Both Plan and Map are the graphical representations of the features on horizontal plane but plan is a large scale representation while map is a small scale representation.

Geodetic Survey	Plane Survey
It is done for fixing widely spaced control points.	It is done for Engineering projects. Use for small area.
Geodetic surveying is done by Department of National Survey of India.	Earth surface is assumed to be flat.
Large areas of earth's surface involved	It is more accurate.

Note: The effect of the curvature of earth's surface is taken into account only if the extent of survey is more than 195.5 km².

- The difference in the length of an arc and its subtended chord on earth's surface for a distance of 18.5 km is about 10 mm.

Classifiaction of Surveying Based on Purpose

(*i*) Topographical Survey: It is conducted to obtain data & to make a map indicating inequalites of land surface. Topographic Survey is done to determine the Natural features of a Country. Scale range is 1 : 25000 to 1 : 1000000.

(*ii*) Hydrographic Survey: It is conducted on or near water bodies. Marine survey is also one of it's type.

(*iii*) Engineering Survey: It is used for design & construction of new routes (roads & railways). Also used to calculate for route alignment.

(*iv*) Geological Survey: It is conducted to obtain data of different strata of earth's surface for the purpose of geological studies.

(*v*) Cadastral Survey : It is used to produce plans of property boundries for legal purpose. The revenue chain is used in cadastral surveying. Also called public land survey.

(*vi*) Astronomic Survey: It is conducted for determination of azimuths, latitudes, longitudes, local time etc. at various places on the earth by observing heavenly bodies. Absolute location of a point on earth surface is obtained by it.

- Archaeological survey is done to collect information about old and nelic structures.
- Reconnaissance Survey is a kind of pre liminary survey which is performed to find out method of survey to be adopted and its rough cost.

Classification based on instrument used -

Chain surveying , Compass surveying, Theodolite survey, Levelling survey, Contouring, EDM survey, Photogrammetric survey, Tacheometric survey.

- **Correct Sequence of Surveys**
  - (a) Traffic Survey
  - (b) Reconnaissance Survey
  - (c) Preliminary Survey
  - (d) Detailed Survey/Location Survey

Principles of Surveying:

(*i*) Work from Whole to Part: So as to localise the error and prevent their accumulation.

(*ii*) Locate a Point by Atleast two Measurements:

Error due to use of wrong scale:

- **Correct length**

$$= \boxed{\frac{\text{R.F of wrong scale}}{\text{R.F. of correct scale}} \times \text{Measured length.}}$$

- **Correct Area**

$$= \left(\frac{\text{R.F of wrong scale}}{\text{R.F. of correct scale}}\right)^2 \times \text{Calculated Area}$$

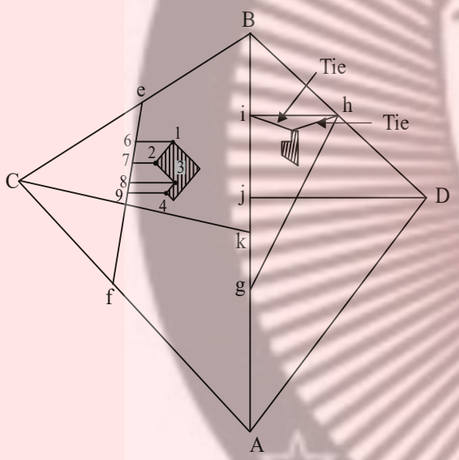
- **Principal of Least Square:**

$$E_m = \pm 0.6745\sqrt{\frac{\sum v^2}{n(n-1)}} = \frac{E_s}{\sqrt{n}}$$

Units of Measurement

1 ft. = 0.3 m	1 mile = 1.609 km
1 yard = 3 ft	1 acre = 43560 sq. ft.
1 hectare = 2.471 acre	1 Nautical mile = 1.852 km

Terms Used in Large Survey Area



(a) Main station : It is a point in chain survey where two triangle sides meet.

(b) Main survey line: Chain line joining two main survey stations,

(c) Tie station or subsidiary station: Station on survey line joining main stations.

(d) Proof line or check line: Provided to check the accuracy of the field work.

(e) Offsets: These are lateral measurement made w.r.t. chain line which may be oblique or perpendicular in nature.

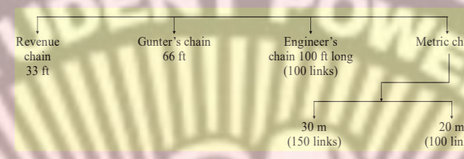
(f) Base line: Longest survey line from which direction of all other sruvey lines are fixed.

(g) Chainage: Distance measured along the main survey line in direction of progress of work.

- **Double line field book is most commonly used for recording ordinary chain survey work.**

Well Conditioned Triangle: Triangle in which all intersections of lines are clear. Angle's between the lines for clear plotting purpose. Intersections should be 30° to 120°. The best angle is 56° 14' for this condition. An equilateral triangle is the most appropriate well conditioned triangle.

Surveying chain: It is used where very high accuracy is not required. A chain consist of a number of large links made up of galvanized mild steel wire of 4 mm diameter.



Note: As per IS specifications, every metre length of the chain should individually be accurate to within ± 2mm when measured under a tension of 80 Newton.

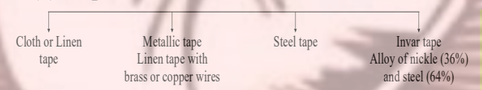
(a) 1 mile = 80 Gunter's chain

(b) 1 acre = 10 × (Gunter's chain)²

(c) The overall length of chain should be within the limits given below

(i) 20 m ± 5 mm for 20m chain.(ii)30 m ± 8 mm for 30m chain

(ii) Tapes:



(iii) Pegs: To mark definite points on ground temporarily.

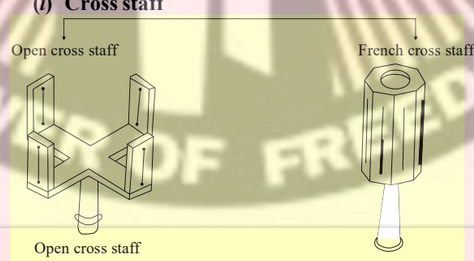
(iv) Arrows: It provides a check over the length of line as entered in the field notes.

(v) Ranging rods: To locate intermediate points such that these points lie on straight lines joining the end stations.

(*vi*) Offset rod: Similary to ranging rod with a sout open hook at the top.

Equipments for Measurement Right angles

(*i*) Cross staff



- Accuracy of the french Cross Staff is less than that of an open cross staff. But french cross staff can be set out at an angles of 45° and 135°.

(*ii*) Optical Square: Pocket instrument, more convenient and accurate than a cross staff.

- Optical Square is used to establish two Points at right angle. The principal used is of Double reflection Hence, Angle between two mirrors is 45°.

Tap Corrections

- **Correction for Slope:**

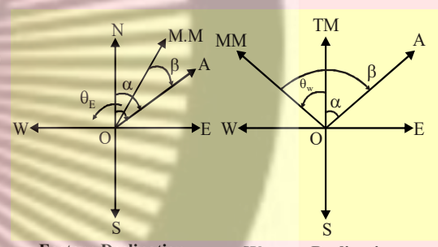
$$C_s = -L - \sqrt{L^2 + h^2}$$

$$C_s = \frac{h^2}{2L}$$

- **Correction for mean sea level**

$$C_h = \frac{-Lh}{R}$$

- **Correction for Temperature:** $C_t = \alpha (T_m - T_o)L$
- **Correction for pull or Tension:** $C_P = \left(\frac{P - P_s}{AE}\right)L$
- **Correction for Sag:** $C_s = -\frac{L_1(wL_1)^2}{24P^2}$
- **Bearing: Direction of a line with respect to fixed meridian is called bearing.**
- **True Meridian/Bearing**
  - → True meridian is a line joining True North pole, True South Pole end and point of reference. It never changes with time.
  - → Angle measured for any line w.r.t True Meridian is called Ture bearing.
- **Bearing Taken W.r.t magnetic meridian is called magnetic Bearing.**



Magnetic Declination

- At any place horizontal angle b/w True Meridian and Magnetic Meridian is called magnetic Declination.

Fore bearing and Back Bearing: B.B = F.B ± 180°

Local Attraction: If the difference b/w fore bearing and back bearing is 180°, the the adjoining stations are free form local attraction.

(*i*) Isogonic Line: Lines passing through the points on earth surface at which the declination is the same at given time. They rediate from North and South pole and follow irregular paths.

(*ii*) Agonic Lines: Lines passing through points of zero declination. True meridian and magnetic meridian coincides with each other.

Variation of magnetic declination			
Secular variation	Annual variation	Diurnal variation	Irregular variation
Due to over a long period of time due to gradual shift in earth's magnetic field.	Due to revolution of earth around the sun. (Yearly)	Due to rotation of earth about its own axis. It's more at pole, in day & summer time.	Due to magnetic disturbances in earth's magnetic field.

Prismatic Compass	Surveyor Compass
• Smaller in size (85 - 110 mm diameter)	• Bigger (circular box of size 150 mm dia)
• Broad Needle with aluminium ring is used	• Measurement quadrantal bearings
• Sighting of the object & reading of the bearing are done simultaneously	• First Object is sighted & then reading of bearing is taken by moving around the looking down from glass cover.
• Agate cap is fitted with prismatic compass	
• Temporary Adjustment Centering, Levelling, focussing.	• Temporary Adjustment Centering & Levelling.
• Tripod is not essential	• Tripod is essential
• Graduation is inverted because we have to see them through prism	• Graduation is erect as we can seen from it top
• Readings are in W.C.B., having 0° at south, 90° at West, 180° at North & 270° at East	• Edge bar type magnetic needle is used
	• It has 0° at N & S, 90° at E & W

Least count of Prismatic Compass is 30', surveyor compass 15', vernier scale - 0.1mm, micrometer - 0.01 mm, theodolite (20" & 15 second), for levelling staff - 5 mm.

Obstalces in chaining

- Forest, Hill - Obstacle to ranging but not chaining
- Small pond, small bend in river - Obstacle to chaining but not ranging
- A big building - Obstacles to both chaining & ranging

Angular measurement	Linear measurement
(a) Loose needle method	(a) Taping or chaining
(b) Fast needle method	(b) Tacheometric method
(c) Method of deflection angle	(c) Electronic distance measuring instrument (EDMI)
(d) Method of direct angle	
(e) Method of included angle	

Accuracy order: Coordinate method > Method of included angle > fast needle method > Loose needle method.

Dip: The angle made by the lines of magnetic force with the earth's surface is called dip. Magnetic needle becomes horizontal at equator but becomes vertical at magnetic poles.

Latitude and Departure

- Projection of a line on N-S direction is called latitude. $\boxed{L = +l\cos\theta}$
- Projectione of a line on E-W direction is called deparature. $\boxed{D = l\sin\theta}$

Adjustment of closing Error

- Sum of all internal Angles of a closed Traverse. = (2n – 4) × 90° where n = No. of sides.
- Sum of all deflection Angle = 360°
- Sum of latitude $\boxed{\Sigma L = 0}$
- Sum of departure $\boxed{\Sigma D = 0}$

Closing error In the Traverse $\boxed{e = \sqrt{(\Sigma L)^2 + (\Sigma D)^2}}$

Bowditch's Method (Compass Rule)

Permissible error in linear Measurment

$$= \boxed{e \propto \sqrt{\ell}}$$

Permissible error in angular measurement

$$= \boxed{e \propto \frac{1}{\sqrt{\ell}.}}$$

- **Correction to latitude:** $C_L = \Sigma L \times \frac{1}{\Sigma \ell}$
- **Correction due to departure:** $C_D = \Sigma D \times \frac{1}{\Sigma \ell}$
- **Transit Method:** $C_L = \Sigma L \times \frac{L}{L_r}, C_D = \Sigma D \times \frac{D}{D_r}$

Axis Method

Correction of any length

$$= \text{That length} \times \frac{\frac{1}{2}\text{closing error}}{\text{Length of Axis}}$$

Direct levelling methods

Simple | Differential | Profile | Fly | Check | Cross-section | Reciprocal | Precise

Sensitivity of level tube can be increased by increasing radius, diameter of tube, length of tube and decreasing the temperature, viscosity of liquid, the roughness of the inner wall of the tube.

$$\phi = \frac{nd}{R} = \frac{S}{L}, \quad \boxed{\phi = \frac{d}{R} = \frac{s}{nL}\text{Radian}}$$

- **Check in Height of Instrument Method**

$$\Sigma BS - \Sigma FS = \Sigma Rise - \Sigma Fall = \text{Last RL} - \text{First RL}$$

Note: First reading made on a point of known reduced level is always a Back sight reading.

Rise and Fall Method	Height of Collination
1. Arithmetic check Σ(Back sights) – Σ(fore sights) = Σ(Rise) – Σ(fall) = Last RL – first RL	1. Arithmetic check Σ(BS) – Σ(FS) = Last RL – first RL
2. Check for intermediate reading is done using ΣRise – Σfall	2. Reduction is easier in it.
3. It is well suited for determining the differences of levels of two points where precision is required.	3. It is most suited for longitudinal /cross-sectional levelling and Contouring.

- **Curvature:** $C_C = -\frac{d^2}{2R} = -0.0785d^2$.
- **Refraction:** $C_r = \frac{1}{7}\left(\frac{d^2}{2R}\right)$
- **Final Combination Correction**

$$C = C_c - C_r = \frac{6}{7}\left(\frac{d^2}{2R}\right),$$

$$C = -0.06735d^2$$

$d = 3.85\sqrt{h}$, d = in km and h = in meter.

Reciprocal Levelling:

- **The true difference Elevation:**

$$H = \frac{1}{2}[(h_a - h_b) + (h_a' + h_b')]$$

- **Determining Areas: Mid ordinate rule Δ = Area = Average ordinate × Length of base**

$$\Delta = \frac{O_1 + O_2 + ... + O_n}{n} \times L$$

- **Simpson's One-Third Rule**

$$\Delta = \frac{d}{3}\left[(O_1 + O_n) + 2(O_3 + O_5 + ... + O_{n-2}) + 4(O_2 + O_4 + ...O_{n-1})\right]$$

Methods of tacheometry -

(a) Tangential method - In it, observations are made for vertical angles & staff intercepts are obtained with cross wires only. Stadia wires are not used at all.It is faster than stadia hair method.

(b) Range finding - It is used to find out the horizontal distance & direction of a line without going to far end of the line. The equipment used is known as range finder.

(c) Stadia method - (i) Fixed hair method - In it, parallactic angle is kept fixed & the staff intercept is varied.

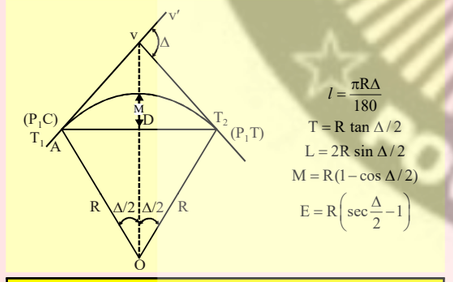
(ii) Moveable hair method - It is also called subtense method .

Fixed hair system: In this system the vertical distance between the upper and lower stadia hair is fixed and this fixed distance is called as stadia interval (I).

- **The stadia diaphragm consist of two stadia hairs at equal distances.**
- **Fixed Hair Method**

$$D = k \times S + C, \qquad K = \frac{f}{i} = 100$$

Addition Constent C = (f + d), f = focal length of object, S = Staff intercept, i = Stadia interval



$$l = \frac{\pi R \Delta}{180}$$

$$T = R \tan \Delta/2$$

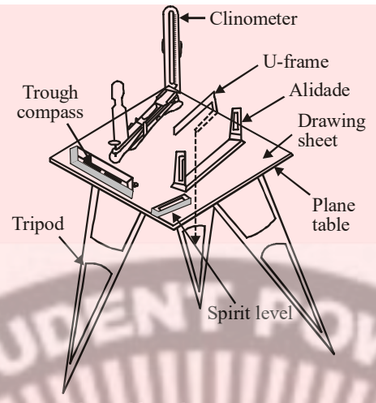
$$L = 2R \sin \Delta/2$$

$$M = R(1 - \cos \Delta/2)$$

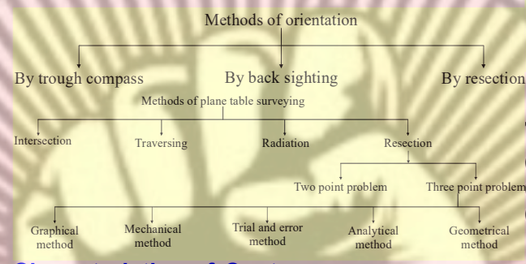
$$E = R\left(\sec\frac{\Delta}{2} - 1\right)$$

Instrument	Purpose
Abney level	To measure slope, cross section, to find gradient
Planimeter	To measure area very accurately
Pantagraph	Used to reduce/enlarge the maps
Hand level	To trace contours
Sextant	To measure horizontal & vertical angle

CIVIL ENGINEERING ROCKET CHART
FOR QUICK REVISION



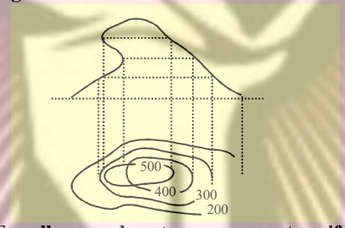
Plain table with accessories



Characteristics of Contour

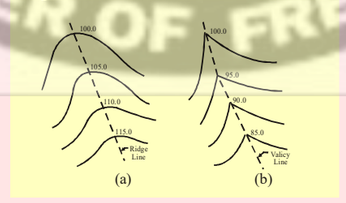
(i) A zero meter contour line represents the constaline. When no value is represented, it indicates a flat terrain.

(ii) Two contours intersect eachother only in case of overhanging cliff or a cave penetrating a hill side.



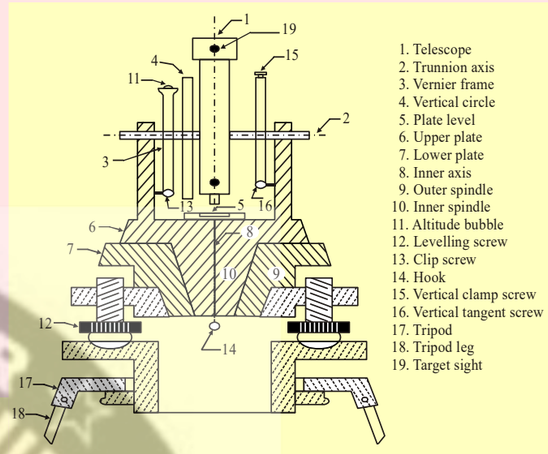
(iii) Equally spaced contours represents uniform slope.

(iv) A watershed or edge line contour crosses the valley contour at right angle. Converally the contours are not visible on the grounds excepts in the case of shore lines.



(v) Direction of steepest slope is along the shortest distance between the contours.

(vi) Two contour lines having same elevation cannot unite and continue as one line.



Total station used for:

(a) Establishing horizontal control.
(b) Establishing vertical control.
(c) Remote object height determination.

- **Levelling staff are of two types:-**

(a) Self reading staff:-

Solid staff, folding staff (used in our country), telescopic staff.

(b) Target staff:-

Height - 4m, thickness - 18 mm, width - 75 mm, least count - 5 mm.

Generally used scales for measurement purpose are :

S.N.	Type of Scale	Scales	R.F. value
1.	Cadastral map	1 cm = 5 m to 0.25 km	$\frac{1}{500}$ to $\frac{1}{5000}$
2.	Topographical map (a) Buildings	1 cm = 2.5 km 1 cm = 10 m or less	$\frac{1}{1000}$ or less
	(b) Town planning	1 cm = 50 m to 100 m	$\frac{1}{5000}$ to $\frac{1}{10,000}$
	(c)Location map	1 cm = 50 m to 200 m	$\frac{1}{5000}$ to $\frac{1}{20,000}$
	(d) Small Scale Topographic Survey	1 cm = 0.25 km to 2.5 km	$\frac{1}{25,000}$ to $\frac{1}{2,50,000}$
	(e) Mines	1 cm = 10 m to 25 m	
	(f) Forest Scale	1 cm = 0.25 km	
3.	Preliminary survey of rails & roads	1 cm = 10 m to 60 m	