E 03
(1.43662×10^{3})

ELECTRICITY

No. 15 | **ITEM:** Planning of regular K-type filter

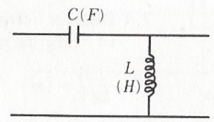
FORMULA:



Low-pass filter

$L=\frac{K}{2\pi f_1}\quad(H)$

$C=\frac{1}{2\pi f_1 K}\quad(F)$



High-pass filter

f_1 = cut-off frequency (r)
K = Nominal inpedance (Hz)

EXAMPLE:

$f_1=500\text{KHz}=5\times10^{5}\text{Hz}\quad\rightarrow\quad L=1.90986\times10^{-1}\text{mH}$
$K=600\Omega\qquad\qquad C=5.30516\times10^{2}\ \text{pF}$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	$f_1\rightarrow 2\pi f_1$	K								
EL−5101	$f_1\rightarrow 2\pi f_1$	K								

OPERATION:

→ [AER]

[2ndF] [CA] [2ndF] [f()=] [A] [B] [2ndF] [f()=] [2] [π] [A] [STO] [A]
[B] [A] [x^{-1}] [,] [1] [÷] [A] [B]

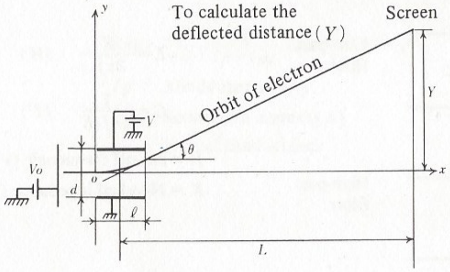
[AER]→[COMP]
Decimal position: 5 [CL] [TAB] [5]
[COMP] [5] [Exp] [5] [COMP] [6] [0] [0] [COMP] → 0.00019
[F↔E] → 1.90986 E −04 $(H)(L)$
($1.90986\times10^{-1}mH$)
[COMP] → 0.00000
[F↔E] → 5.30516 E −10 $(F)(C)$
($5.30516\times10^{2}pF$)

ELECTRICITY

No. 16 | **ITEM:** Leaning to static electricity of a cathode-ray tube

FORMULA:

To calculate the deflected distance (Y)



d : Distance of deflecting plates (m)
l : Length of deflecting plate (m)
V : Deflecting plate voltage (V)
V_0 : Acceleration voltage (V)
L : Distance between the center of deflecting plate and screen (m)

$$Y=\frac{LlV}{2dV_0} \quad (m)$$

EXAMPLE:

$d = 1\text{cm} = 1\times10^{-2}\text{m}$
$l = 3\text{cm} = 3\times10^{-2}\text{m}$
$L = 30\text{cm} = 3\times10^{-1}\text{m}$ → $Y = 4.500\times10^{-2}\text{m}$
$V = 200\text{V}$
$V_0 = 2\text{KV} = 2\times10^{3}\text{V}$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	L	l	V	V_0	d					
EL−5101	L	l	V	V_0	d					

OPERATION:

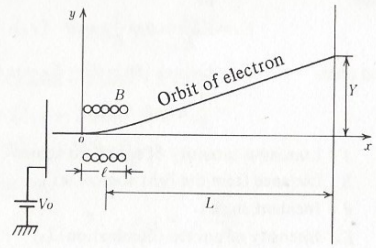
→ 〔AER〕
[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [E] [2ndF] [f()=]
[A] [B] [C] [÷] [2] [E] [D]

〔AER〕→〔COMP〕
Decimal position: 3 [CL] [TAB] [3]
[COMP] [3] [Exp] [(−)] [1]
[COMP] [3] [Exp] [(−)] [2]
[COMP] [2] [0] [0] [COMP] [2] [Exp] [3]
[COMP] [1] [Exp] [(−)] [2] [COMP] → 0.045
[F↔E] → 4.500 E −02
(4.500×10^{-2})

ELECTRICITY

No. 17 | **ITEM:** Leaning to electromagnetism of a cathode-ray tube

FORMULA: To calculate the deflected distance (Y).



B Intensity of magnetic field
l Area of magnetic field (m)
V_0 Acceleration voltage (V)
L Distance between the center of deflecting coil and screen (m)

$$Y=\frac{0.297LBl}{\sqrt{V_0}} \quad (m)$$

EXAMPLE:

$V_0 = 2\text{kv} = 2\times10^{3}\text{v}$
$L = 30\text{cm} = 3\times10^{-1}\text{m}$
$l = 3\text{cm} = 3\times10^{-2}\text{m}$ → $Y = 2.032$ (m)
$B = 3.4\times10^{4}$ Gauss

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	l	L	B	V_0						
EL−5101	l	L	B	V_0						

OPERATION:

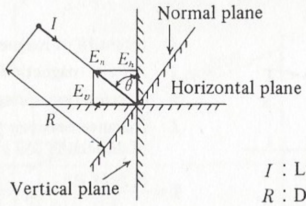
→ 〔AER〕
[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [2ndF] [f()=]
[•] [2] [9] [7] [A] [B] [C] [÷] [√] [D]

〔AER〕→〔COMP〕
Decimal position: 3 [CL] [TAB] [3]
[COMP] [3] [Exp] [(−)] [2] [COMP] [3] [Exp] [(−)] [1]
[COMP] [3] [•] [4] [Exp] [4] [COMP] [2] [Exp] [3] [COMP] → 2.032 (m)

ELECTRICITY

No. 18	ITEM: Illuminance of a point light source

FORMULA:



$E_n = \dfrac{I}{R_2}$ [l_x]

$E_h = E_n \cos\theta = \dfrac{I}{R^2}\cos\theta$ [l_x]

$E_v = E_h \cos(90° - \theta) = E_h \sin\theta$

$= \dfrac{I}{R^2}\sin\theta$ [l_x]

I : Luminous intensity of spot light source [cd]
R : Distance from the light source [m]
θ : Incident angle
E_n : Intensity of normal illumination [I_x]
E_h : Intensity of horizontal illumination [I_x]
E_v : Intensity of vertical illumination [I_x]

EXAMPLE:

$I = 100$cd $E_n = 25.000$ (L_x)
$R = 2$m → $E_h = 21.651$ (L_x)
$\theta = 30°$ $E_v = 12.500$ (L_x)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	I	$R \to 1/R^2$	θ							
EL−5101	I	$R \to 1/R^2$	θ							

OPERATION:

Angular mode : DEG
→ [AER]

2ndF CA 2ndF f()= A B C 2ndF f()= A ÷ B x^2 STO B ,
B 2ndF →REC C , J (E for EL-5101)

[AER] → [COMP]

Decimal position: 3 CL TAB 3

COMP 1 0 0 COMP 2 COMP 3 0 COMP → 25.000 (E_n)
COMP → 21.651 (E_h)
COMP → 12.500 (E_v)

ENGINEERING

No. 1	ITEM: Moment of Inertia of (N) Elements

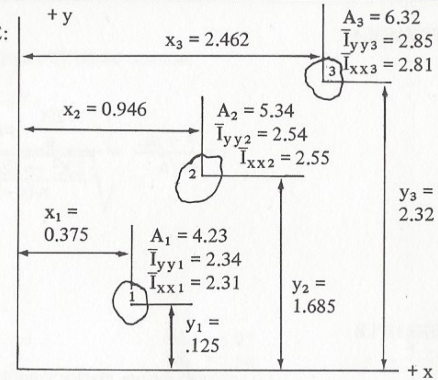
FORMULA:

1. $\bar{x} = \dfrac{\Sigma Ax}{\Sigma A}$ 2. $\bar{y} = \dfrac{\Sigma Ay}{\Sigma A}$
3. $I_{xy} = \Sigma Axy - \bar{y}\Sigma Ax - \bar{x}\Sigma Ay + \bar{x}\bar{y}\Sigma A$
4. $I_{yy} = \Sigma Ax^2 + \Sigma \bar{I}_{yy} - \Sigma(A_y)^2 \div A$
5. $I_{xx} = \Sigma Ay^2 + \Sigma \bar{I}_{xx} - \Sigma(Ay)^2 \div A$

Radius of Gyration:

6. $\rho_{xx} = \sqrt{\dfrac{I_{xx}}{A}}$ 7. $\rho_{yy} = \sqrt{\dfrac{I_{yy}}{A}}$

EXAMPLE:



OPERATION:

MODE KEY IN:
STAT .375 x,y .125 x 4.23 DATA
.946 x,y 1.685 x 5.34 DATA
2.462 x,y 2.32 x 6.32 DATA

Notes:
x_1 x,y y_1 x A_1 DATA
x_2 x,y y_2 x A_2 DATA
x_n x,y y_n x A_n DATA

→ [AER]

2ndF CA 2ndF f(A B 2ndF)=
F ÷ E STO C , I ÷ E STO
D , H − D F − C I +
C D E , G + A − F x^2
÷ E STO C , J + B −
I x^2 ÷ E STO D , √ (
C ÷ E , √ (D ÷ E

[AER → COMP]

COMP

COMP A =?: = 7.73 $\Sigma\bar{I}_{yy} = 2.34 + 2.54 + 2.85 = 7.73$
COMP B =?: = 7.67 $\Sigma\bar{I}_{xx} = 2.31 + 2.55 + 2.81 = 7.67$

From STAT Mode:
$E = \Sigma A$, $F = \Sigma Ax$, $G = \Sigma Ax^2$, $H = \Sigma Axy$,
$I = \Sigma Ay$ $J = \Sigma Ay^2$

COMP	1.396962240	Answer 1	$\bar{x}$
COMP	1.522281309	Answer 2	$\bar{y}$
COMP	11.01793397	Answer 3	I_{xy}
COMP	20.40263064	Answer 4	I_{yy}
COMP	20.09178455	Answer 5	I_{xx}
COMP	1.133133646	Answer 6	ρ_{yy}
COMP	1.124468535	Answer 7	ρ_{xx}

Compliments of
Paul Kollmeyer

STATISTICS

No. 1	ITEM: t-Test

FORMULA:

$$t=\frac{\bar{X}-\mu_0}{s/\sqrt{n}}=\frac{\frac{\Sigma X}{n}-\mu_0}{\sqrt{\frac{\Sigma X^2-n(\Sigma X/n)^2}{n(n-1)}}}=\frac{\frac{F}{E}-A}{\sqrt{\frac{G-E(F\div E)^2}{E(E-1)}}}$$

EXAMPLE:

Note: Before placing your data for X and Y in the STAT mode put the formula in the AER mode.

In the STAT mode:

Store memory	Contents
E	n
F	Σx
G	Σx^2
H	Σxy
I	Σy
J	Σy^2

MEMORY	A	B	C	D	E	F	G	H	I	J
EL-5100	μ_0									

OPERATION:

→ (AER)

[2ndF] [CA] [2ndF] [f()=] [A]

1; f(A) = (F ÷ E–A) ÷ √ ((G–E x(F ÷ E)^2) ÷ (E x(E–1_

(AER) → (COMP)

Decimal position: [CL] [TAB] [3]

[COMP] A= ? (Place in value of μ_0)

COMP (Value of t)

$t > t_a$ or $t < t_a$

Compliments of
Morton Rosenstein

SURVEYING

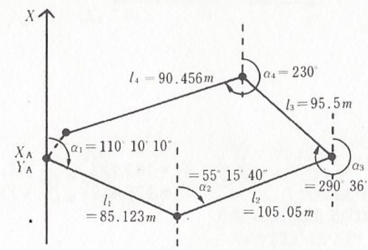
No. 1	ITEM: Closed traverse

FORMULA:

This program computes the coordinate by closed traverse.
Error of closure of latitudes = $\Sigma\Delta X_i$
Error of closure of longitudes = $\Sigma\Delta Y_i$
Sum of distance = Σl_i

$$\text{Accuracy}=\frac{\Sigma l_i}{\sqrt{(\Sigma\Delta x_i)^2+(\Sigma\Delta y_i)^2}}$$

EXAMPLE:



→ $\Sigma\Delta x_i = 5.97$
$\Sigma\Delta y_i = 7.54$
$\Sigma l_i = 376.13$
Accuracy = 39.11

Clear the memory before calculation

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	$\Sigma\Delta x_i$	$\Sigma\Delta y_i$	Σl_i	l_i $\to\Delta X_i$	α_i					$\to\Delta Y_i$
EL−5101	$\Sigma\Delta x_i$	$\Sigma\Delta y_i$	Σl_i	l_i $\to\Delta X_i$	α_i $\to\Delta Y_i$					

OPERATION:

Angular mode : DEG

→ (AER)

[2ndF] [CA] [2ndF] [f()=] [D] [E] [2ndF] [f()=] [D] [+] [C] [STO] [C] [D] [2ndF] [→REC] [E] [→DEG] [STO] [D] [,]

[D] [+] [A] [STO] [A] [E] [+] [B] [STO] [B] [E] [,]

↑[J] for EL-5100 ↑[J] for EL-5100

[A] [,] [B] [,] [C] [,] [C] [÷] [√] [(] [A] [x^2] [+] [B] [x^2] [)]

(AER) → (COMP)

Decimal position : 2 [CL] [TAB] [2]

[0] [STO] [A] [0] [STO] [B] [0] [STO] [C]

[COMP] [8] [5] [•] [1] [2] [3] [COMP] [1] [1] [0] [•] [1] [0] [1] [0] [COMP] [COMP] [COMP] [COMP] [COMP] [COMP]

[COMP] [1] [0] [5] [•] [0] [5] [COMP] [5] [5] [•] [1] [5] [4] [0] [COMP] [COMP] [COMP] [COMP] [COMP] [COMP]

[COMP] [9] [5] [•] [5] [COMP] [2] [9] [0] [•] [3] [6] [COMP] [COMP] [COMP] [COMP] [COMP] [COMP]

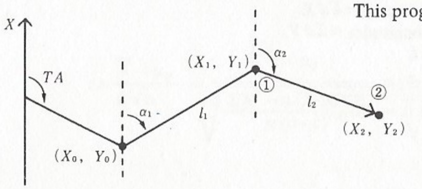
[COMP] [9] [0] [•] [4] [5] [6] [COMP] [2] [3] [0] [COMP] [COMP] [COMP] → 5.97 ($\Sigma\Delta x_i$)
[COMP] → 7.54 ($\Sigma\Delta y_i$)
[COMP] → 376.13 (Σl_i)
[COMP] → 39.11 (Accuracy)

SURVEYING

No. 2	ITEM: Open traverse

FORMULA:

This program computes the coordinates of an open traverse.



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

EXAMPLE:

$X_0 = 100$
$Y_0 = 100$
$l_1 = 50.123, \quad \alpha_1 = 30°30'40''$
$l_2 = 71.234, \quad \alpha_2 = 100°35'55''$

$\rightarrow$ ① $\left(\begin{array}{l} X_1 = 143.183 \\ Y_1 = 125.448 \end{array} \right.$ ② $\left(\begin{array}{l} X_2 = 130.081 \\ Y_2 = 195.466 \end{array} \right.$

Store the contents of X_0, Y_0 before calculation

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	X_{i-1}	Y_{i-1}	l_i	α_i						
EL−5101	X_{i-1}	Y_{i-1}	l_i	α_i						

OPERATION:

Angular mode : DEG
→ [AER]

[2ndF] [CA] [2ndF] [f()=] [C] [D] [2ndF] [f()=] [C] [2ndF] [→REC] [D] [→DEG] [+] [A] [STO] [A] [,]
[E] [+] [B] [STO] [B]
↑
([J] for EL-5100)

[AER] → [COMP]
Decimal position: 3 [CL] [TAB] [3]

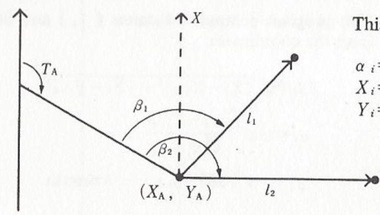
[1] [0] [0] [STO] [A] [1] [0] [0] [STO] [B]
[COMP] [5] [0] [•] [1] [2] [3] [COMP] [3] [0] [•] [3] [0] [4] [0] [COMP] → 143.183
[COMP] → 125.448
[COMP] [7] [1] [•] [2] [3] [4] [COMP] [1] [0] [0] [•] [3] [5] [5] [5] [COMP] → 130.081
[COMP] → 195.466

SURVEYING

No. 3	ITEM: Radiate traverse

FORMULA:

This program computes the coordinate by radiate traverse.



$\alpha_i = T_A + \beta_i + 180°$ (Field angle)
$X_i = X_A + l_i \cos \alpha_i$
$Y_i = Y_A + l_i \sin \alpha_i$

EXAMPLE:

$X_A = 200$
$Y_A = 200$
$T_A = 110°20'30''$

$\left(\begin{array}{l} l_1 = 50.123 \\ \beta_1 = 95°10'20'' \end{array} \right.$ $\left(\begin{array}{l} X_1 = 245.235 \\ Y_1 = 221.589 \end{array} \right.$

$\rightarrow$

$\left(\begin{array}{l} l_2 = 71.234 \\ \beta_2 = 123°45'12'' \end{array} \right.$ $\left(\begin{array}{l} X_2 = 241.775 \\ Y_2 = 257.699 \end{array} \right.$

Store the contents of T_A, X_A, Y_A before calculation

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	T_A	X_A	Y_A	l_i	β_i					
EL−5101	T_A	X_A	Y_A	l_i	β_i					

OPERATION:

Angular mode : DEG
→ [AER]

[2ndF] [CA] [2ndF] [f()=] [D] [E] [2ndF] [f()=] [D] [2ndF] [→REC] [(] [E] [→DEG] [+] [A] [→DEG] [+] [1] [8] [0]
↓ ([J] for EL-5100)
[)] [+] [B] [,] [E] [+] [C]

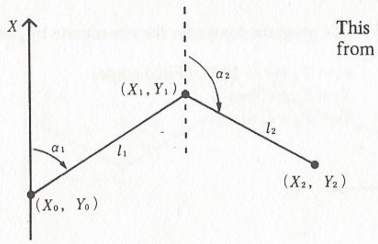
[AER] → [COMP]
Decimal position : 3 [CL] [TAB] [3]

[1] [1] [0] [•] [2] [0] [3] [0] [STO] [A] [2] [0] [0] [STO] [B] [2] [0] [0] [STO] [C]
[COMP] [5] [0] [•] [1] [2] [3] [COMP] [9] [5] [•] [1] [0] [2] [0] [COMP] → 245.235
[COMP] → 221.589
[COMP] [7] [1] [•] [2] [3] [4] [COMP] [1] [2] [3] [•] [4] [5] [1] [2] [COMP] → 241.775
[COMP] → 257.699

SURVEYING

No. 4	ITEM: Inverse calculation

FORMULA:



This program computes distance (l_i) and field angles (α_i) from the coordinates.

$$l_i = \sqrt{(X_i - X_{i-1})^2 + (Y_i - Y_{i-1})^2}$$

$$\alpha_i = \tan^{-1}\frac{Y_i - Y_{i-1}}{X_i - X_{i-1}}$$

$\alpha_i < 0$: $360 + \alpha_i \cdots\cdots$ Azimuth

EXAMPLE:

$\begin{pmatrix} X_0 = 2 \\ Y_0 = 1 \end{pmatrix}$ $\begin{pmatrix} l_1 = 3.6056 \\ \alpha_1 = 56°18'35'' \end{pmatrix}$

$\begin{pmatrix} X_1 = 4 \\ Y_1 = 4 \end{pmatrix}$ → $\begin{pmatrix} l_2 = 2.2361 \\ \alpha_2 = 116°33'54'' \end{pmatrix}$

$\begin{pmatrix} X_2 = 3 \\ Y_2 = 6 \end{pmatrix}$

Store the contents of X_0, Y_0 before calculation

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	X_{i-1}	Y_{i-1}	X_i	Y_i						
EL−5101	X_{i-1}	Y_{i-1}	X_i	Y_i						

OPERATION:

Angle mode : DEG

→ [AER]

[2ndF] [CA] [2ndF] [f()=] [C] [D] [2ndF] [f()=] [(] [C] [−] [A] [)] [→POL] [(] [D] [−] [B] [)] [,]

[C] [STO] [A] [D] [STO] [B] [E] [2ndF] [→D.MS] [,] [3] [6] [0] [+] [E] [=] [2ndF] [→D.MS]

([J] for EL-5100) ([J] for EL-5100)

[AER] → [COMP]

Decimal position : 4 [CL] [TAB] [4]

[2] [STO] [A] [1] [STO] [B]

[COMP] [4] [COMP] [4] [COMP] → 3.6056

[COMP] → 56.1835 (56°18'35")

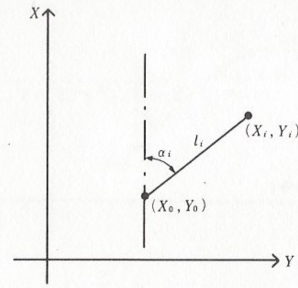
[COMP] [COMP] [3] [COMP] [6] [COMP] → 2.2361

[COMP] → 116.3354 (116°33'54")

SURVEYING

No. 5	ITEM: Inverse radiate calculation

FORMULA:



$$l_i = \sqrt{(X_i - X_0)^2 + (Y_i - Y_0)^2}$$

$$\alpha_i = \tan^{-1}\frac{Y_i - Y_0}{X_i - X_0}$$

$\alpha_i < 0$: $360 + \alpha_i \cdots\cdots$ Azimuth

EXAMPLE:

(X_0, Y_0) : (4.2, 5.3) → l_i = 7.0328

(X_i, Y_i) : (7.7, 11.4) α_i = 60°9'14"

Store the contents of X_0, Y_0 before calculation

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	X_0	Y_0	X_i	Y_i						
EL−5101	X_0	Y_0	X_i	Y_i						

OPERATION:

Angule mode : DEG

→ [AER]

[2ndF] [CA] [2ndF] [f()=] [C] [D] [2ndF] [f()=] [(] [C] [−] [A] [)] [→POL] [(] [D] [−] [B] [)] [,]

[E] [2ndF] [→D.MS] [,] [3] [6] [0] [+] [E] [=] [2ndF] [→D.MS]

([J] for EL-5100) ([J] for EL-5100)

[AER] → [COMP]

Decimal position : 4 [CL] [TAB] [4]

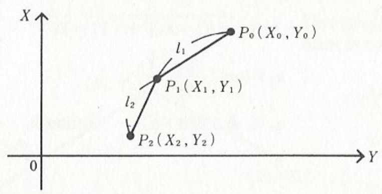
[4] [•] [2] [STO] [A] [5] [•] [3] [STO] [B]

[COMP] [7] [•] [7] [COMP] [1] [1] [•] [4] [COMP] → 7.0328 (l_i)

[COMP] → 60.0914 (60°9'14") (α_i)

No. 6 **ITEM:** Distance between two points

FORMULA:



$$l_i = \sqrt{(X_i - X_{i-1})^2 + (Y_i - Y_{i-1})^2}$$

EXAMPLE:

	X coordinates	Y coordinates	Distance
P_0	214.123	167.508	
P_1	179.173	146.524	40.7656(l_1)
P_2	151.968	132.560	30.5795(l_2)

Clear the memory before calculation

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	X_{i-1}	Y_{i-1}	X_i	Y_i	l_i					
EL−5101	X_{i-1}	Y_{i-1}	X_i	Y_i	l_i					

OPERATION:

→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [C] [D] [2ndF] [f()=] [√‾] [(] [(] [C] [−] [A] [)] [x^2] [+] [(] [D] [−] [B]
[)] [x^2] [)] [STO] [E] [C] [STO] [A] [D] [STO] [B] [E]

〔AER〕→〔COMP〕

Decimal position : 4 [CL] [TAB] [4]

[0] [STO] [A] [0] [STO] [B]

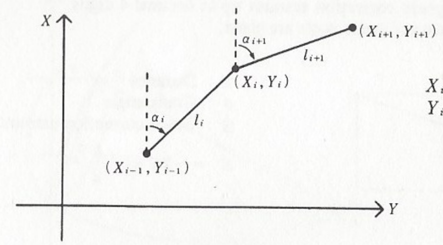
[COMP] [2] [1] [4] [•] [1] [2] [3] [COMP] [1] [6] [7] [•] [5] [0] [8] [COMP]

[COMP] [1] [7] [9] [•] [1] [7] [3] [COMP] [1] [4] [6] [•] [5] [2] [4] [COMP] → 40.7656 (l_1)

[COMP] [1] [5] [1] [•] [9] [6] [8] [COMP] [1] [3] [2] [•] [5] [6] [0] [COMP] → 30.5795 (l_2)

No. 7 **ITEM:** Calculation of coordinates

FORMULA:



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

EXAMPLE:

X	Y	l_i	α_i
4.2	5.3		
7.7	11.4	7	60° 20′ 14″
10.1	19.0	8	72° 30′ 24″

Store the contents of X_0, Y_0 before calculation

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	X_{i-1}	Y_{i-1}	l_i	α_i						
EL−5101	X_{i-1}	Y_{i-1}	l_i	α_i						

OPERATION:

Angular mode : DEG

→〔AER〕

([E] for EL-5101)

[2ndF] [CA] [2ndF] [f()=] [C] [D] [2ndF] [f()=] [C] [2ndF] [→REC] [D] [→DEG] [+] [A] [STO] [A] [,] [J] [+] [B]
[STO] [B]

〔AER〕→〔COMP〕

Decimal position : 1 [CL] [TAB] [1]

[4] [•] [2] [STO] [A] [5] [•] [3] [STO] [B]

[COMP] [7] [COMP] [6] [0] [•] [2] [0] [1] [4] [COMP] → 7.7 (X)

[COMP] → 11.4 (Y)

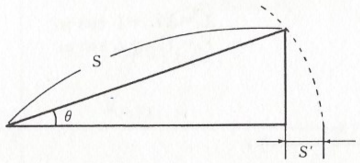
[COMP] [8] [COMP] [7] [2] [•] [3] [0] [2] [4] [COMP] → 10.1 (X)

[COMP] → 19.0 (Y)

No. 8	ITEM: Calculation of the angle of slope to correct

FORMULA:

Determine the grade correction amount up to decimal 4 digits when the distance and grade angle are given.



S : Distance
θ : Grade angle
S': Grade correction amount

$$S' = -2S \sin^2 \frac{\theta}{2}$$

EXAMPLE:

$S = 15.891$
$\theta = 19°55'00''$ → $S' = 0.9505$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	S	θ								
EL−5101	S	θ								

OPERATION:

Angular mode : DEG
→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [2ndF] [f()=] [(−)] [2] [A] [×] [(] [SIN] [•] [5] [B] [→DEG] [)] [x^2]

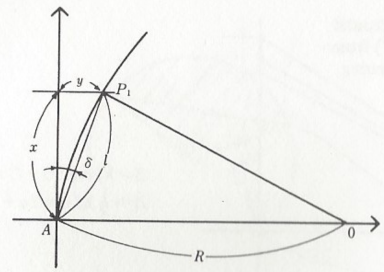
〔AER〕→〔COMP〕
Decimal position: 4 [CL] [TAB] [4]

[COMP] [1] [5] [•] [8] [9] [1] [COMP]

[1] [9] [•] [5] [5] [0] [0] [COMP] → −0.9505

No. 9	ITEM: Setting of a simple curve by offsets from tangent

FORMULA:



x : Distance in the tangential direction from the beginning of curve
y : Distance of offset cooresponding to x
δ : Deflection angle
R : Radius of curve

$$y = l \sin\delta = 2R \sin^2\delta$$
$$x = l \cos\delta = 2R \sin\delta \cdot \cos\delta$$
$$= R \sin 2\delta$$

EXAMPLE:

$R = 200$ → $x = 11.745$
$\delta = 1°41'00''$ → $y = 0.345$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	R	δ								
EL−5101	R	δ								

OPERATION:

Angular mode : DEG
→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [2ndF] [f()=] [A] [×] [SIN] [2] [B] [→DEG] [,]
[2] [A] [×] [(] [SIN] [B] [→DEG] [)] [x^2]

〔AER〕→〔COMP〕
Decimal position: 3 [CL] [TAB] [3]

[COMP] [2] [0] [0] [COMP]

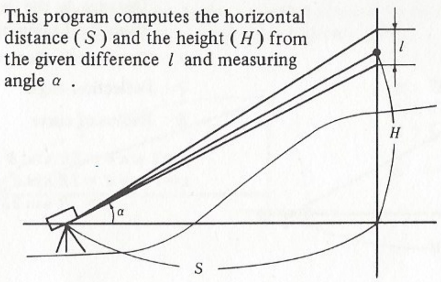
[1] [•] [4] [1] [0] [0] [COMP] → 11.745 (x)
[COMP] → 0.345 (y)

SURVEYING

No. 10 | **ITEM:** Tachymetry

FORMULA:

This program computes the horizontal distance (S) and the height (H) from the given difference l and measuring angle α .



$$S=Kl\cos^2\alpha+C\cos\alpha$$
$$H=\frac{1}{2}Kl\sin 2\alpha+C\sin\alpha$$

EXAMPLE:

α = 8°47′
l = 1.325 (m)
K = 100
C = 0.3

→ S = 129.707 (m)
H = 20.041 (m)

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	K	C	l	α						
EL−5101	K	C	l	α						

OPERATION:

Angular mode : DEG
→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [C] [D] [2ndF] [f()=] [D] [→DEG] [STO] [D] [A] [C] [×] [(] [COS] [D] [)]
[x²] [+] [B] [×] [COS] [D] [,] [A] [C] [÷] [2] [×] [SIN] [2] [D] [+] [B] [×] [SIN] [D]

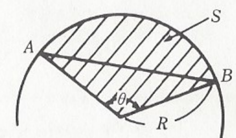
〔AER〕→〔COMP〕
Decimal position: 3 [CL] [TAB] [3]

[COMP] [1] [0] [0] [COMP] [•] [3] [COMP]
[1] [•] [3] [2] [5] [COMP] [8] [•] [4] [7] [COMP] → 129.707
[COMP] → 20.041

SURVEYING

No. 11 | **ITEM:** Calculation of a simple curve

FORMULA:



$$\theta=2\cdot\sin^{-1}\frac{\overline{AB}}{2R}$$
$$S=R^2\pi\frac{\theta}{360}$$

EXAMPLE:

R = 45
$\overline{AB}$ = 31.415 → S = 722.040

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	$\overline{AB}$	R								
EL−5101	$\overline{AB}$	R								

OPERATION:

Angular mode : DEG
→〔AER〕

[2ndF] [CA] [2ndF] [f()=] [A] [B] [2ndF] [f()=] [2] [×] [2ndF] [SIN⁻¹] [(] [A] [÷] [2] [B] [)] [÷] [3] [6]
[0] [×] [π] [B] [x²]

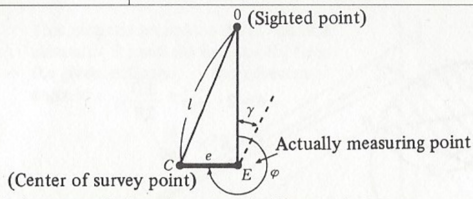
〔AER〕→〔COMP〕
Decimal position: 3 [CL] [TAB] [3]

[COMP] [3] [1] [•] [4] [1] [5] [COMP]
[4] [5] [COMP] → 722.040

SURVEYING

No. 12	ITEM: Regression to the center

FORMULA:



When it is supposed that the eccentric distance is $CE = e$, distance between the survey point and sighted point is $C0 = l$ and the azimuth of actually surveying point is φ, it is needed to compensate for the correct direction $C0$ by γ.
In $\triangle 0CE$, the following equations are established according to the sine proportion formula;

$$\frac{e}{\sin\gamma} = \frac{l}{\sin(360° - \varphi)}$$

$$\therefore \sin\gamma = \frac{e\sin(360° - \varphi)}{l}$$

($\gamma = \sin\gamma$ can be applied in general because γ is too small.)

$$\therefore \gamma = \sin^{-1}\frac{e\sin(360° - \varphi)}{l}$$

(This equation is employed for the program.)

EXAMPLE:

$\varphi = 271°34'22''$
$e = 3.185$ → $\gamma = 0°02'40''$
$l = 4108.3$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	l	e	φ							
EL−5101	l	e	φ							

OPERATION:

Angular mode : DEG
→ [AER]

2ndF CA 2ndF f()= A B C 2ndF f()= 2ndF SIN⁻¹ (B × SIN (3 6 0 − C

→DEG) ÷ A) = 2ndF →D.MS

[AER] → [COMP]

Decimal position: 4 CL TAB 4

COMP 4 1 0 8 • 3 COMP

3 • 1 8 5 COMP

2 7 1 • 3 4 2 2 COMP → 0.0239 (0°02′40″)

SURVEYING

No. 13	ITEM: Area conversion

FORMULA:

Area calculation by double meridian distance (DMD)

ΔX_i : Latitude
ΔY_i : Departure

$$D.M.D_i = D.M.D_{i-1} + \Delta Y_{i-1} + \Delta Y_i$$
$$\Delta S_i = D.M.D_i \times \Delta X_i$$
Area: $S = \Sigma \Delta S_i$

EXAMPLE:

Boundary	Side length l_i [m]	Azimuth α_i	DMD D.M.D_i	Double area
1	16.25	92° 31′	16.23433	−11.58380
2	10.01	0° 0′	32.46865	325.01122
3	5.46	270° 04′	27.00866	0.17159
4	6.65	0° 02′	21.55253	143.32430
5	10.78	271° 20′	10.77932	2.70388
6	16.21	180° 00′	0.00224	−0.03625

S = 229.79547

$l_i \to \Delta X_i$

MEMORY	A	B	C	D	E	F	G	H	I	J
EL−5100	$\Sigma\Delta S_i$	DMD_{i-1}	ΔY_{i-1}		α_i					ΔY_i
EL−5101	$\Sigma\Delta S_i$	DMD_{i-1}	ΔY_{i-1}							

$\alpha_i \to \Delta X_i$

Clear the memory before calculation

OPERATION:

Angular mode : DEG
→ [AER]

(J for EL-5100)

2ndF CA 2ndF f()= D E 2ndF f()= D 2ndF →REC E →DEG STO D B + C + E STO

B , E STO C A + B D STO A B D , A ÷ 2

(J for EL-5100)

[AER] → [COMP]

Decimal position: 5 CL TAB 5

0 STO A 0 STO B 0 STO C

COMP 1 6 • 2 5 COMP 9 2 • 3 1 COMP → 16.23433 (D.M.Di)
COMP → −11.58380 (Double area)
COMP COMP 1 0 • 0 1 COMP 0 COMP → 32.46865
COMP → 325.01122
COMP COMP 5 • 4 6 COMP 2 7 0 • 0 4 COMP → 27.00866
COMP → 0.17159
COMP COMP 6 • 6 5 COMP • 0 2 COMP → 21.55253
COMP → 143.32430
COMP COMP 1 0 • 7 8 COMP 2 7 1 • 2 0 COMP → 10.77932
COMP → 2.70388
COMP COMP 1 6 • 2 1 COMP 1 8 0 COMP → 0.00224
COMP → −0.03625
COMP → 229.79547 (S)

SHARP ELECTRONICS CORPORATION
10 Keystone Place
Paramus, New Jersey 07652

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