BASIC SURVEYING
UNIT-1

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Surveying

- Science, Art and technology of determining or locating position on, above or beneath the surface of earth.
- It is that discipline which includes all methods of measurement for collection of data and processing information about physical earth and environment and decimating in different forms as suitable for a purpose.

Objective of Surveying

- To prepare plan of existing land use or cover etc.
- To measure area and volume of a land cover / use
- To set out points on ground for laying out a construction project.

Summery

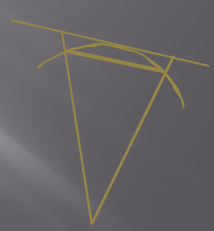
- *Surveying has to do with the determination of the relative position of points*
- *It is the art of*
  - *Measuring horizontal and vertical distances between objects,*
  - *Measuring the direction of lines and angles between lines,*
  - *Establishing points by predetermined angular and linear measurements.*
- *Along with the actual survey measurements, computations are involved*
- *Distances, angles, directions, locations, elevations, areas, and volumes are thus determined from the data of the survey.*
- *Survey data is portrayed graphically with the construction of maps, profiles, cross sections, tables and diagrams*

Principles of Surveying

- To work from whole to part
  - To control propagation of errors
    - The area is divided into parts using control points
    - Location of control points are established with high accuracy
    - Each part is measured separately
    - The error in measurement of a part is not transferred to other part
- Redundant observations
  - To check consistency of observations
    - Different alternatives measurements are carried out
    - results are compared to check consistency

Classification of Surveying

- Primary
  - Plane Surveying
    - Curvature of earth not considered
    - Straight lines
  - Geodetic
    - Curvature of earth considered
    - Curved Lines



The course is limited to Plane surveying only

Classification of Surveying

- Secondary
  - Based on Instruments
    - Chain surveying
    - Compass surveying
    - Levelling
    - Plane table surveying
    - Theodolite surveying
    - Tacheometric surveying
    - Photogrammetric surveying
    - GPS Surveying
    - Remote sensing

Classification of Surveying

contd

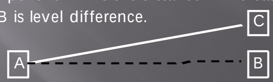
- Based on methods
  - Triangulation
  - Traverse
  - Trilateration
  - Tringulateration
  - Resection
- Based on object
  - Geological surveying
  - Mine surveying
  - Archaeological surveying
  - Engineering Surveying
  - Cadastral Surveying
  - Hydrographic Surveying etc.
- Based on nature of field
  - Land surveying
  - Marine surveying
  - Astronomical surveying

Plane Surveying Classification

- Topographical surveying
  - to determine the natural and artificial features of country such as rivers, lakes, hills, roads, railways, towns etc.
- Cadastral surveying
  - to determine the boundaries of fields, estates, houses, etc
- City surveying
  - to locate the premises, streets, water supply and sanitary system etc.
- Engineering surveying
  - to collect data for designing of engineering works such as roads, reservoirs, railways etc.

Distance

- Depends on Location of two points (X,Y,Z Coordinates)
- Can be considered as Horizontal and vertical distances
- Horizontal Distance is referred as distance whereas vertical distance is considered height.
- Surveying measures distance (Horizontal) and vertical distances separately.
- vertical distances are known as level (Elevation) difference between two points.
- Two points A and C constitute a straight line (length) whose horizontal component AB is the distance. Whereas vertical component CB is level difference.



Distance measurement

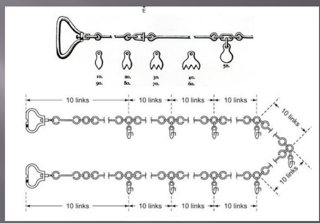
- Direct method
  - Measuring device directly follows the shortest path (along length) between two points
  - Pacing, passometer, pedometer, odometer, perambulator, chaining etc.
- Indirect method
  - Measuring instrument does not travel along the length.
  - Theodolite, tacheometer, GPS, Electronic Distance measurement etc.

Chain Surveying

- Only linear measurements are made in the field.
- Suitable for surveys of the small extent on open ground to obtain data for an exact description of the boundaries of a piece of land or to take simple details.
- The principle of chain survey or Chain Triangulation, is to provide a skeleton or framework consisting of a number of connected triangles, as the triangle is the simplest shape that can be plotted from the lengths of measured sides.
- For good results in plotting, the framework should consist of triangles which are as nearly equilateral as possible.

Chain and Accessories

- Chain or Tape
- Arrow
- Peg
- Ranging Rod
- Offset rod



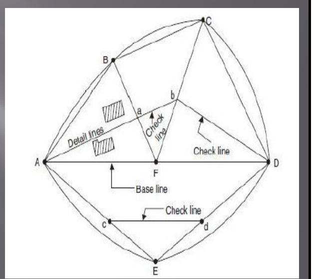
The use and details of other accessories shall be demonstrated during Practical Classes.

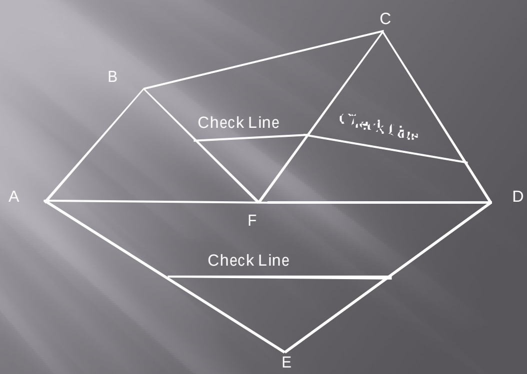
Types of Chains and Tapes

- Chains
  - Gunter's Chain
    - 66 ft long with 100 link
  - Engineer's Chain
    - 100 ft long with each link 1 ft
  - Metric Chain
    - 5, 10, 15, 20, or 30 m chain consisting of 20 cm links
- Tapes usually come in 5,10,15,20,30 m lengths graduated in mm
  - steel tapes
  - Cloth, Fiberglass, and PVC Tapes
    - Lower accuracy and stored on reels
  - Invar Tapes
    - Made of special nickel steel to reduce length variations due to temperature changes

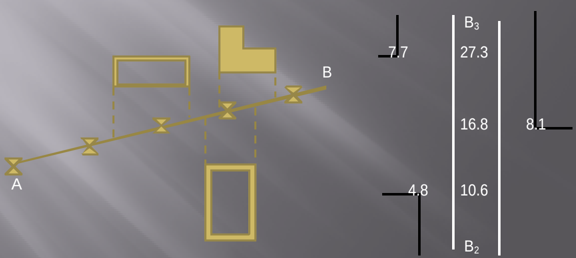
Chain Triangulation

- Area is divided in Triangles
- A base line is decided usually longest in the area to be surveyed
- Each side is measured
- Suitable offsets can be taken
- Few check lines are measured which are verified with their computed values.





Details and offsets

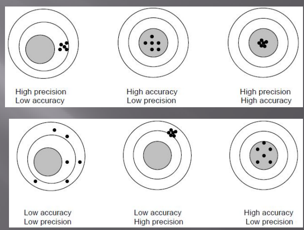


Errors

- Error is the difference between true value and observed value
- Types of Errors
  - Mistakes or Blunder
    - misunderstanding the problem, carelessness, fatigue (tiredness), missed communication and poor judgment
  - Systematic
    - Systematic errors can be determined and therefore corrected
    - Due to measuring system which includes instrument, observer and environment
    - magnitude and algebraic sign can be determined hence corrected
    - With constant measuring system, the systematic errors remain constant
  - Random or Accidental
    - Due to unknown reasons
    - errors remaining after elimination of mistakes and systematic errors
    - Smaller errors occur more frequently than larger ones
    - Change sign from positive to negative
- Sources of Errors
  - Environment, Instrument, Observer
- Nature of Error
  - Cumulative or Compensating

Precision and Accuracy

- Accuracy
  - absolute proximity of the observed value to the 'true' measurement
- Precision
  - how close is one measurement to another i.e. proximity of observations amongst themselves



A *known distance of 100m (i.e. true value) was measured three times by a surveying* student as 99.02m, 99.0m and 99.04m. This measurement is precise but not accurate.

Corrections to tape measurement

- Incorrect Tape Length Correction
- Temperature Correction
- Pull Correction
- Sag Correction
- Correction for Misalignment
- Slope correction

Incorrect Tape Length Correction

- Steel tapes may become damaged over time through "kinking", "stretching" or through breakage and repair. A kinked tape will have its length shorted somewhat and rather then discarding the instrument a tape correction can be applied as

$$C_L = \left(\frac{l - l'}{l'}\right) L$$

- Where
  - C_L is the correction applied to the recorded measurement
  - l is the actual tape length
  - l' is the nominal or designated tape length
  - L is the recorded or observed length

Incorrect Tape Length Correction example

- A measurement of 171.278 m was recorded with a 30-m tape that was only 29.996 m long under standard conditions. What is the corrected measurement?

$$C_L = \left(\frac{l - l'}{l'}\right) L$$

$$C_L = \left(\frac{29.996 - 30.000}{30.000}\right) 171.278$$

CL =(-133.33 X10^{-6}*)171.278 =* -0.022836*m*

Actual Length = Measured Length + CL

= 171.278 -0.022836 = 171.255 m

Temperature Correction

- Steel tapes are calibrated at a "standard" temperature
  - Above this temperature, the tape elongates and provides distances that are shorter then actual
  - Below this temperature the tape contracts to a shorter length and produces longer than actual distances
  - Can be determined as following

$$C_T = \alpha(T_1 - T)L$$

- Where
  - C_T is temperature correction
  - α is coefficient of thermal expansion
  - T_1 is tape temperature during measurement
  - T is the standard temperature

Temperature Correction Example

- You must lay out two points that are exactly 100.000 m apart. Field conditions indicate that standard conditions apply except the measured temperature is 27°C. Determine the distance to be laid out. α= *11.6X10*$^{-6}$ and standard temperature is 20°C.

$C_T = \alpha(T_1 - T)L$

$= 11.6\text{X}10^{-6}$ (27-20)100 =0.008 m

Distance to be laid should be (100.000-0.008) = 99.992 m

Pull Correction

- Steel tapes are calibrated at a "standard" pull or tension
  - Above this temperature, the tape elongates and provides distances that are shorter then actual
  - Below this temperature the tape contracts to a shorter length and produces longer than actual distances
  - depends on the cross-section area of the tape and its modulus of elasticity
  - Can be determined as following

$$C_P = (P_i - P)\frac{L}{AE}$$

Where
- C_P is correction due to pull
- E is the Young's modulus (Pa)
- A is the tape area (m2)
- P_1 is the tape tension during measurement (N)
- P is the standard pull (N)

Pull Correction example

- A 30-m tape is used with a 100N force instead of the standard tension of 50N. If the cross section area of the tape is 1.8 mm^2, what is the error due to pull per tape length? Modulus of elasticity E = 200x10^9 N / m^2

$$C_P = (P_i - P)\frac{L}{AE}$$

$$C_P = (100 - 50)\frac{30.000}{1.8X10^{-6}X\,200x10^9}$$

= 0.0042 m

The corrected tape length would be 30.004 m

Sag Correction

- Steel tapes provide direct measurement only when they are "fully supported" along their length
- when only end supports are provided, the tape sag in the form of a catenary and always produces a shorter tape length
- This shorting produces measurements longer than actual distances
- The sag error (B'B) depends on the pull tension (P_1), the weight of the tape per unit length (w) and the length of the sag tape (L), given as

$$C_S = \frac{w^2L^3}{24P_1^2}$$

Where
- C_s is the sag correction (m)
- P_1 is the tape tension during measurement (N)
- w is the weight of tape per unit length (N / m)
- L is the tape reading including sag (m)

Sag Correction example

- A 30-m tape is used with standard tension of 50N. However, the tape is supported at the ends only. If the unit weight of tape is 0.14N / m, determine the sag correction?

$$C_S = \frac{w^2L^3}{24P_1^2}$$

$$C_S = \frac{0.14^2\,X\,30.000^3}{24X\,50^2}$$

= - 0.0088 m

Corrected distance = 30.000 – 0.0088 = 29.991 m

Normal Tension

- Sag tends to shorten the tape and pull tends to extend it, therefore, a pull amount that will exactly balance the sag amount

$$(P_1 - P)\frac{L}{AE} = \frac{w^2L^3}{24P_1^2}$$

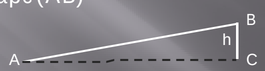
- Which gives

$$P_1 = \frac{0.204wL\sqrt{AE}}{\sqrt{P_1 - P}}$$

- P_1 is solved by trial and error

Slope Correction

- Two ends of tape (AB) not on same level h (BC) is the difference in vertical direction between two ends of tape (AB)



- Correction for Slope is can be computed as AB-AC
- Can be approximated as h^2 / 2L if AB is L
- Similar Corrections can be applied for **Misalignment**

Measurement along slope

- For a measured distance along slope, horizontal distance can be calculated. Horizontal length is less than length along slope For a given horizontal distance, slope distance can be calculated
- The increase in length along slope is called hypotenusal allowance

Horizontal Distance

- Horizontal distance AC =AB Cos θ = L Cos θ
- If difference in level BC (h) , Horizontal Distance = $\sqrt{L^2 - h^2}$
- If slope is in 1: n gradient then Horizontal Distance AC is equal to $\dfrac{L.n}{\sqrt{1+n^2}}$

Hypotenusal allowance

- Length along slope is always more than Hz Distance
- Measure distance AB_1 as L on slope and mark at B instead of B_1
- B_1B is hypotenusal allowance and is given by L(Sec θ -1)

Measurement of Directions

- Direction needs to be measured with reference to a fixed (Natural or Assumed) line. This reference is named Meridian.
- Direction of a survey line with respect to a meridian is known as bearing.
  - Natural
    - Magnetic meridian
      - the direction indicted by a freely suspended magnetic needle.
    - True meridian
      - line of intersection of earth's surface formed by a plane passing through north and south poles and the given place.
  - Assumed
    - Arbitrary meridian
      - any convenient direction assumed as meridian for measuring direction of survey lines
- Corresponding to every meridian there is a bearing i.e. Magnetic bearing, True Bearing, Arbitrary Bearing
- Magnetic bearing can be measured with a compass

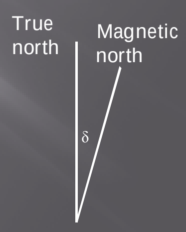
Declination and Dip

- the horizontal angle made by magnetic meridian and true meridian at a place is termed as magnetic declination
- The direction of magnetic meridian varies from place to place across the globe. Hence, the bearings taken with reference to magnetic meridian of the survey lines will not represent true relative angles between them.
- This deflection of the needle from the horizontal position in vertical plane is called dip of the needle.
- Apart from local effects due to presence of magnetic ores in ground or such other localised influences, the magnetic dip of the compass needle will vary from place to place

Declination

- Magnetic Declination (δ)= (True Bearing – Magnetic Bearing)
- +ve towards east and –ve towards west

If magnetic bearing of a line is $48^o 24'$, declination $5^o 38'$ West, True bearing will be $48^o 24' - 5^o 38' = 42^o 46'$

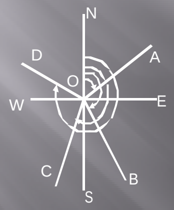


Variation of Declination

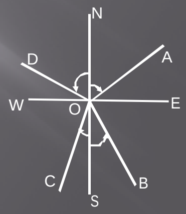
- **Secular Variation**
  - a slow continuous swing with a cycle of about 400 to 500 years
- **Diurnal Variation**
  - a swing of the compass needle about its mean daily position
- **Periodic Variation**
  - a minor variation of the magnetic meridian during the week, a lunar month, year, eleven years
- **Irregular Variation**
  - caused by magnetic storms which can produce sudden variations of the magnetic meridian

Bearing representation

- **Whole Circle Bearing**
  - measured clock wise from the direction of the north of the meridian towards the line around the circle



- **Quadrantal or reduced Bearing**
  - Measured from either the north or the south, clock wise or counter clockwise which ever is nearer to the line towards the east or west



Conversion of Bearings

- The whole circle bearing of a line can be converted to quadrantal bearing by reducing it to an angle less than 90^{o} which has the same numerical value of the trigonometric functions

S No	WCB	Quadrant	Rule
1	Between 0^{o} to 90^{o}	N.E.	Q.B = W.C.B
2	Between 90^{o} to 180^{o}	S.E.	Q.B = 180^{o}-W.C.B
3	Between 180^{o} to 270^{o}	S.W.	Q.B = W.C.B-180^{o}
4	Between 270^{o} to 360^{o}	N.W.	Q.B = 180^{o}-W.C.B

- Draw the diagram of bearing and conversion is easily evident rather than memorizing rule

Conversion of Bearings example

- Convert the following whole circle bearings of lines to quadrantal bearings

34^{o}, 112^{o}, 215^{o}, 313^{o}

Quadrantal

N 34^{o} E, S 68^{o} E, S 35^{o} W, N 47^{o} W

And vice versa

Compass

- Prismatic compass
- Surveyors compass

Prismatic and Surveyor compass differences

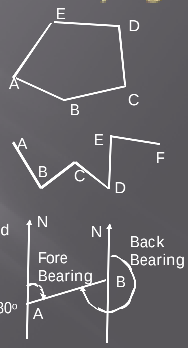
Item	Surveyors Compass	Prismatic compass
Graduated Ring	1. The graduated ring is attached to the box and rotates along with the line of sight. 2. The graduations have 0° at N and S., and 90° at E and W. The letters E and W are interchanged from their true positions to read the bearing in its proper quadrant (below fig.). As the graduated ring is attached to the box, it moves with the sight. If the hearing of a line in the first quadrant is to be measured, since the letters E and W are reversed from their natural positions, the proper quadrant NE will be read 3. The graduations are engraved erect, since the graduated ring is read directly	1. The graduated ring is attached with the needle and does not rotate with the line of sight 2. The graduations have 0° at S, 90° at W, 180° at N and 270° at E (as below fig.). When the needle points north, the reading under the prism should be zero. It is so because the prism is placed exactly opposite the object vane, i.e. on the observer's side, and the south end will be under the prism while the needle points north. Hence, the Zero is placed at the south end then the ring is graduated clockwise from it 3. Graduations are engraved inverted since the graduated ring is read through the prism

Prismatic and Surveyor compass differences

Magnetic Needle	The needle is of edge bar type	The needle is a broad needle.
Reading System	1. The readings are taken directly by seeing through the top of the box glass. 2. Sighting and reading cannot be done simultaneously.	1. The readings are taken with the help of a prism, provided at the eye vane. 2. Sighting and reading can be done simultaneously.
Tripod	The instrument cannot be used without a tripod.	The instrument can be held in hand also while taking observations.
Vanes	The eye vane consists of the small vane with a small slit.	The eye vane consists of a metal vane with a large slit.

Principle of Compass Surveying

- Compass surveying is based on concept of traversing
- traverse work consists of series of lines the lengths and directions
- Length is measured with chain or tape
- Directions are measured with a compass
- It can be either closed or open traverse
- Closed traverse form a closed polygon
- Open traverse do not form a closed polygon
- Every line has two directions forward (AB) and backward (BA)
- Forward direction is known as FORE bearing and backward direction is BACK bearing
- Difference between fore and back bearing is 180º



Included angles from bearings

- When two lines meet at a point two angles i.e., interior and exterior angles. Their sum is 360º
- There are two cases
  - W.C.B of two lines measured from their point of intersection
    - Subtract the smaller bearing from the greater one. The difference will be the included angle
  - W.C.B. of two lines not measured from their point of intersection
    - Compute the back bearing of a line at intersection point and apply the previous method
- Always draw the sketch of the given bearings, therefore, interior and exterior angles will be evident. Calculate appropriately the included and excluded angles.

Included angles and bearings example

- Find the angle between the lines OA (25°45') and OB (140°00').

  Angle AOB = Bearing of OB – Bearing of OA

  = 140°00' - 25°30' = 114°30'

- The bearing of a line AB is 133°30' and the angle ABC is 120°00' what is the bearing of BC?

  Bearing of AB = 133°30'

  bearing of BA = 133°30' + 180° = 313°30'

  bearing of BC = bearing of BA + Angle ABC

  = 313°30' + 120°00' = 433°30' – 360° = 73°00'

Local Attraction

- The deflection of compass needle due to the presence of ferro-magnetic materials or other magnetic forces is known as local attraction
- Due to local attraction, the difference between the fore bearing and back bearing of a survey line will not be equal to 180º
- Local attraction can be eliminated if the fore bearing and back bearing do not differ by 180º
- Compute the difference of Fore and back bearing of every line and find out the line for which the difference is exactly 180º or nearest to 180º. Distribute the difference from 180 to both bearings (FB & BB) to make the difference exactly 180º. This line is free from local attraction.
- There are two methods:
  - First Method or method of station corrections
  - Second Method or method of included angles

First Method or method of station correction

- Local attraction at a station is same for all the bearings at that station
- The stations forming the line having FB & BB differing exactly 180º are free from local attraction and all bearings taken from those stations are correct.
- Bearing to this station from next station is corrected as required. Correction for local attraction at next station is computed.
- Correct the other bearings at this station with the computed correction.
- Proceed to next station and compute correct bearings for other lines at that station and thus corrections for next station.
- Repeat the process to all the stations till the bearing for starting line is computed or termination of traverse in case of open traverse
- This method is applicable for open and closed traverses

Local Attraction Example method 1

Station	Line	Observed FB	Observed BB	Differnce	Loc. Att. Error	Corrected FB	Corrected BB
A					0		
	AB	**35^{0}30'**	**215^{0}30'**	180^{0}00'		**35^{0}30'**	**215^{0}30'**
B					0		
	BC	**115^{0}15'**	294^{0}15'	179^{0}00'		**115^{0}15'**	295^{0}15'
C					1^{0}0' (-ve)		
	CD	180^{0}45'	3^{0}45'	177^{0}00'		181^{0}45'	1^{0}45'
D					2^{0}0' (+ve)		
	DA	283^{0}45'	**101^{0}45'**	182^{0}00'		281^{0}45'	**101^{0}45'**

Second Method or method of included angles

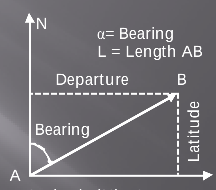
- Local attraction cancels out in the computed included angle at any station
- Find the included angle at all the stations.
- Check that the sum of included angles is (n-2)X 180^o. The difference is equally distributed to all the included angles to make the correct sum.
- From the unaffected station, compute the correct bearings using included angle and correct bearing of a line.
- Continue till all bearings are computed in cyclic order (clock wise or anti-clockwise)

Local Attraction Example method 2

Station	Line	Observed FB	Observed BB	Differnce	Obs. Incl. Angle	Corrected FB	Corrected BB
A							
	AB	**35^{0}30'**	**215^{0}30'**	180^{0}00'		**35^{0}30'**	**215^{0}30'**
B					100^{0}15'		
	BC	**115^{0}15'**	294^{0}15'	179^{0}00'		**115^{0}15'**	295^{0}15'
C					103^{0}30'		
	CD	180^{0}45'	3^{0}45'	177^{0}00'		181^{0}45'	1^{0}45'
D					80^{0}00'		
	DA	283^{0}45'	**101^{0}45'**	182^{0}00'		281^{0}45'	**101^{0}45'**
A					66^{0}15'		
Sum					**360^{0}00'**		

Latitudes and Departures

- The latitude of a line is its projection on the north–south meridian
- Commonly represented by 'N'
- North is positive
- The departure of a line is its projection on the east– west line
- East is positive
- Commonly represented by 'E'



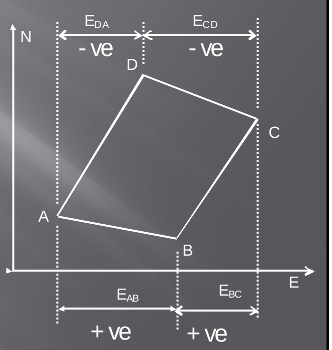
Latitude (N) = L cos α
Departure (E) = L sin α

Closed traverse Adjustment

- The errors will not let the closed traverse to close i.e. Closing error
- Since angles and lengths are measured so the closing error will be because of Angular or linear measurements
- Adjustment of angular mis-closure
  - Sum of all included angles should be (n-2) X 180^o
  - Distribute the mis-closure equally to all included angles to satisfy the sum criterion
- Adjustment of linear mis-closure
  - To be discussed in next slides

Adjustment of linear mis-closure

- For a closed traverse
  - Sum of all latitudes = 0
    $\Sigma N = 0$
    - If ΣN **is not 0** it will be the north component of closing error
  - Sum of all departures = 0
    $\Sigma E = 0$
    - If ΣE **is not 0** it will be the East component of closing error



Computations of Linear Closing Error

- Total linear closing error will be $\sqrt{(\Sigma N^2 + \Sigma E^2)}$
- Perimeter of traverse is P i.e P = $l_1 + l_2 + \ldots + l_n$
- Relative error = Total linear closing error / P represented as x:100 or 1000 or 10000 etc.
- Direction of closing error will be $\tan^{-1}\left(\frac{\Sigma E}{\Sigma N}\right)$

Adjustment of Linear Closing Error

- Compass Rule or Bowditch Rule
  - Assumes angles are as accurate as distances
  - Proportion both errors based on total distance (Perimeter)
- Transit rule
  - When angles are more accurate than distances
  - Proportion Lat. error based on total N-S distance
  - Proportion Dep. error based on total E-W distance
- Least-Squares (In next Semester)
  - Uses square roots of sums of Lat. and Dep.
  - Typically requires computer program

Bowditch or Compass Rule

- Proportion Lat., Dep. error to length of side
- Can be computed as follows: ΔLat_{AB} & ΔDep_{AB} are corrections in latitude and departure of line AB respectively

$$\Delta Lat_{AB} = Length_{AB} \cdot \left(\frac{-\Sigma N}{\Sigma Lengths}\right)$$

$$\Delta Dep_{AB} = Length_{AB} \cdot \left(\frac{-\Sigma E}{\Sigma Lengths}\right)$$

Transit rule

- Proportion Lat., Dep. error to total latitude or departure
- Can be computed as follows: ΔLat_{AB} & ΔDep_{AB} are corrections in latitude and departure of line AB respectively

$$\Delta Lat_{AB} = Lat_{AB} \cdot \left(\frac{-\Sigma N}{\text{Sum of latitudes without sign}}\right)$$

$$\Delta Dep_{AB} = Dep_{AB} \cdot \left(\frac{-\Sigma E}{\text{Sum of departures without sign}}\right)$$

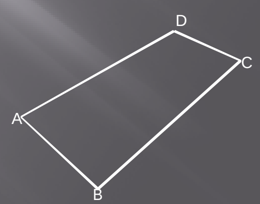
Computation of coordinates

- Consecutive coordinates
  - The latitude and departure of a point calculated with reference to preceding point
- Independent or total coordinates
  - The coordinates of any point with respect to a common origin.
  - The origin may be a station of the traverse or a point entirely outside the traverse

Gale's Traverse Table

- Angular corrections and linear adjustments can be carried out in tabular form. This table is known as Gale's Traverse Table.
- The lengths and bearings are given below. Find the independent coordinates if A is (500, 500)

Line	Length	Bearing
AB	255	$140^0 45'$
BC	656	$35^0 00'$
CD	120	$338^0 45'$
DA	668	$227^0 30'$



Station	Line	Length m)	Observed			Latitude			Departure			Independent	
			Bearing	Incl. Ang.	Corr.	Obs.	Corr.	Corrected	Obs.	Corr.	Corrected	N	E
A												500.000	500.000
	AB	255	$140^0 45'$			-197.470	0.066	-197.536	161.340	0.242	161.098		
B				$74^0 15'$	0							302.464	661.098
	BC	656	$35^0 00'$			537.364	0.170	537.194	376.266	0.623	375.644		
C				$123^0 45'$	0							839.658	1036.742
	CD	120	$338^0 45'$			111.841	0.031	111.810	-43.493	0.114	-43.607		
D				$68^0 45'$	0							951.468	993.135
	DA	668	$227^0 30'$			-451.295	0.173	-451.468	-492.501	0.634	-493.135		
A				$93^0 15'$	0							500.000	500.000
Sum		**1699**		**360º00'**		**0.440**	**0.440**	**0.000**	**1.612**	**1.612**	**0.000**		