CE 371 Surveying

TRAVERSING _4

Coordinate geometry

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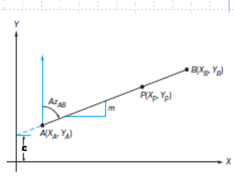
Overview

- The Use of Rectangular Coordinates
- Coordinates of Unoccupied Points
- Missing Line in Traversing

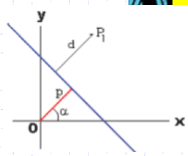
The Use of Rectangular Coordinates

- The equation of straight line is
- $Y = mX + c$
- $m = \frac{\Delta Y}{\Delta X}$
- $c = Y - mX = Y - \frac{\Delta Y}{\Delta X}X$
- $Y = \frac{\Delta Y}{\Delta X}X + (Y - \frac{\Delta Y}{\Delta X}X)$
- Multiplying by ΔX
- $\Delta X.Y = \Delta Y.X + (\Delta X.Y - \Delta Y.X)$
- $\Delta Y.X - \Delta X.Y + (\Delta X.Y - \Delta Y.X) = 0$
- $a.X + b.Y + c = 0$
- Where:
- $a = \Delta Y$ $b = -\Delta X$ $c = \Delta X.Y - \Delta Y.X$



Perpendicular distance from a point to a line

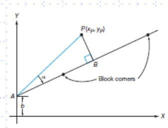
$$d = \frac{ax_1 + by_1 + c}{\pm\sqrt{a^2 + b^2}}$$



- where the sign of the radical is taken opposite to that of c if c≠ 0 and the same as that of b if c = 0.
- The distance d is positive if P_1 is on the opposite side of the line from the origin and negative if it is on the same side of the line as the origin.

Perpendicular distance from a point to a line

- Compute Az_{AB}
- Compute Az_{AP}
- $\alpha = Az_{AB} - Az_{AP}$
- Compute the length AP
- PB = AP sin(α)

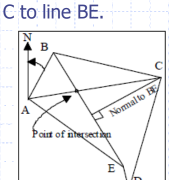


Example

- The coordinates of stations for the shown traverse are given in the table below. Compute the following:

1. Length of line BE.
2. Azimuth of line BE
3. Coordinates of the intersection of lines AC & BE.
4. Normal distance from point C to line BE.

Sta	X	Y
A	1.000	1.000
B	1.125.66	1.255.96
C	1.716.29	1.102.38
D	1.523.57	408.32
E	1.517.53	611.29



Solution

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1) Length of line BE

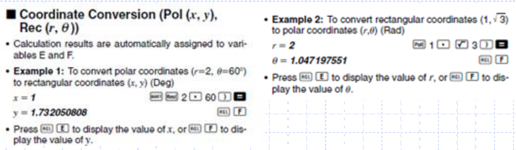
ΔX_{BE} = XE - XB = 1517.53 - 1125.66 = 391.87 m

ΔY_{BE} = YE - YB = 611.29 - 1255.96 = -644.67 m

$L_{BE}=\sqrt{(\Delta X_{BE})^2+(\Delta Y_{BE})^2}=754.43 m.$

2) Azimuth of line BE

$Az_{BE}=\arctan(\Delta X_{BE}/\Delta Y_{BE})+180^o=148^o 42' 22''$



■ Coordinate Conversion (Pol (x, y), Rec (r, θ))

- Calculation results are automatically assigned to variables E and F.
- **Example 1:** To convert polar coordinates (r=2, θ=60°) to rectangular coordinates (x, y) (Deg)

  x = **1** [SHIFT] [Rec] 2 [,] 60 [)] [=]

  y = **1.732050808** [RCL] [F]
- Press [RCL] [E] to display the value of x, or [RCL] [F] to display the value of y.
- **Example 2:** To convert rectangular coordinates (1, $\sqrt{3}$) to polar coordinates (r,θ) (Rad)

  r = **2** [Pol] 1 [,] [√] 3 [)] [=]

  θ = **1.047197551** [RCL] [F]
- Press [RCL] [E] to display the value of r, or [RCL] [F] to display the value of θ.

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Solution

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3) Point of intersection of lines AC and BE is found by solving equations of AC and BE simultaneously. The table below shows the constants a, b, and c

Const	Line BE	Line AC
a	$+\Delta Y_{BE}=-644.67$	$+\Delta Y_{AC}=102.38$
b	$-\Delta X_{BE}=-391.87$	$-\Delta X_{AC}=-716.29$
c	$Y_B\Delta X_{BE}-X_B\Delta Y_{BE}=1217852.3$	$Y_A\Delta X_{AC}-X_A\Delta Y_{AC}=613910.0$
Eqns	$\mathbf{-644.67X-391.87Y+1217852.3=0}$	$\mathbf{102.38X-716.29Y+613910.0=0}$

The coordinates of the point of intersection: (1258.77,1036.99).

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Solution cont.

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4. Normal distance from C to line BE is found from

- $d=\frac{-644.67X-391.87Y+1217852.3}{-\sqrt{(644.67)^2+(391.87)^2}}$
- Substitute coordinates of C(1716.29, 1102.38) into the right hand side

- d= 0.854515020(1716.29) + 0.519426685(1102.38) − 1614.2725
- d= 424.93m

- Therefore, the normal distance = 424.93 m

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Circle in rectangular coordinates

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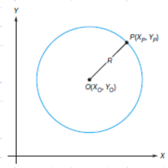
The equation of a circle with radius R and center at (X_o, Y_o) is:

$$(X - X_o)^2 + (Y - Y_o)^2 = R^2$$



Example

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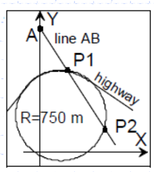
A circular arc of a highway has a radius=750 m, and a center at X_o= 255.35 m, Y_o= 655.10 m. Determine the coordinates of the point of intersection of this arc with line AB, where (X_A, Y_A)= (0.00, 1844.20) and Az_{AB}=150.000º.



Solution:

Line AB equation and circular curve equation are:

$(Y - 1844.20)/(X - 0.00) = 1/\tan(150^o)$ (I)

$(X - 255.35)^2 + (Y - 655.10)^2 = 750.00^2$ (II)

Equation (I) can be written as:

$Y = 1844.20 + X/\tan(150^o)$ (III)

From (III) into (II) yields:

$(X - 255.35)^2 + (1844.20 + X/\tan(150^o) - 655.10)^2 = 750.00^2$

Example cont.

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Expanding, rearranging, and collecting terms gives the quadratic equation:

$4X^2 - 4629.86X + 916662.43 = 0$ (IV)

The solution of the quadratic equation is:

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

$$X = \frac{4629.86 \pm \sqrt{21435603.6 - 14666598.9}}{8} = 903.95 \quad \text{or } 253.52 \text{ m}$$

Substituting (V) back into (III) gives:

Y = 278.51 or 1405.09 m.

From the figure, the point of intersection is P1(253.52, 1405.09).

Coordinates of Unoccupied Points

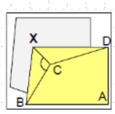
- There are points that cannot be included in the traverse because it is not possible to set up the instrument over them.
- Such points are connected to the traverse stations by tie lines whose lengths and azimuths are used to determine the coordinates of the unoccupied points.
- Unoccupied points can be a nail in a tree, a fence corner, or a chimney.

Example

- A map is to be drawn for a tract of land ABXD. Point X is a corner of a building and can not be occupied by the total station. Therefore, traverse ABCD is run. Coordinates of traverse stations are given below. Angle to the right at C from B to X is 100.5635°. Length of CX is 70.34 m. Compute coordinates of the unoccupied point X.

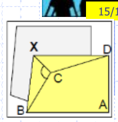
X_A	Y_A	X_B	Y_B	X_C	Y_C	X_D	Y_D
810.55	125.83	510.45	130.15	600.76	218.15	805.19	250.23

- Solution



Example cont.

- Solution
  - ΔX_{CB}=510.45-600.76= -90.31
  - ΔY_{CB}=130.15-218.15= -88.00



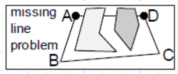
- Az_{CB}= arctan(-90.31/-88.00) +180 = 225.7422°
- Az_{CX}=Az_{CB}+ Ar_{BCX} = 225.7422+100.5635 = 326.3057°

  - ΔX_{CX}=L_{CX} sin (Az_{CX}) = 70.34 sin(326.3057)= -39.022
  - ΔY_{CX}=L_{CX} cos (Az_{CX}) = 70.34 cos(326.3057)= 58.524

- X_X= X_C+ ΔX_{CX} = 600.76 -39.022 = 561.738
- Y_X= Y_C+ ΔY_{CX} = 218.15 +58.524 = 276.674

Missing Line in Traversing

- An open traverse (traverse ABCD in the figure) can be used to determine the distance between two points (distance AD in the figure). Such line is called a missing line.



- Example:
- In order to determine length of AD, the following measurements are made:
- L_{AB}=150.54 m, L_{BC}=410.34 m, L_{CD}=120.04 m,
- Angle to the right at B and C are Ar_B=60.0876° , Ar_C=70.4340°. Compute length of AD. Let coordinates of A = (200.00, 100.00), and azimuth of AB = 200.0000°

Missing Line in Traversing con.

- Az_{BC} = BAz_{AB} + Ar_B = (200.000° - 180°) + 60.0876° = 080.0876°
- Az_{CD} = BAz_{BC} + Ar_C = (80.0876°+ 180°) +70.4340° = 330.5216°
-

Side	Length (m)	Azimuth	ΔX (m)	ΔY (m)
AB	150.54	200.0000°	-51.488	-141.461
BC	410.34	080.0876°	404.214	70.637
CD	120.04	330.5216°	-59.071	104.500
DA	?	?	?	?
Σ			293.655	33.676

ΔX_{DA}=-293.655
ΔY_{DA}=-33.676

- L_{DA}= 295.580 Az_{DA}= 263.4580°

Summary

- The Use of Rectangular Coordinates
- Coordinates of Unoccupied Points
- Missing Line in Traversing