INSTITUTE OF AERONAUTICAL ENGINEERING

Dundigal, Hyderabad -500 043

DEPARTMENT OF CIVIL ENGINEERING

SURVEYING

COURSE LECTURER

B SURESH

Assistant Professor

COURSE GOAL

- To introduce the students to various surveying techniques such as leveling contouring
- Measurement of area and volume
- To impart knowledge regarding various survey instruments like Theodolites compass tachometers etc..,

Course outline

Unit	Title	content
I	INTRODUCTION DISTANCES AND DIRECTION	Overview of plane surveying (chain, compass and plane table), Objectives, Principles and classifications, scales, conventional symbols, signals. DISTANCES AND DIRECTION: Distance measurement methods; use of chain tape and Electronic distance measurements, Meridians, Azimuths and Bearings, declination, computation of angle Distance measurement methods; use of chain tape and Electronic distance measurements, Meridians, Azimuths and Bearings, declination, computation of angle.

II	**LEVELING CONTOURING**	**Concept and Terminology, Temporary and permanent Adjustments, method of leveling. CONTOURING: Characteristics and Uses of contours- methods of conducting contour surveys and their plotting. Characteristics and Uses of contours- methods of conducting contour surveys and their plotting**
III	COMPUTATION OF AREAS AND VOLUMES	Area from field notes, computation of areas along irregular boundaries and area consisting of regular boundaries. Embankments and cutting for a level section and two level sections with and without transverse slopes, determination of the capacity of reservoir, volume of barrow pits
IV	THEODOLITE	Theodolite, description, uses and adjustments - temporary and permanent, Measurement of horizontal and vertical angles. Principles of Electronic Theodolite, Trigonometrical leveling, Traversing.

V	TACHEOMETRIC SURVEYING CURVES INTRODUCTION TO ADVANCED SURVEYING:	: Stadia and tangential methods of tachometry. Distance and Elevation formulae for Staff vertical position. Types of curves, design and setting out – simple and compound curves. Total Station and Global positioning system, Introduction to Geographic information system (GIS).

Unit-I

- Definitions, Principle, Various types of surveying-Based on methods and instruments,
- Classifications, uses, necessity and use of various scales and verniers
- Different types of ranging, tapes, chains, linear measurements, approximate, direct, optical and electronic methods, Chain Surveying, Minor Instruments for setting out right angle.

Surveying

- ***"Surveying is the art of and science of determining the relative positions of various points or stations on the surface of the earth by measuring the horizontal and vertical distances, angles, and taking the details of these points and by preparing a map or plan to any suitable scale."***

Leveling

- Leveling is a branch of surveying which deals with the measurement of relative heights of different points on, above or below the surface of the earth. Thus in leveling, the measurements (elevations) are taken in the vertical plane.

Objective of Surveying

- The object of surveying is to prepare a map or plan to show the relative positions of the objects on the surface of the earth. The map or plan is drawn to some suitable scale. It also shows boundaries of districts, states, and countries too. It also includes details of different engineering features such as buildings, roads, railways, dams, canals etc.

Uses of Surveying

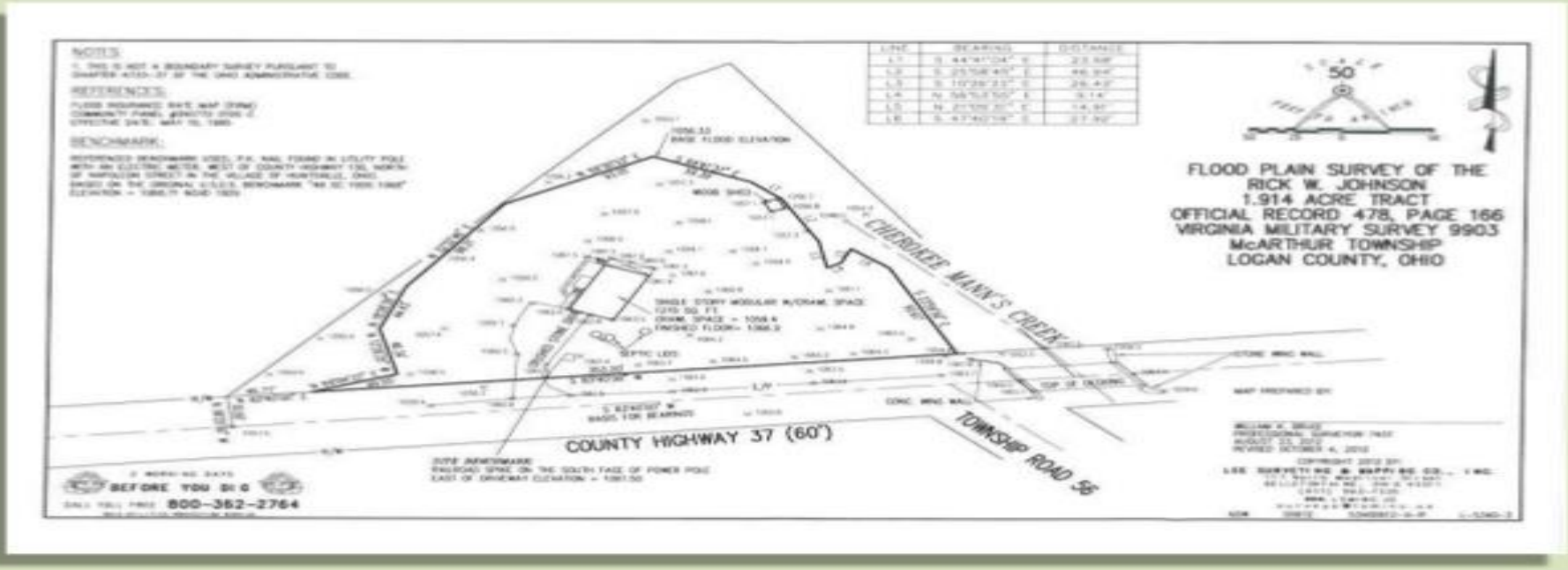
- The surveying may be used for following purposes:
- To prepare a topographical map which shows hills, valleys, rivers, forests, villages, towns etc.
- To prepare a cadastral map which shows the boundaries of fields, plots, houses and other properties..
- To prepare an engineering map which shows the position of engineering works such as buildings, roads, railways, dams, canals.

- To prepare a contour map to know the topography of the area to find out the best possible site for roads, railways, bridges, reservoirs, canals, etc.
- Surveying is also used to prepare military map, geological map, archaeological map etc.
- For setting out work and transferring details from the map on the ground.

Primary Divisions of Surveying

- We know that the shape of the earth is spheroidal. Thus the surface is obviously curved. Surveying is primarily divided into two types considering the curvature of the earth's surface.
- Plane Surveying
- Geodetic Surveying

- **Plain Surveying**
- The plain surveying is that type of surveying in which earth surface is considered as a plane and the curvature of the earth is ignored. In such surveying a line joining any two stations is considered to be straight. The triangle formed by any three points is considered as a plane triangle, and the angles of the triangle are considered as plain angles.
- Surveying is carried out for a small area of less than 250 km^2 . It is carried out by local or state agencies like R & B department, Irrigation department, Railway department.



Primary Divisions of Surveying

- **Geodetic Surveying**
- The geodetic Surveying is that type of surveying in which the curvature of the earth is taken into account. It is generally extended over larger areas. The line joining any two stations is considered as curved line. The triangle formed by any three points is considered to be spherical and the angles of the triangle are considered to be spherical angles. Geodetic surveying is conducted by the survey of India Department and is carried out for a larger area exceeding 250 km^2

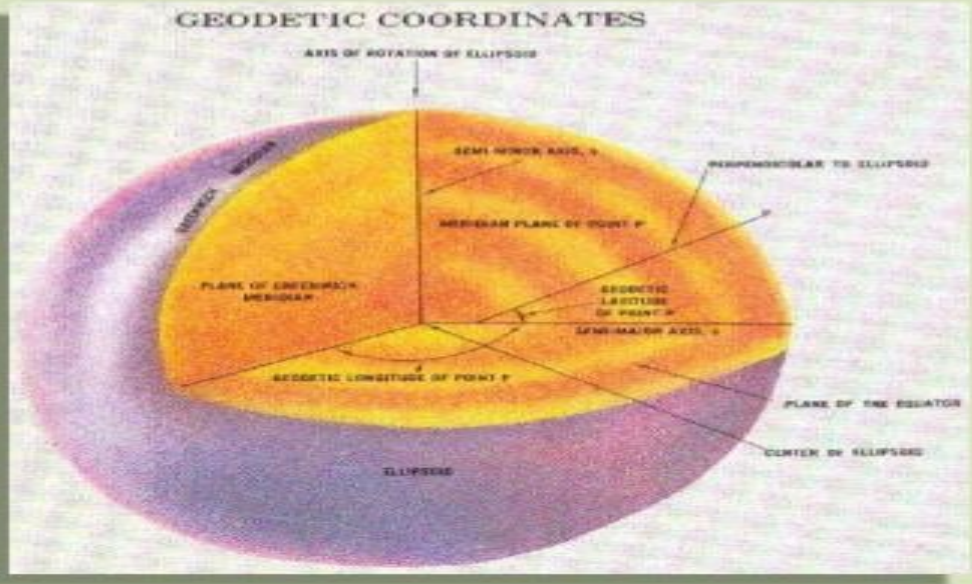
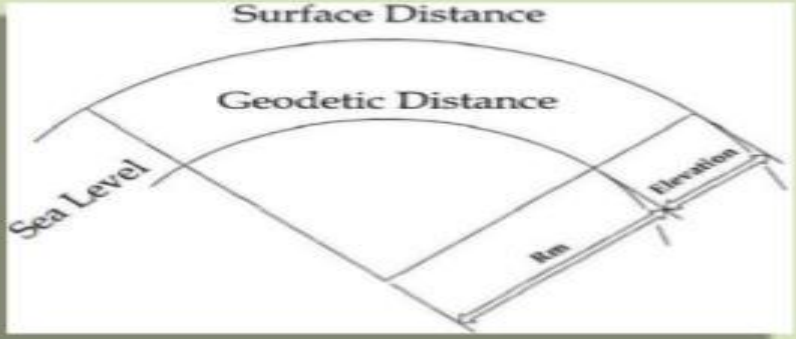



Figure 1. Direct geodetic problem



Plain Surveying Vs Geodetic Surveying

No.	Plain Surveying	Geodetic Surveying
1	The earth surface is considered as plain Surface.	The earth surface is considered as Curved Surface.
2.	The Curvature of the earth is ignored	The curvature of earth is taken into account.
3	Line joining any two stations is considered to be straight	The line joining any two stations is considered as spherical.
4.	The triangle formed by any three points is considered as plain	The Triangle formed by any three points is considered as spherical.
5.	The angles of triangle are considered as plain angles.	The angles of the triangle are considered as spherical angles.
6.	Carried out for a small area < 250 km^2	Carried out for a small area > 250 km^2

Classification of Surveying

- Survey can be classified into various categories depending on methods used and nature of the field.
- Classification Based on Instruments.
- **Chain Survey:**
- This is the simplest type of surveying in which only linear measurements are made with a chain or a tape. Angular measurements are not taken.

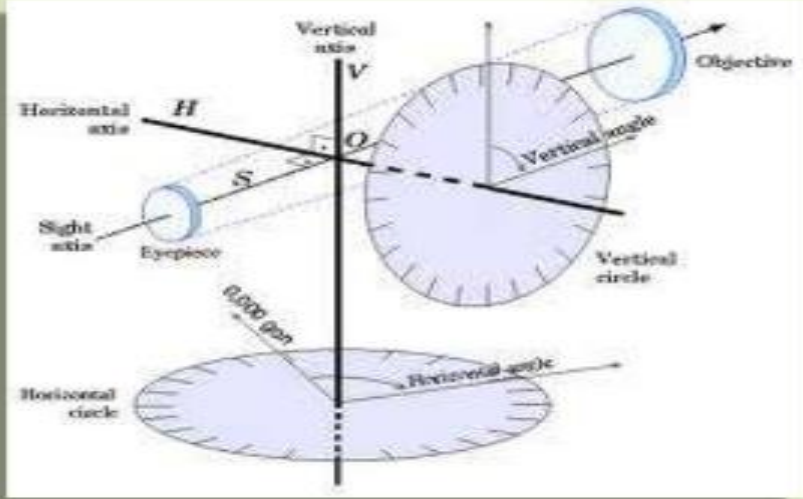
- **Compass Survey:**
- In Compass Survey, the angles are measured with the help of a magnetic compass.
- **Chain and compass survey:**
- In this survey linear measurements are made with a chain or a tape and angular measurements with a compass.

Classification of Surveying

- **Plane Table Surveying**
- It is a graphical method of surveying in which field works and plotting both are done simultaneously.
- **Theodolite Survey:**
- In theodolite survey the horizontal angles are measured with the theodolite more precisely than compass and the linear measurements are made with a chain or tape.

Plane Table Surveying

Theodolite Survey



Classification of Surveying

- **Tachometry Survey:**
- A special type of theodolite known as tachometer is used to determine horizontal and vertical distances indirectly.
- **Leveling Survey:**
- This type of survey is used to determine the vertical distances (elevations) and relative heights of points with the help of an instrument known as level.

- **Photogrammetric Survey:**
- Photogrammetry is the science of taking measurements with the help of photographs taken by aerial camera from the air craft.
- **EDM Survey:**
- In this type of survey all measurements (length, angles, co-ordinates) are made with the help of EDM instrument (i.e.. Total Station).

- Classification Based on methods.
- **Triangulation:**
- Triangulation is basic method of surveying, when the area to be surveyed is large, triangulation is adopted. The entire area is divided into network of triangles.
- **Traversing:**
- A Traversing is circuit of survey lines. It may be open or closed. When the linear measurements are done with a chain and a tape and the directions or horizontal angles are measured with a compass or a theodolite respectively the survey is called traversing.

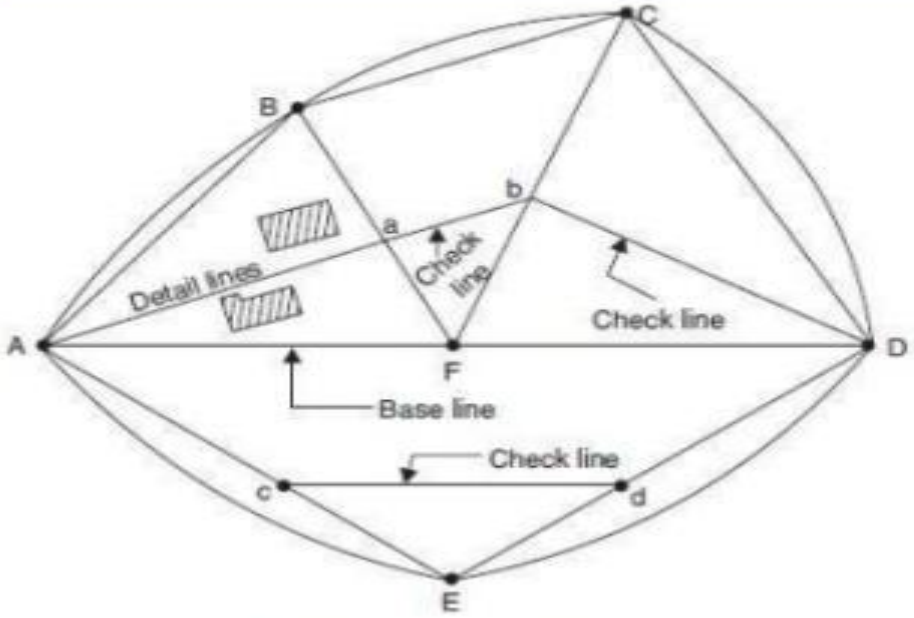
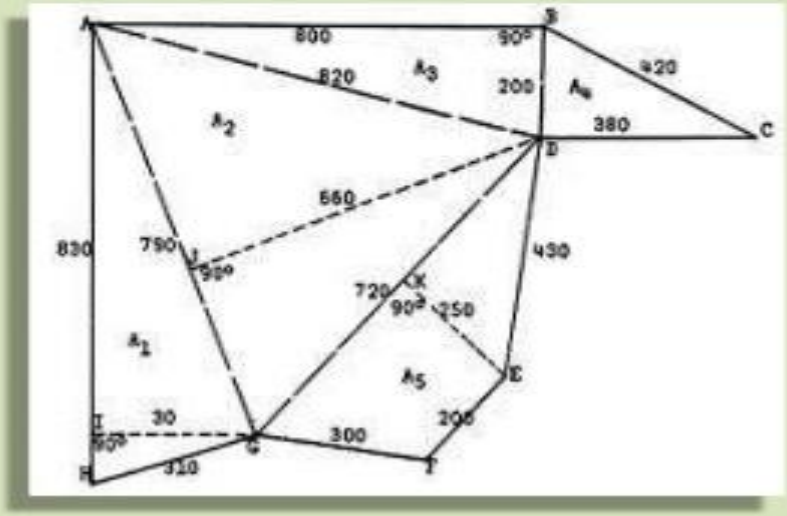
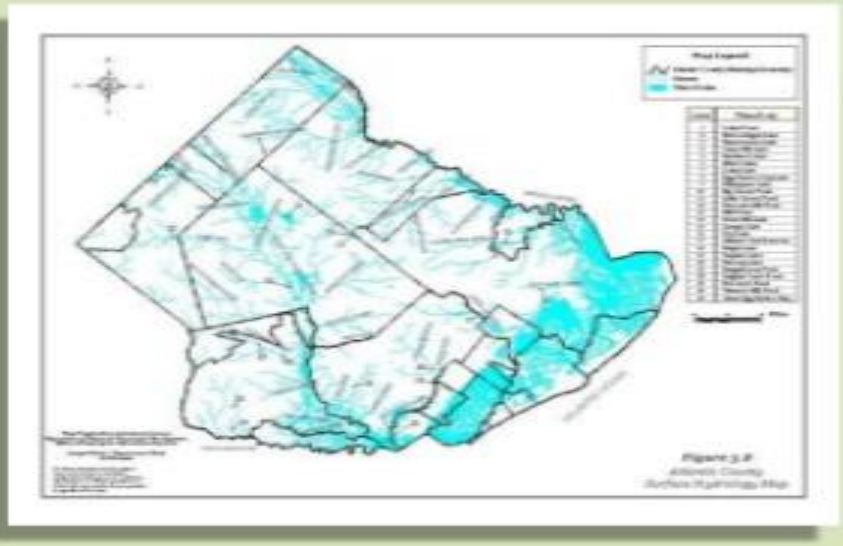


Fig. 12.11. Network of triangles

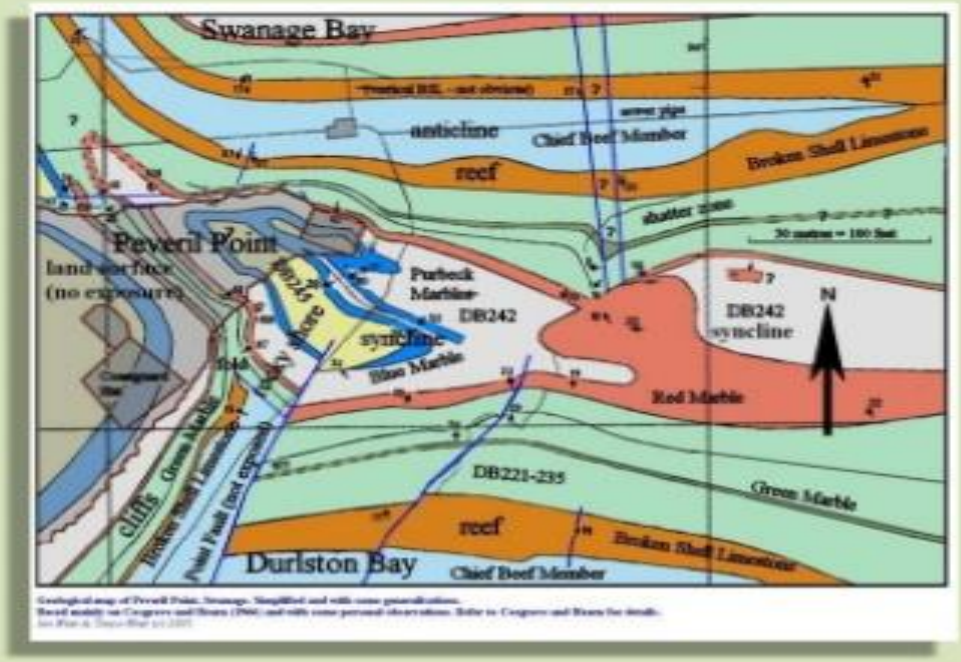


- Classification based on Purpose
- **Geological Survey:**
- In this both surface and subsurface surveying are conducted to locate different minerals and rocks. In addition, geological features of the terrain such as folds and faults are located.



Hydrological Maps

Geological Maps



Classification of Surveying

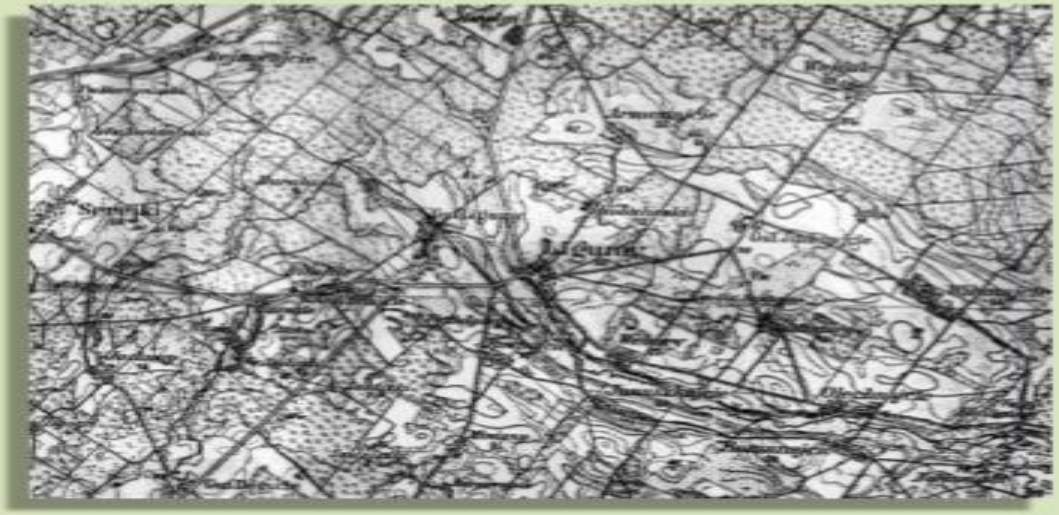
- **Mine Survey**
- Mine Survey includes include both surface and underground surveys. It is conducted for the exploration of mineral deposits and to guide tunneling and other operations associated with mining.

Classification of Surveying

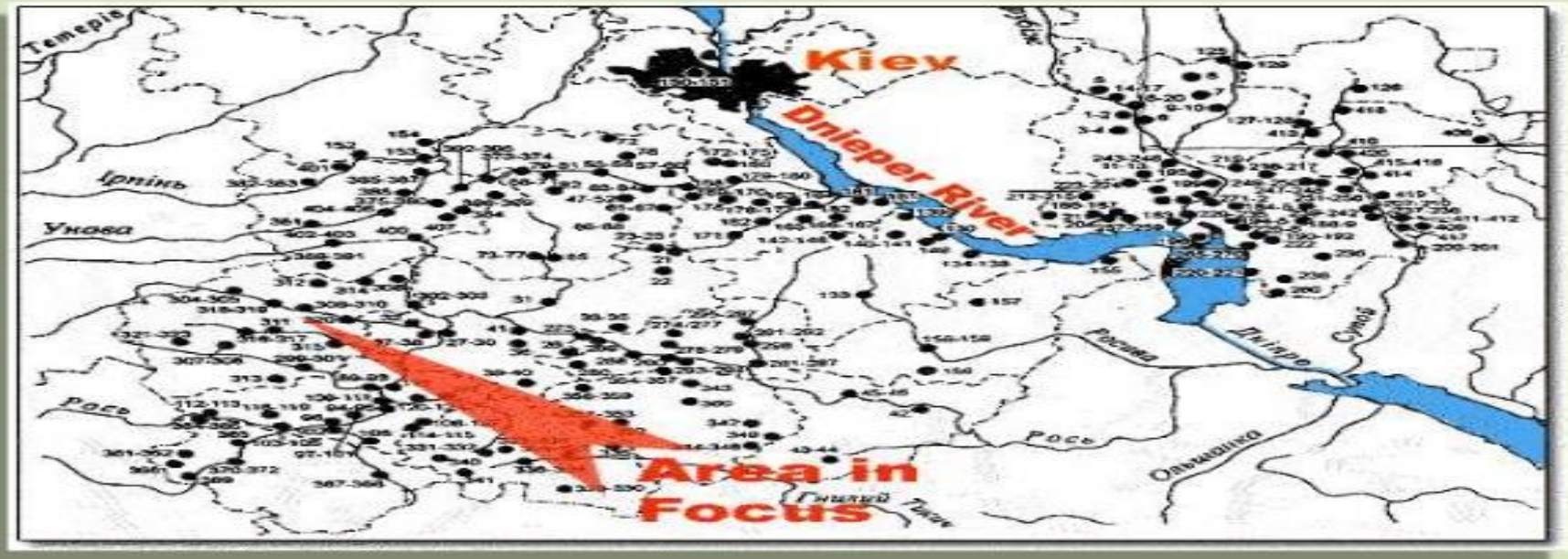
- **Archaeological Survey**
- It is conducted to locate relics of antiquity, civilization, kingdoms, forts, temples, etc.

- **Military Survey**
- It has a very important and critical applications in the military. Aerial surveys are conducted for this purpose. It is conducted to locate strategic positions for the purpose of army operations.

Military Survey



Archaeological Survey



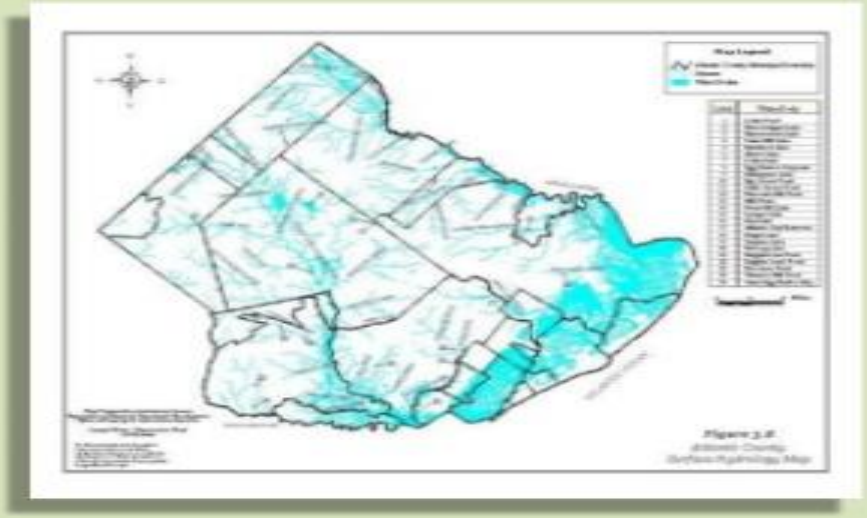
Classification of Surveying

- Classification based on Nature of field
- **Land Survey**
- Land Survey is done on land to prepare plan and maps of a given area. Topographical, city and cadastral surveys are some of the examples of land surveying.
- **Hydrological Surveying**
- This survey is conducted on or near the body of water such as lake, river, coastal area. This Survey consists of locating shore lines of water bodies.

Land Survey

Hydrological Surveying

Hydrological Maps

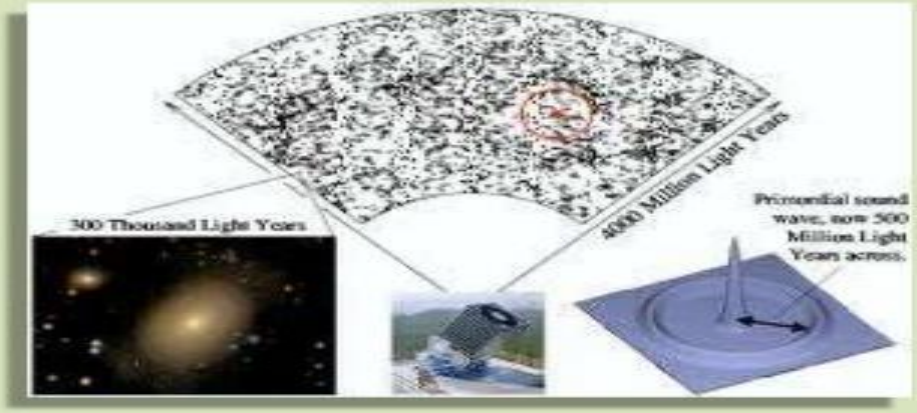


Hydrological Maps

Classification of Surveying

- **Astronomical Survey**
- This survey is conducted for the determining of latitudes, longitudes, azimuths, local time, etc. for various places on earth by observing heavenly bodies (sun or the stars).
- **Aerial Survey**
- An aerial survey is conducted from aircraft. Aerial cameras take photographs of the surface of the earth in overlapping strips of land. This is also known as photographic survey.

Astronomical Survey



Aerial Survey

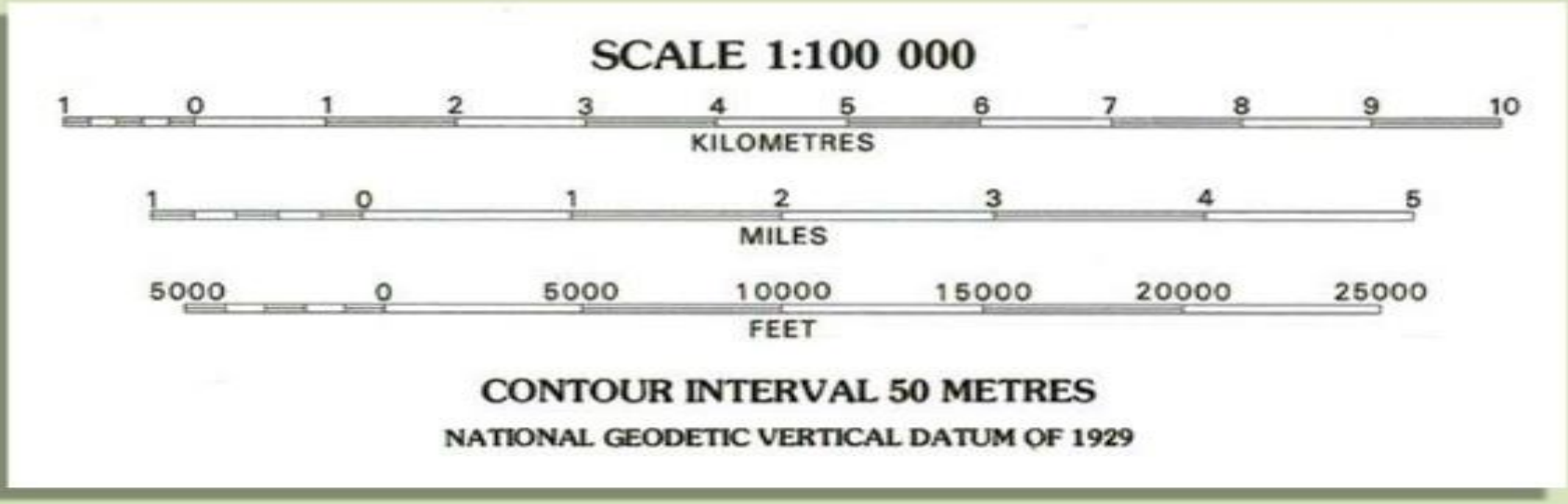
Plan and Maps

- One of the basic objective of surveying is to prepare plans and maps.
- **Plan**
- A plan is the graphical representation to some scale, of the features on, near or below the surface of the earth as projected on a horizontal plane. The horizontal plane is represented by plane of drawing sheets on which the plan is drawn to some scale However the surface of the earth is curved it cannot be truly represented on a plane without distortion. In plane surveying the area involved are small, the earth's surface may be considered as plane and hence plan is constructed by orthographic projections. A plan is drawn on a relatively large scale.

- **Map**
- If the scale of the graphical projection on a horizontal plane is small, the plan is called a map. Thus graphical representation is called a plan if the scale is large while it is called a map if the scale is small.
- On plan, generally only horizontal distances and directions or angles are shown. On topographical map, however the vertical distances (elevations) are also represented by contour lines.

- **Scale**
- It is basic requirement for the preparation of plan or map Scale is used to represent large distances on paper. The ratio by which the actual length of the object is reduced or increased in the drawing is known as the 'Scale' for example., if 1 cm on a map represents a distance of 10 metres on the ground, the scale of the map is said to be 1 cm = 10 m.

Scale

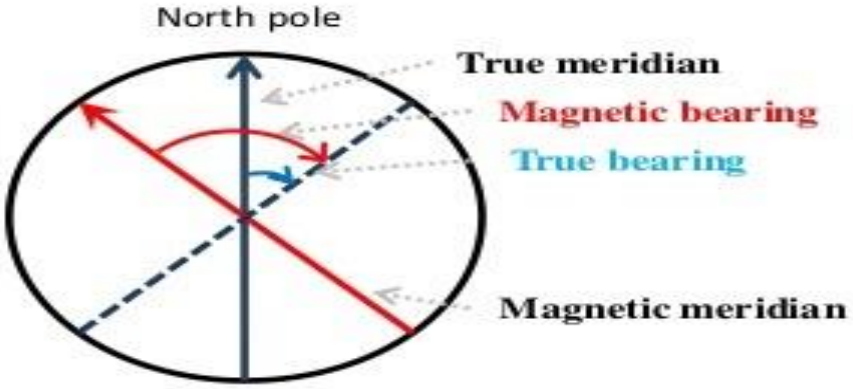


Types of Scales

- (a) Plain Scale
- (b) Diagonal Scale
- (c) Chord Scale
- (d) Vernier Scale

Important Definitions

True meridian:
Line or plane passing through geographical north pole and geographical south pole



Magnetic meridian:
The direction indicated by a freely suspended and properly balanced magnetic needle is known as *Magnetic Meridian*. The angle between the magnetic meridian and a line is known as magnetic bearing or simple bearing of the line.

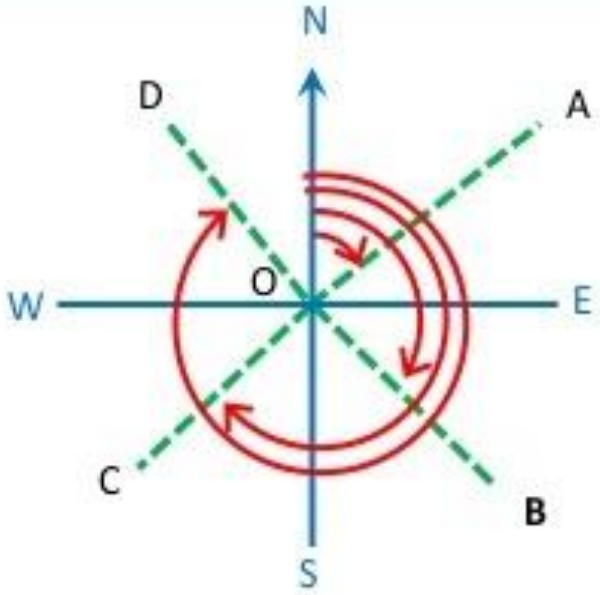
Arbitrary Meridian:
Convenient direction is assumed as a meridian.

Grid meridian:
Sometimes for preparing a map some state agencies assume several lines parallel to the true meridian for a particular zone these lines are termed as grid meridian.

Designation of Magnetic Bearing

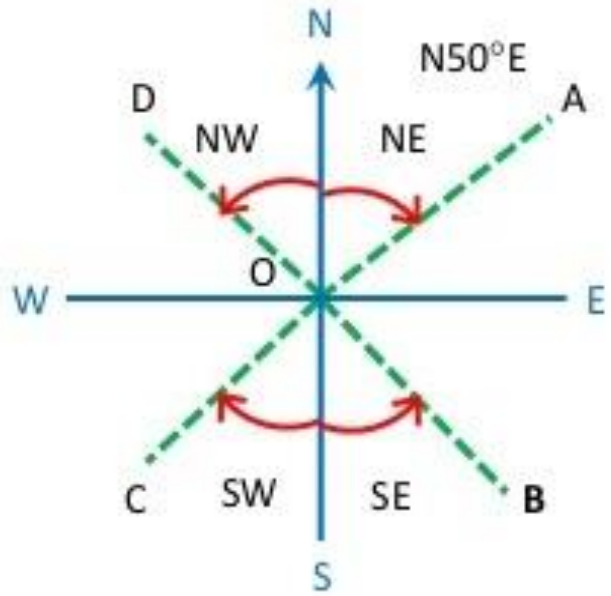
Whole circle bearing (WCB)

The magnetic bearing of a line measured clockwise from the North Pole towards the line is known as WCB. Varies 0-360°



Quadrantal bearing (QB)

The magnetic bearing of a line measured clockwise or anticlockwise from NP or SP (whichever is nearer to the line) towards the east or west is known as QB. This system consists of 4-quadrants NE, SE, NW, SW. The values lie between 0-90°

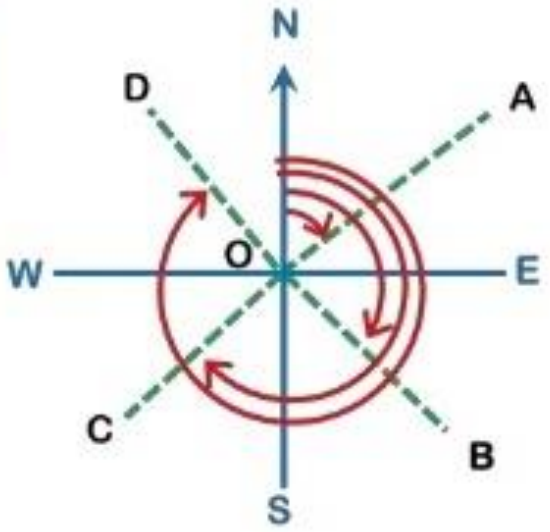


Conversion of W.C.B into R.B

Reduced Bearing (RB)

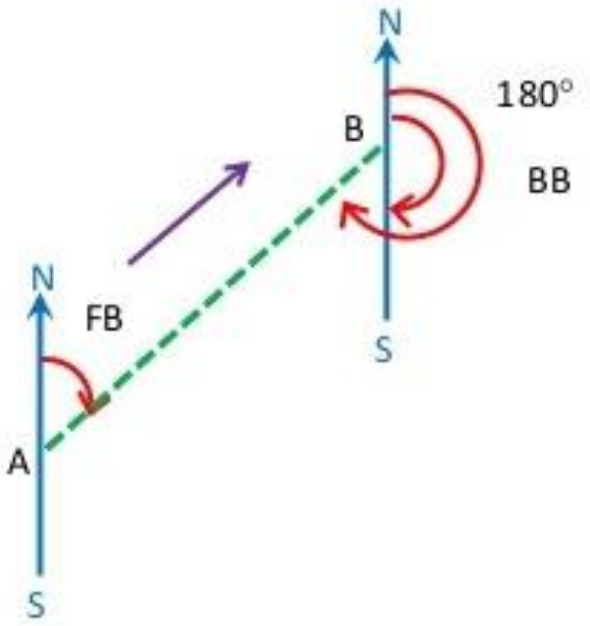
When the whole circle bearing of a line is converted to quadrantal bearing it is termed as reduced bearing.

CASE	W.C.B between	Rule for R.B	Quadrant
I	0° and 90°	W.C.B	N.E.
II	90° and 180°	180° - W.C.B	S.E.
III	180° and 270°	W.C.B - 180°	S.W.
IV	270° and 360°	360° - W.C.B	N.W.



Fore and Back Bearing

Every line may be defined by two bearings, one observed at either end of the line. Both the bearings expressed in W.C.B System differ each other by 180°.



Fore Bearing (F.B)

The bearing of a line in the direction of the progress of survey, is called *Fore or Forward Bearing (F.B)*

Back Bearing (B.B)

while the bearing in the opposite direction of the progress of survey is known as *Reverse or Back Bearing (B.B).*

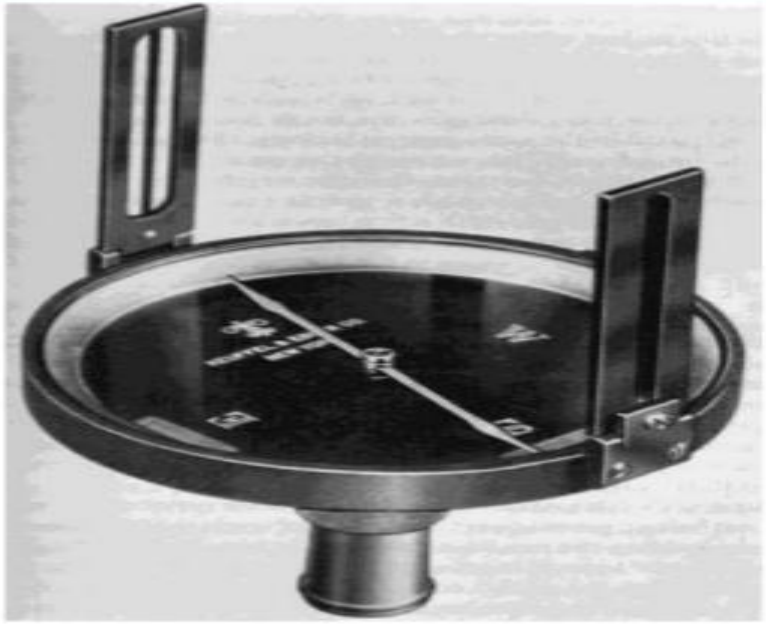
- In WCB the difference between FB and BB should be exactly 180°
- BB=FB+/-180°
- Use the +ve sign when FB<180°
- Use the –ve sign when FB> 180°

Compass surveying

- In Compass survey chain or tape is used for linear measurements and compass is used for fixing direction.
- In compass freely suspended magnetic needle directs to north- south and the bearing of line is obtained by line of sight.

Prismatic Compass

- Box with center point
- Magnetized Needle
  - Lift needle
- Blade Sights
- Level tubes
- Base
  - Jacob's staff
  - Tripod



Prismatic Compass

- **Magnetic declination:** The horizontal angle between the magnetic meridian and true meridian is known as magnetic declination.

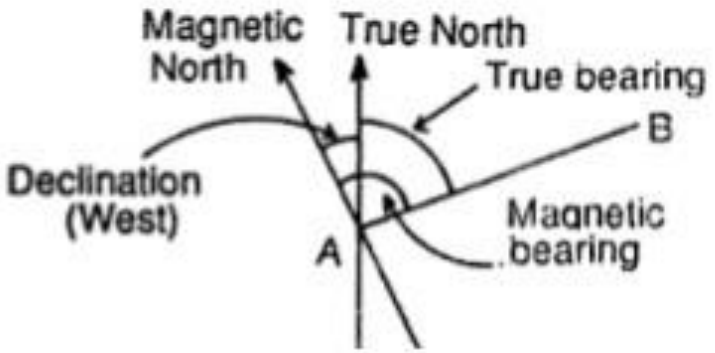
- **Dip of the magnetic needle:** If the needle is perfectly balanced before magnetisation, it does not remain in the balanced position after it is magnetised. This is due to the magnetic influence of the earth. The needle is found to be inclined towards the pole. This **inclination of the needle with the horizontal** is known as dip of the magnetic needle.

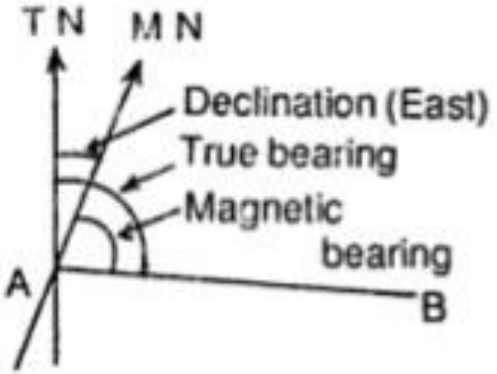
- **Local Attraction**
- **Method of correction for traverse:**
  - **First method:** Sum of the interior angle should be equal to (2n-4) x 90. if not than distribute the total error equally to all interior angles of the traverse. Then starting from unaffected line the bearings of all the lines are corrected using corrected interior angles.

  - **Second method:** Unaffected line is first detected. Then, commencing from the unaffected line, the bearing of other affected lines are corrected by finding the amount of correction at each station.

Prismatic Compass

Remember the following:





Determination of true bearing and magnetic bearing:

(a) True bearing = magnetic bearing ± declination

Note [use the positive sign when declination east, and the negative sign when declination west.]

(b) Magnetic bearing = true bearing ± declination

Note [Use the positive sign when declination west, and the negative sign when declination east.]

Levelling & Contouring

Definition, Principle, & Object of Levelling

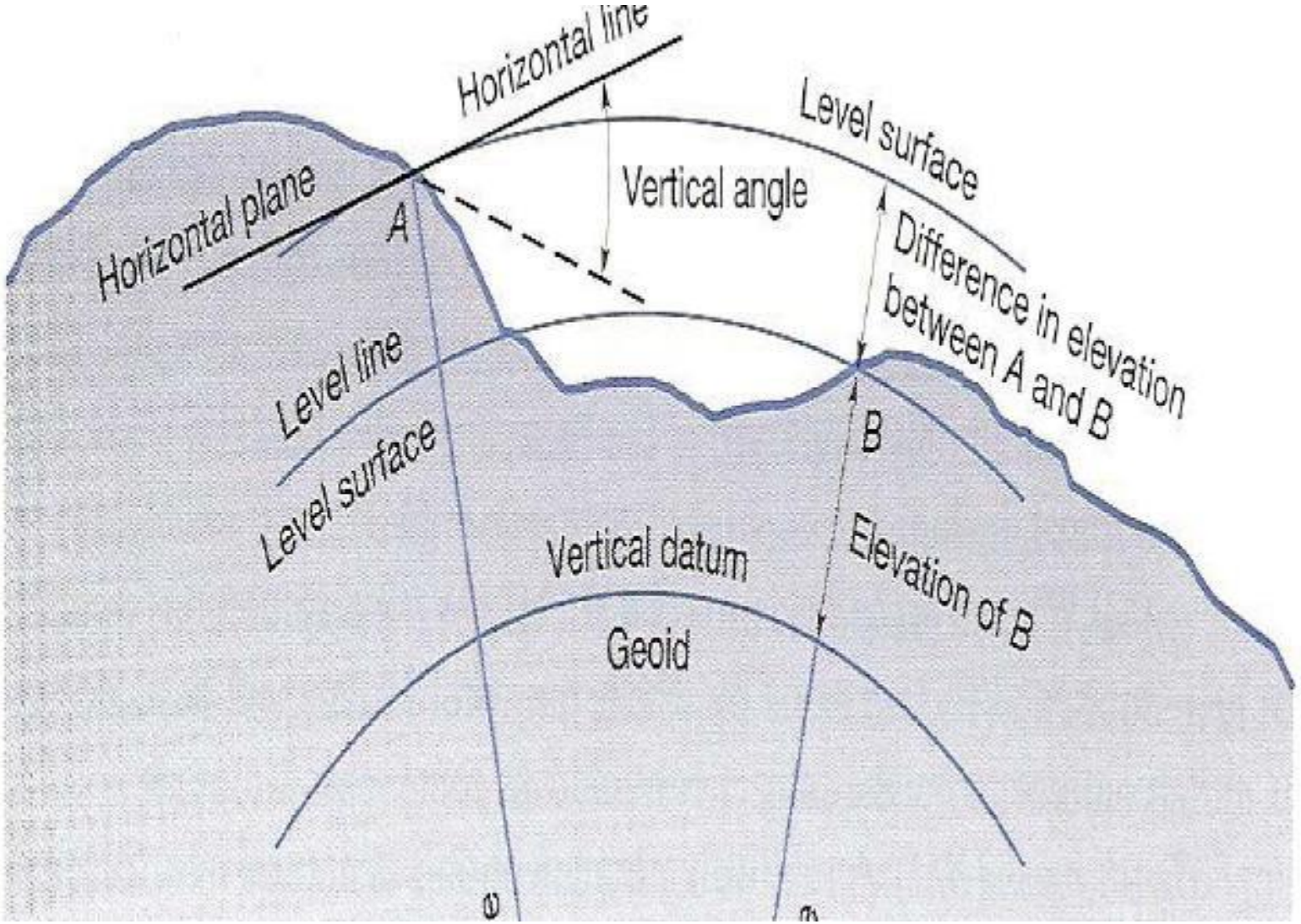
- *Definition:- Levelling is defined as "an art of determining the relative height of different points on, above or below the surface".*

Principle of levelling

- *Principle:- The principle of levelling is to obtain horizontal line of sight with respect to which vertical distances of the points above or below this line of sight are found.*

Object of levelling

- *The objective of levelling is to*
- *1) Find the elevation of given point with respect to some assumed reference line called datum.*
- *2)To establish point at required elevation with respect to datum.*


Horizontal line
Level surface
Horizontal plane
Vertical angle
A
Difference in elevation
between A and B
Level line
B
Level surface
Vertical datum
Elevation of B
Geoid

Definitions used in levelling

- *Level surface:- It is the surface parallel to the mean spheroidal surface of the earth*
- *Level line:- Line lying on level surface.*
- *Horizontal plane:- Horizontal plane through a point is a plane tangential to level surface.*
- *Horizontal line:- It is a straight line tangential to level line.*

- *Datum:- "It is an arbitrary level surface from which elevation of points may be referred". In India mean sea level is considered as datum of zero elevation it is situated at Karachi.*

  Mean sea level is the average height of sea for all stages of tides it is derived by averaging the hourly tide height over a period of 19 years.

- *Elevation or Reduced level:- It is height or depth of any point above or below any datum. It is denoted as R.L.*

- *Bench Mark (B.M.):- It is a fixed reference point of known elevation with respect to datum.*
- *Line of collimation:- It is a line joining the intersection of cross hairs of diaphragm to the optical centre of object glass and its continuation. It is also known as line of sight.*
- *Height of instrument:- It is the elevation of line of collimation with respect to datum*
- *Back sight:- It is a staff reading taken at a known elevation. It is the first staff reading taken after setup of instrument.*

- *Fore sight(F.S.):-* *It is the last staff reading taken denoting the shifting of the instrument.*
- *Intermediate sight.(I.S.):-It is staff reading taken on a point whose elevation is to be determined.All staff reading between B.S. and F.S. are Intermediate sight.*
- *Change Point:- It is a point on which both fore and back sight are taken.*

Instruments for levelling

- *The following instruments are essentially required*
- *for levelling*
- *Level*
- *Levelling staff*

Level and types of level

- *Level:- The instrument used to furnish horizontal line of sight for observing staff readings and determining R.L.s*
- *Types*
- *Dumpy level*
- *Tilting level*
- *Wye level*
- *Automatic level*

Dumpy level

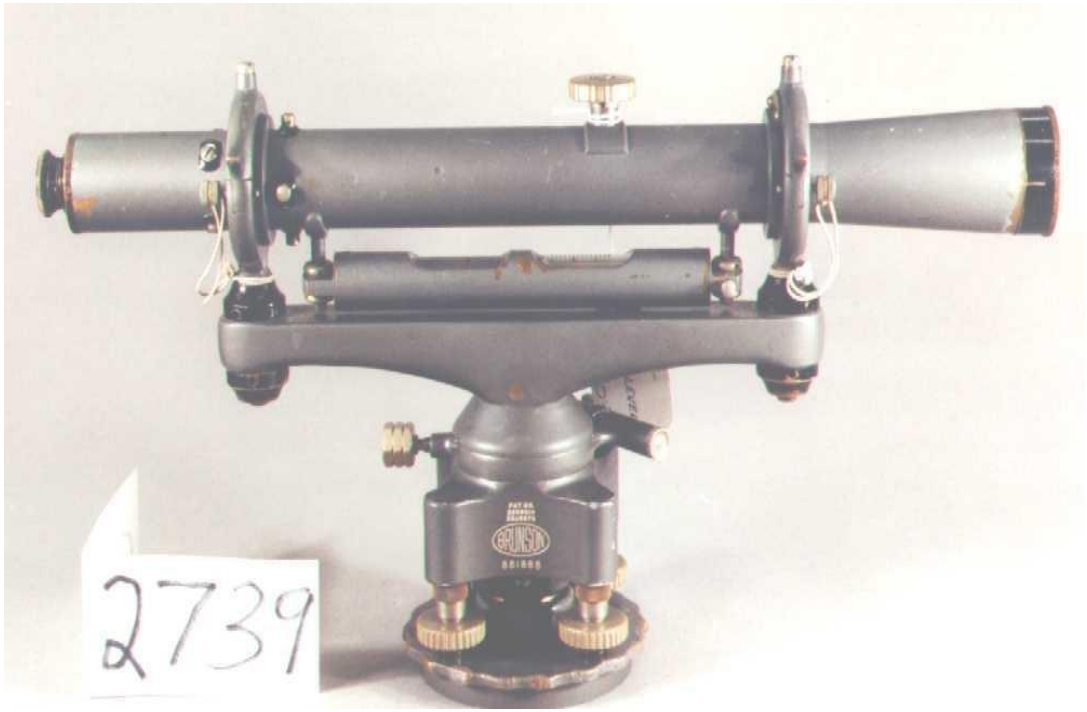
The Dumpy level is a simple, compact and stable instrument. The telescope is rigidly fixed to its supports. Hence it cannot be rotated about horizontal axis.

Tilting level

It is also known as I.O.P. level (Indian office Pattern). In this level the telescope tilts about its horizontal axis hence it is called tilting level

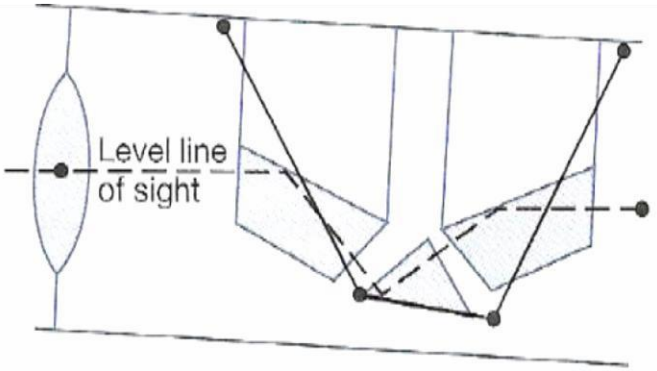
Wye level

- *The essential difference between wye level and other levels is that in wye level the telescope is carried by two vertical wye supports. The telescope can be rotated, moved or even raised in wyes.*

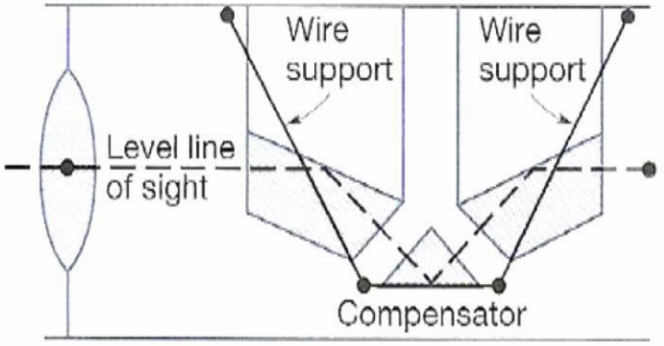


Automatic level

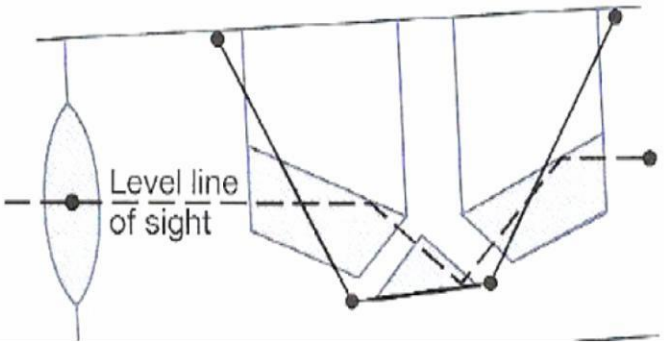
- *It is also known as self aligning level. It is a recent development. The fundamental difference between auto level and other levels is that the levelling is not manually but it is levelled automatically. It is achieved by inclination compensating device.*



When telescope tilts up, compensator swings backward.



Telescope horizontal



Levelling Staffs

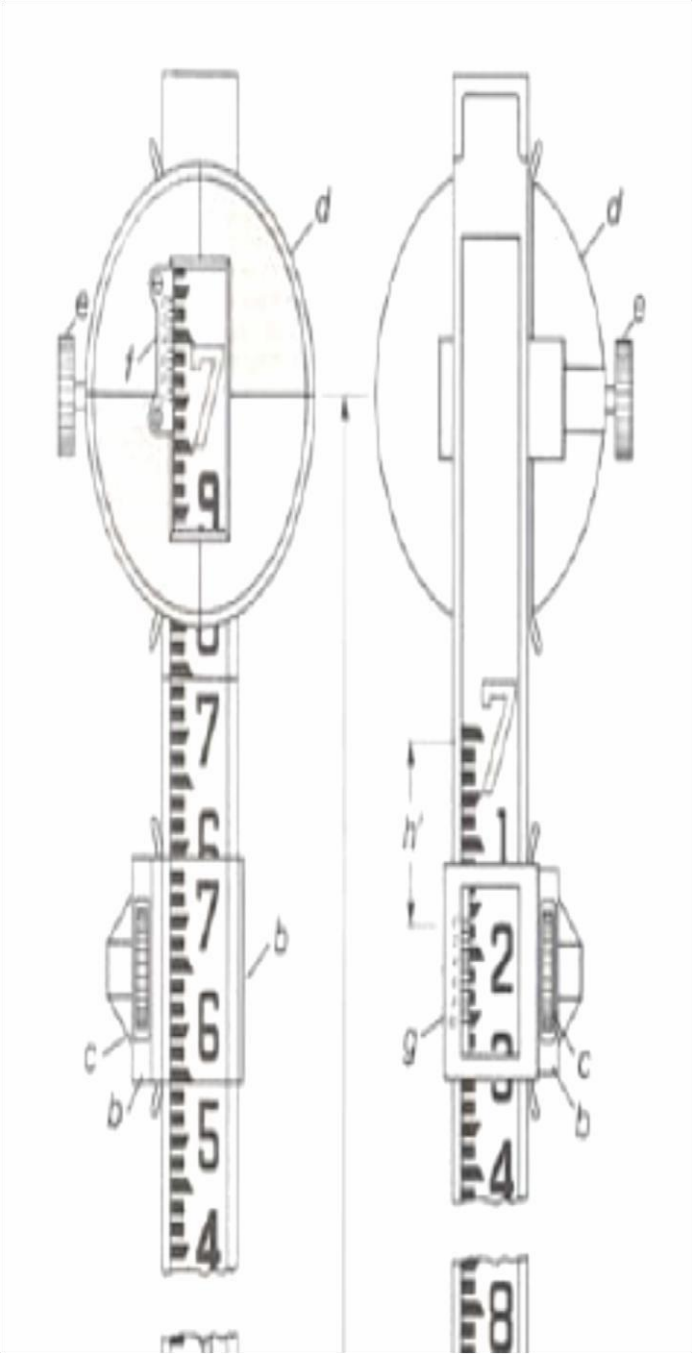
- *Levelling staffs are scales on which these distances are measured.*
- *Levelling staffs are of two types*
- *Self reading staff*
- *Target staff*

Self reading staff

- *The self reading staff can be read directly by the level man looking through the telescope.*
- *Common types of self reading staffs*
- *Ordinary staff*
- *Sopwith telescopic staff*
- *Folding Staff*

Target staff

- *For very precise works and sight target staff are used.A* movable target is provided in this staff.A vernier is provided on target to give precise reading. In target staff level man directs the staff man to move the target up and down until it bisects by the line of sight.The staff man observe the staff reading


d
e
f
d
e
h'
g
c
b
b
c
b

Bench Marks

- *Bench mark is a point of known elevation*
- *There are 4 kinds of bench marks*
- *GTS (Great trigonometrically survey bench mark)*
- *Permanent bench mark*
- *Arbitrary bench mark*
- *Temporary bench mark*

GTS Bench mark

- *They are the bench marks established with very high degree of precision at regular intervals by the survey of India Department all over the country Their position and R.Ls values above mean seal level at Karachi are given in catalogue formed by the department.*
- *Mean sea level*

Permanent Bench mark

- *Permanent bench marks are fixed in between GTS bench marks by govt. agencies such as railways, PWD, etc. This bench marks are written on permanent objects such as milestones, culverts, bridges etc their value are clearly written and their position are recorded for future reference.*

- *Arbitrary bench marks*:- *These are reference points whose R.L.s are arbitrarily assumed. They are used in small works such bench mark may be assumed as 100. or 50 m*
- *Temporary bench marks*:- *They are the reference points established during the levelling operations when there is a break in work, or at the end of day's work the value of reduced levels are marked on some permanent objects such as stones, trees etc.*

Temporary Adjustments of a level

- *These adjustments are performed at every setup of instrument*
- *Setting up of level*
- *Levelling of telescope*
- *Focusing of the eye peace*
- *Focusing of object glass*

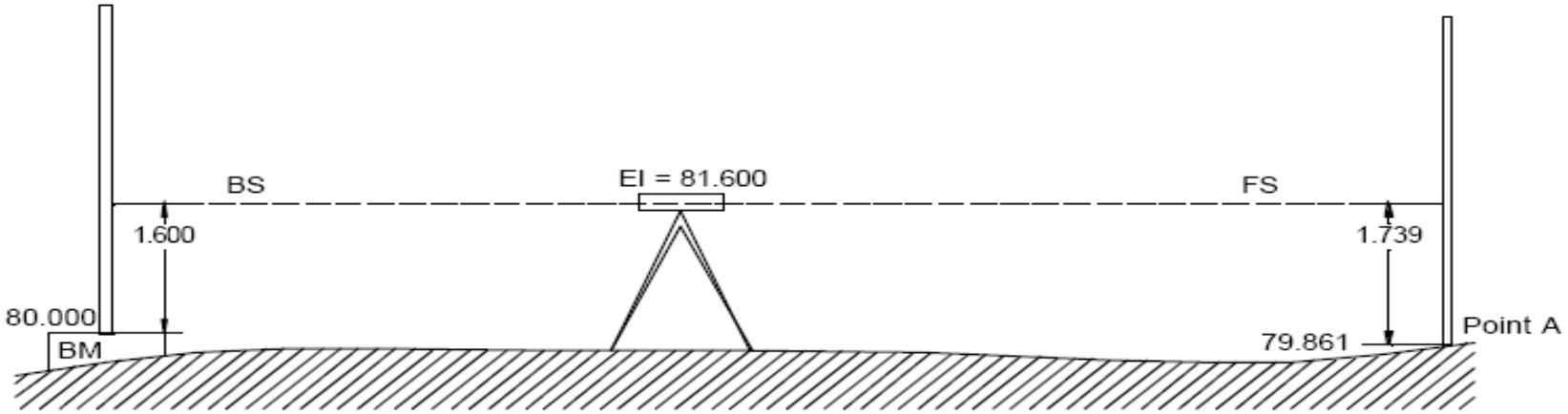
- *Setting up the level:- This includes*
- *A) Fixing the instrument on tripod*
- *B) Levelling the instrument approximately by Tripod*
- *Levelling:- Levelling Levelling is done with the help of foot screws. The purpose of levelling is to make vertical axis truly vertical. It is done with the help of foot screws*
- *A) Place the telescope parallel to a pair of foot screw then hold the foot screws between thumb and first finger and turn them either inward or outward until the longitudinal bubble comes in the centre.*
- *B) Turn the telescope through 90^0 so that it lies parallel to third foot screw, turn the screw until the bubble comes in the centre.*

- *Focusing the eye piece:- To focus the eye piece, hold a white paper in front of object glass, and move the eye piece in or out till the cross hair are distinctly seen.*
- *Focusing of object glass:- Direct the telescope to the levelling staff and on looking through the telescope, turn the focusing screw till the image appears clear and sharp.*

Classification of levelling

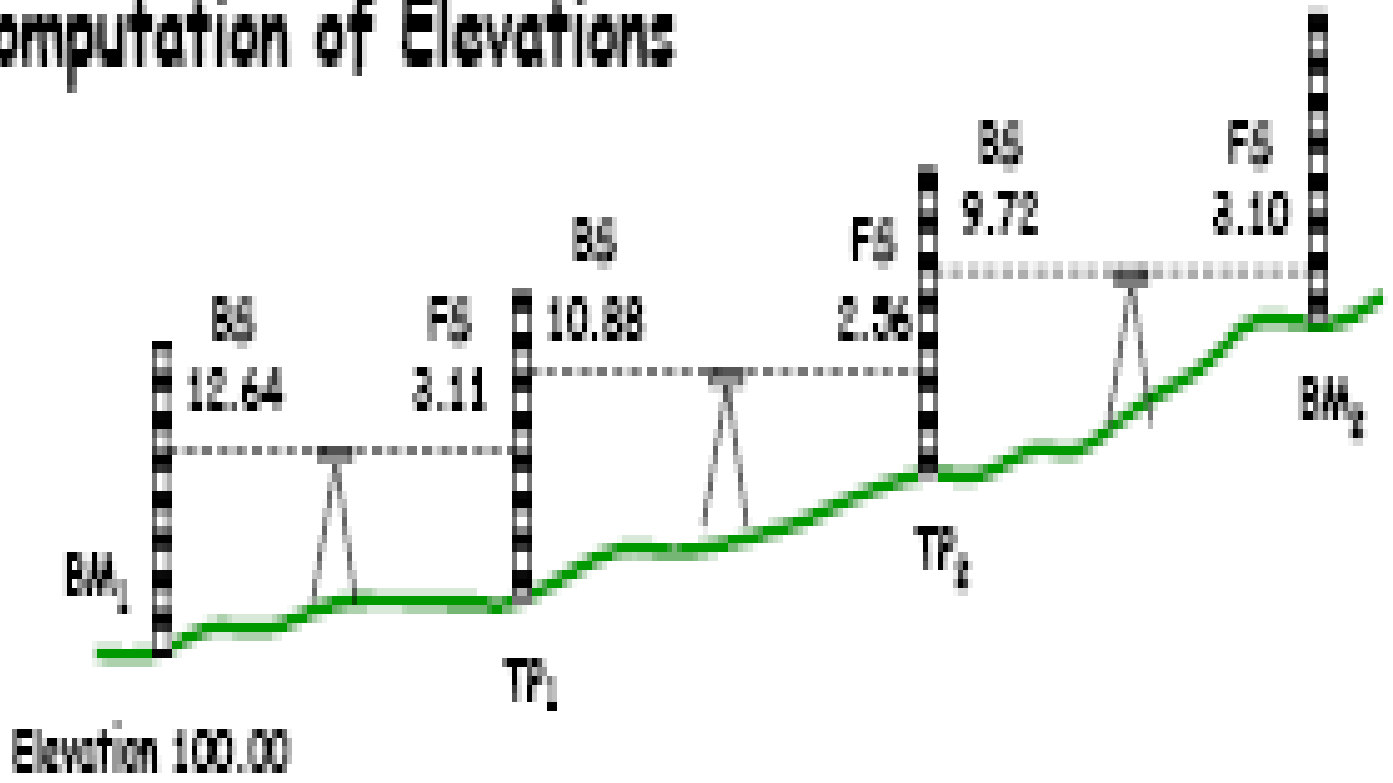
- Simple levelling
- Differential leveling
- Fly levelling
- Check levelling
- Profile levelling
- Cross levelling
- Reciprocal levelling
- Precise levelling
- Trignometric levelling
- Barometric levelling
- Hypersometric levelling

- *Simple levelling*:- *It is the simplest method used, when it is required to find the difference in elevation between 2 points.*

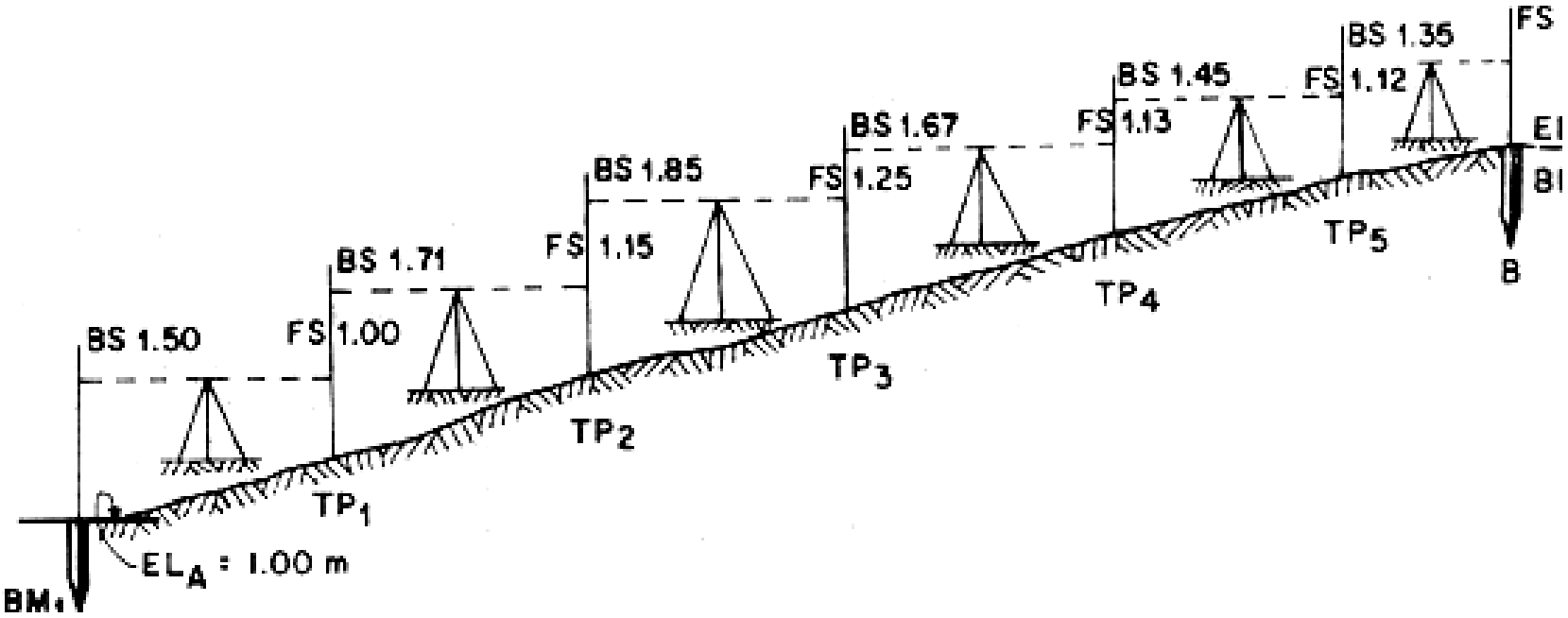


- *Differential Levelling*:- *This method is used to find the difference in the elevation between points if they are too far apart or the difference in elevation between them is too much.*

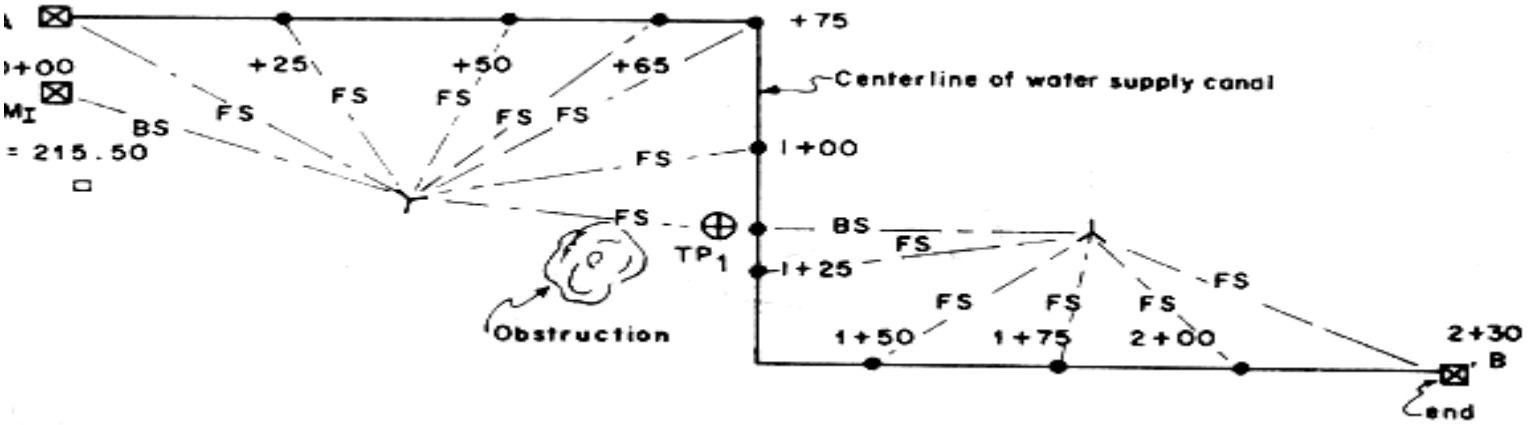
Computation of Elevations

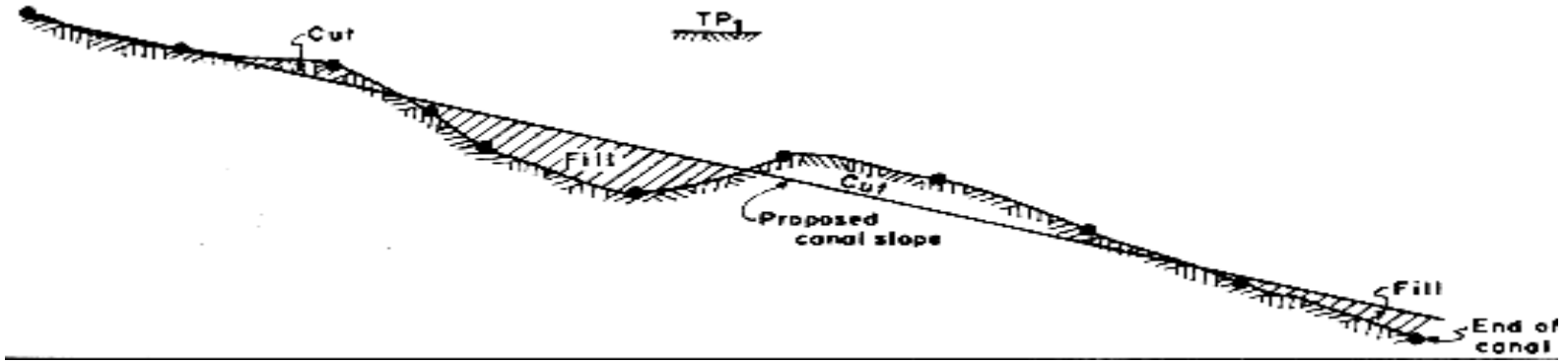


- *Fly levelling:- Fly levelling is just like differential levelling carried out to check the accuracy of levelling work. In fly levelling only B.S.and F.S. are taken*



- *Check levelling:- This kind of levelling is carried out to check the accuracy of work. It is done at the end of the days work in the form of fly levelling to connect the finishing point and starting point.*
- *Profile levelling or L-Section:- This method is used for taking levels along the centre line of any alignment like road, railway canal etc. The object is to determine the undulations of the ground surface along the alignment*


+75
Centerline of water supply canal
+25
+50
+65
FS
BS
= 215.50
1+00
TP1
1+25
Obstruction
1+50
1+75
2+00
2+30
B
end


Cut
TP1
Fill
Cut
Proposed
canal slope
Fill
End of
canal

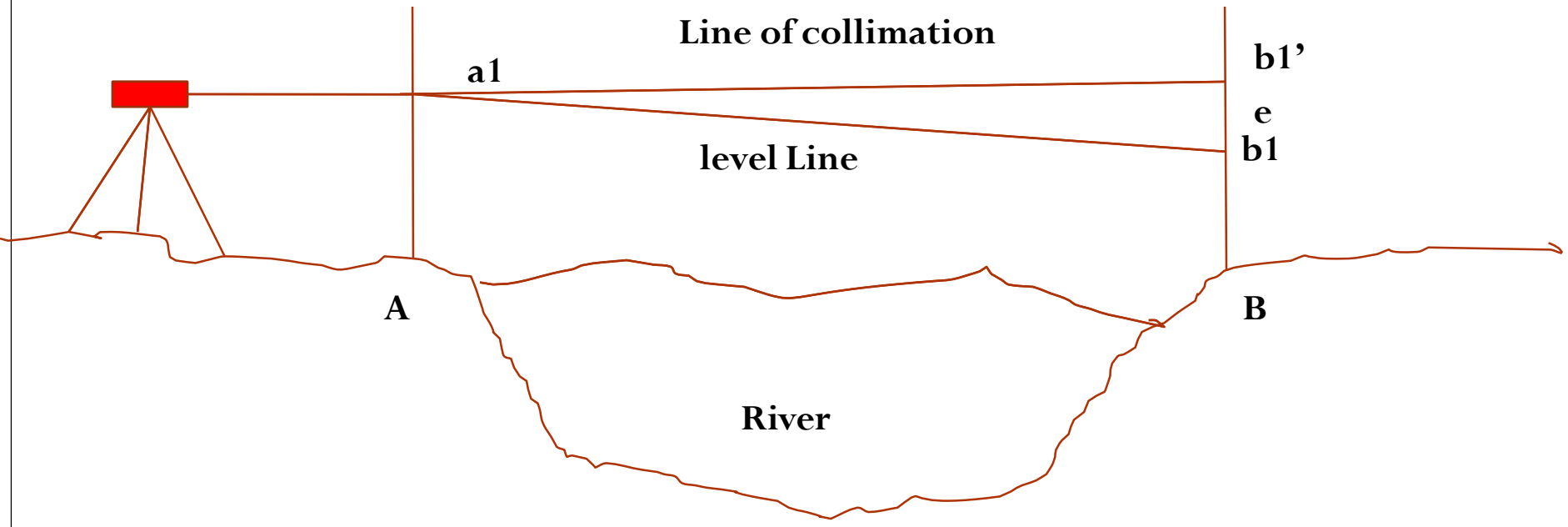
- *Cross- sectioning:- This operation is carried out perpendicular to alignment at an interval of 10, 20 ,30, 40 m.The idea is to make an estimate of earthwork.*
- *Precise levelling:- It is used for establishing bench marks for future public use. It is carried out with high degree of accuracy using advanced instruments*
- *Trignometric levelling:- In this method vertical distances between points are computed by observing horizontal distances and vertical angle between points.*

- *Barometric levelling:- In this method the altitude difference is determined by means of a barometer.*
- *Hyposometric levelling:- The working of Hyposometry for determining the elevation depends upon the fact that the temperature at which water boils varies with the atmospheric pressure. The boiling point of water reduces at higher altitude thus knowing the boiling point of water, the atmospheric pressure can be calculated and knowing the atmospheric pressure altitude or elevation can be determined*

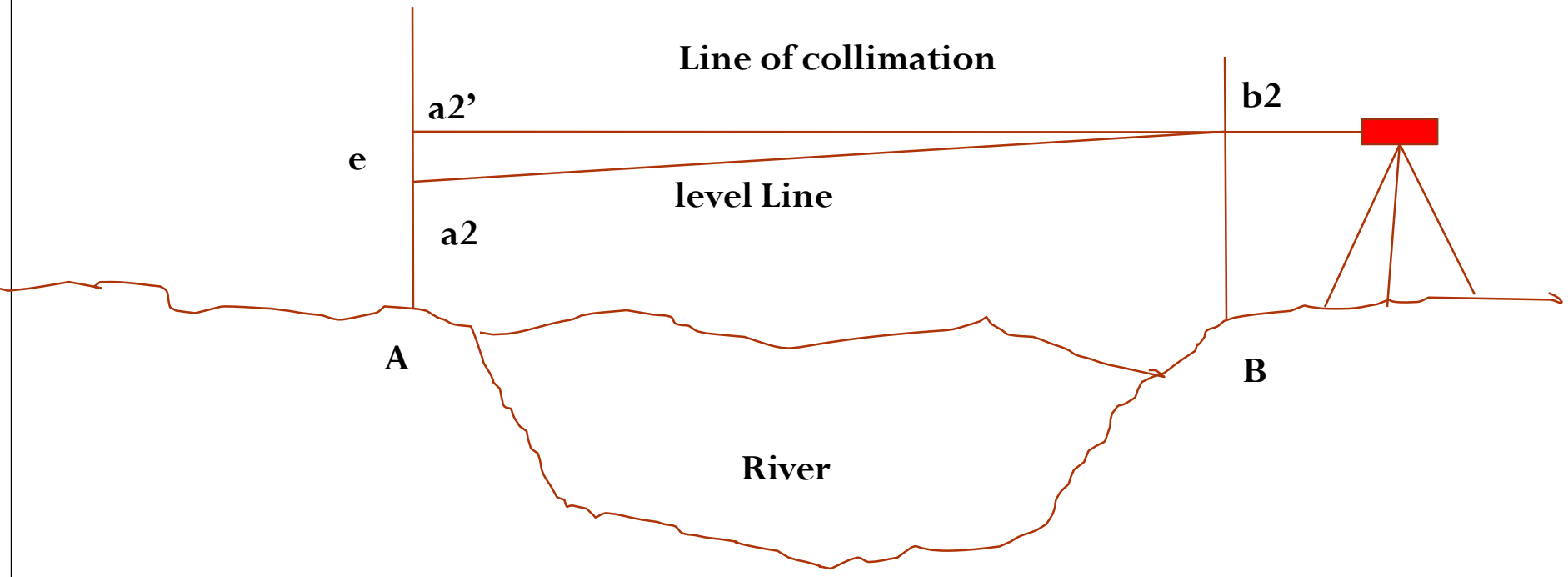
Reciprocal levelling

- ***Reciprocal levelling***:-*This method is adopted to accurately determine the difference of level between two points which are far apart. It is also used when it is not possible to set up level in mid way between two points*
- Let A and B be the two points on opposite banks of a river. It is required to find out the level difference between A & B
- Set up the level very near to A and take the reading at A and B let the reading be a1 and b1
- Shift the level and set up very near to B and observe A and B to get reading a2 and b2
- Let d is the true difference of level between A and B, and e= error due to curvature, refrection and imperfect adjustment.

- Thus to eliminate the error take an average of the difference in elevation taken from 2 points
- i.e. from A the true difference will be =(bb11-'e)-a1
- From B the difference will be= b2-((aa2-'e)
- Therefore dd==={{((bb11-'a1)+(b2-a'2)}/2

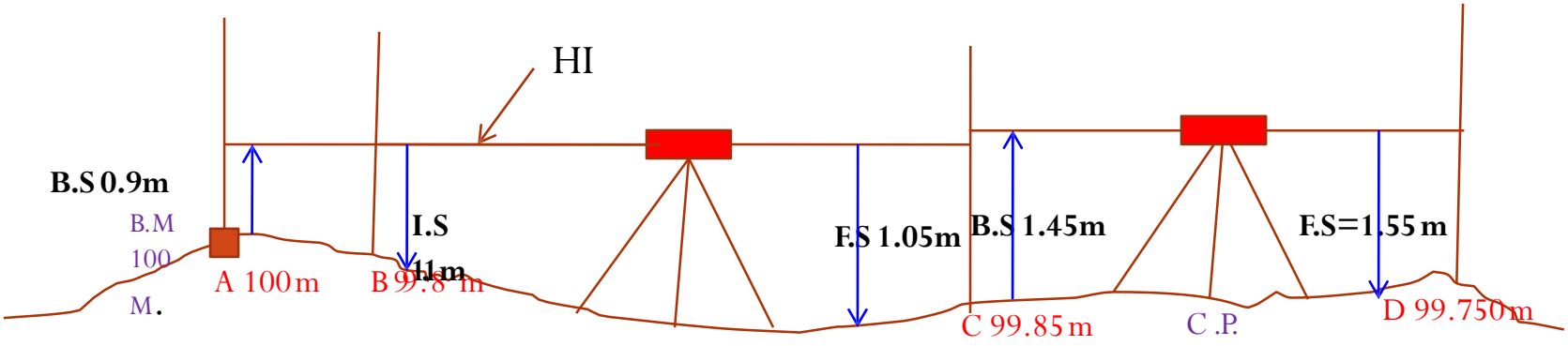


- Thus to eliminate the error take an average of the difference in elevation taken from 2 points
- i.e. from A the true difference will be =(b1'-e)-a1
- From B the difference will be= b2-(a2'-e)
- Therefore d={(b1-a1)+ (b2-a2)}/2



Methods of Reducing levels

- *Height of Instrument Method:- This method consist of finding H.I. for every setup of instrument, and then obtaining the R.L. of point of reference with respect to H.I*

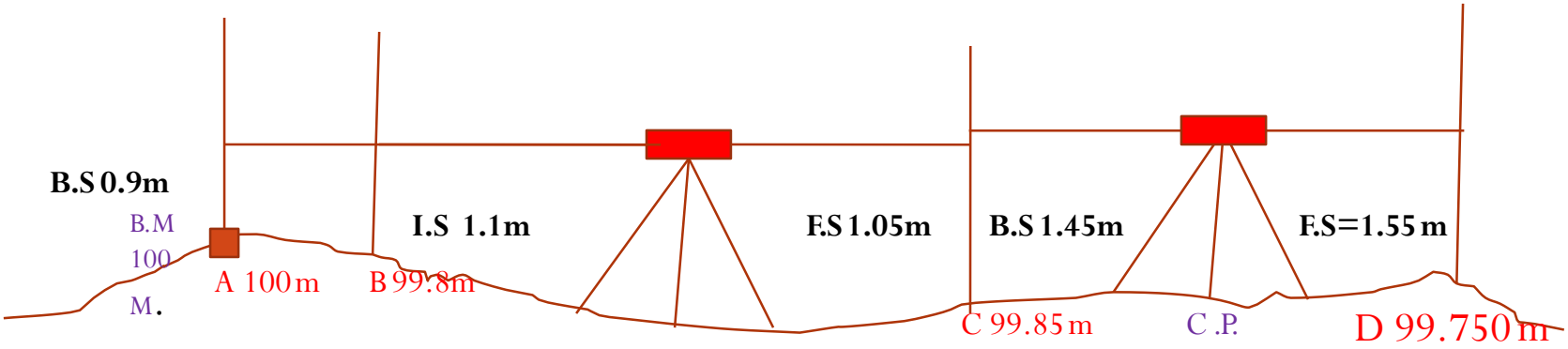


Station	B.S	I.S	F.S	H.I	R.L	Remark
A	0.9			100.9	100.00	B.M
B		1.1			99.800	
C	1.450		1.05	101.3	99.850	C.P.
D			1.550		99.750	

Rise and fall method

This method consist of determining the difference of level between consecutive points by comparing each point with immediate preceding point.

Rise And Fall Method



Station	B.S	I.S	F.S	Rise	Fall	R.L	Remark
A	0.9					100.00	B.M
B		1.1			0.2	99.800	
C	1.450		1.05	0.05		99.850	C.P.
D			1.550		0.1	99.750	

Example

- The following staff readings were observed successively with a level the instrument is moved by third sixth and eighth readings.
- : 2.228 :1.606 :0.988 :2.090 :2.864 :1.262 0.602 :1.982 :1.044 :2.684 m enter the reading in record book and calculate R.L. if the first reading was taken at a B.M of 432.383m

H.I. Method

Station	B.S	I.S	F.S	HI	RL	REMARKS
1	2.228			434.612	432.384 M	B.M.
2		1.606			433.006	
3	2.090		0.988	435.714	433.624	3RD C.P.
4		2.864			432.850	
5	0.602		1.262	435.054	434.452	6TH C.P
6	1.044		1.982	434.116	433.072	8TH C.P
7			2.684		431.432	
	5.964		6.916			

CHECK $\sum$ B.S- $\sum$ F.S= 5.964-6.916= -0.952 = LAST R.L- FIRST R.L= 431.432-432.384=-0.952

Rise and fall method

Station	B.S	I.S	F.S	Rise	Fall	RL	REMARKS
1	2.228					432.384 M	B.M.
2		1.606		0.622		433.006	
3	2.090		0.988	0.618		433.624	3RD C.P.
4		2.864			0.774	432.850	
5	0.602		1.262	1.602		434.452	6TH C.P
6	1.044		1.982		1.38	433.072	8TH C.P
7			2.684		1.64	431.432	
	5.964		6.916				

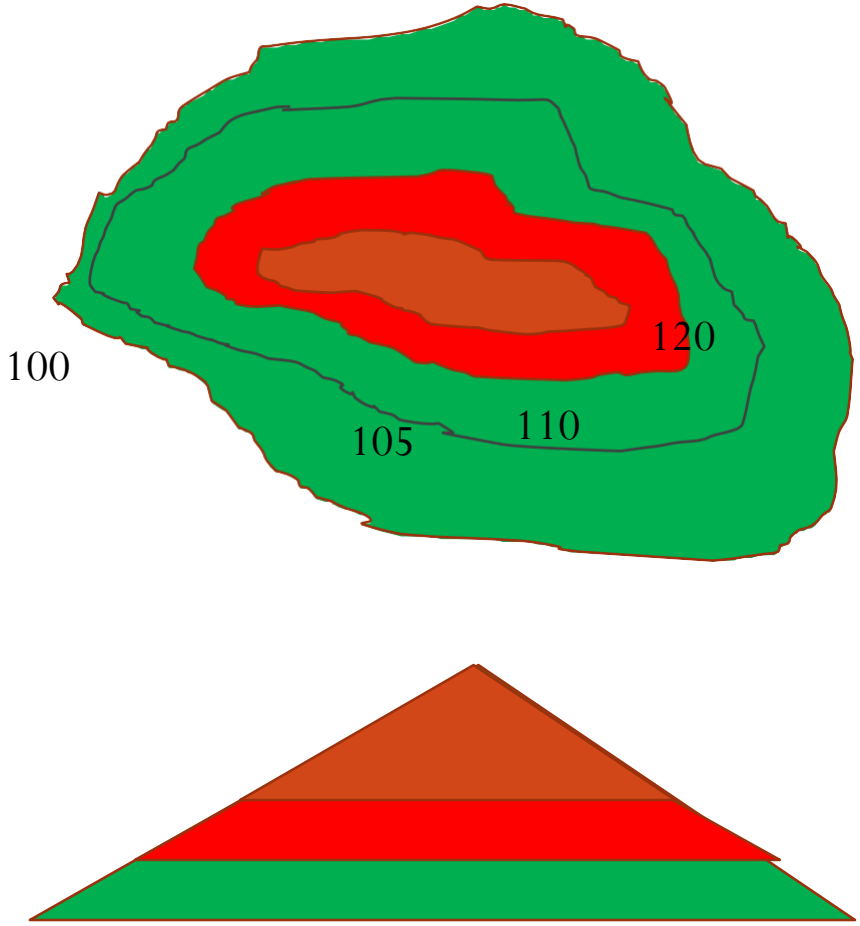
CHECK ∑ B.S- ∑ F.S= 5.964-6.916= -0.952 =

LAST R.L- FIRST R.L= 431.432-432.384=-0.952

∑RISE- ∑ FALL= 2.842-3.794=-0.952

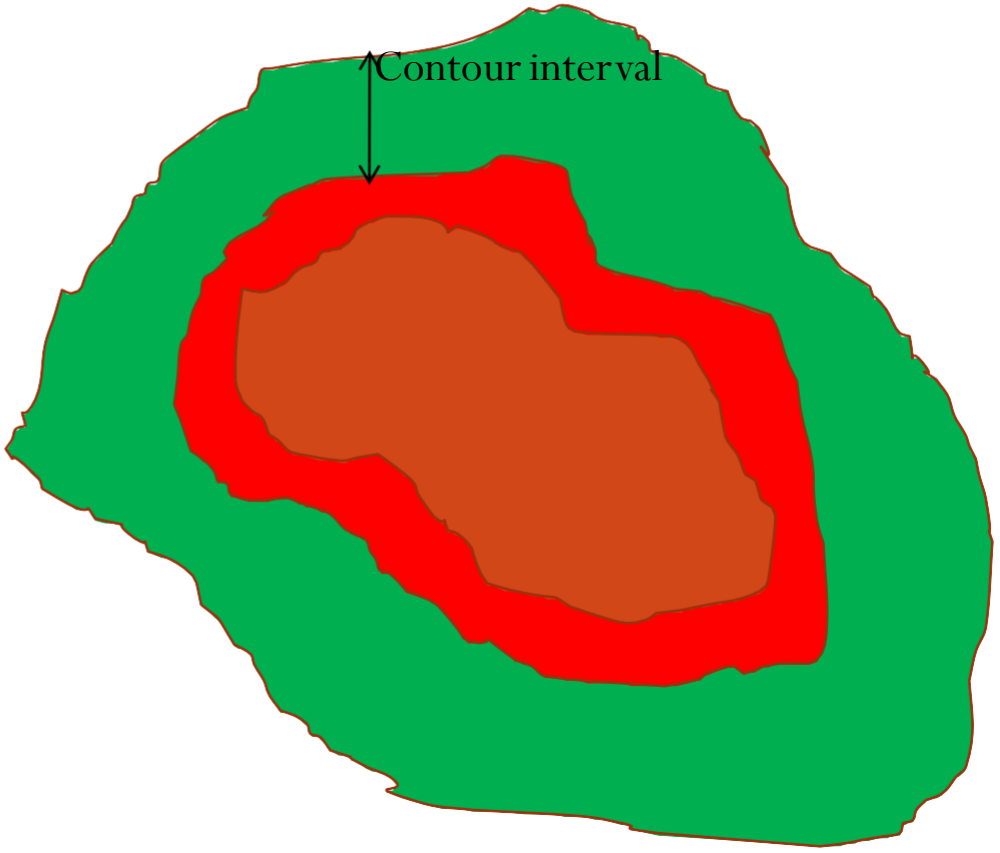
Contour

A contour is an imaginary line joining points of equal elevation



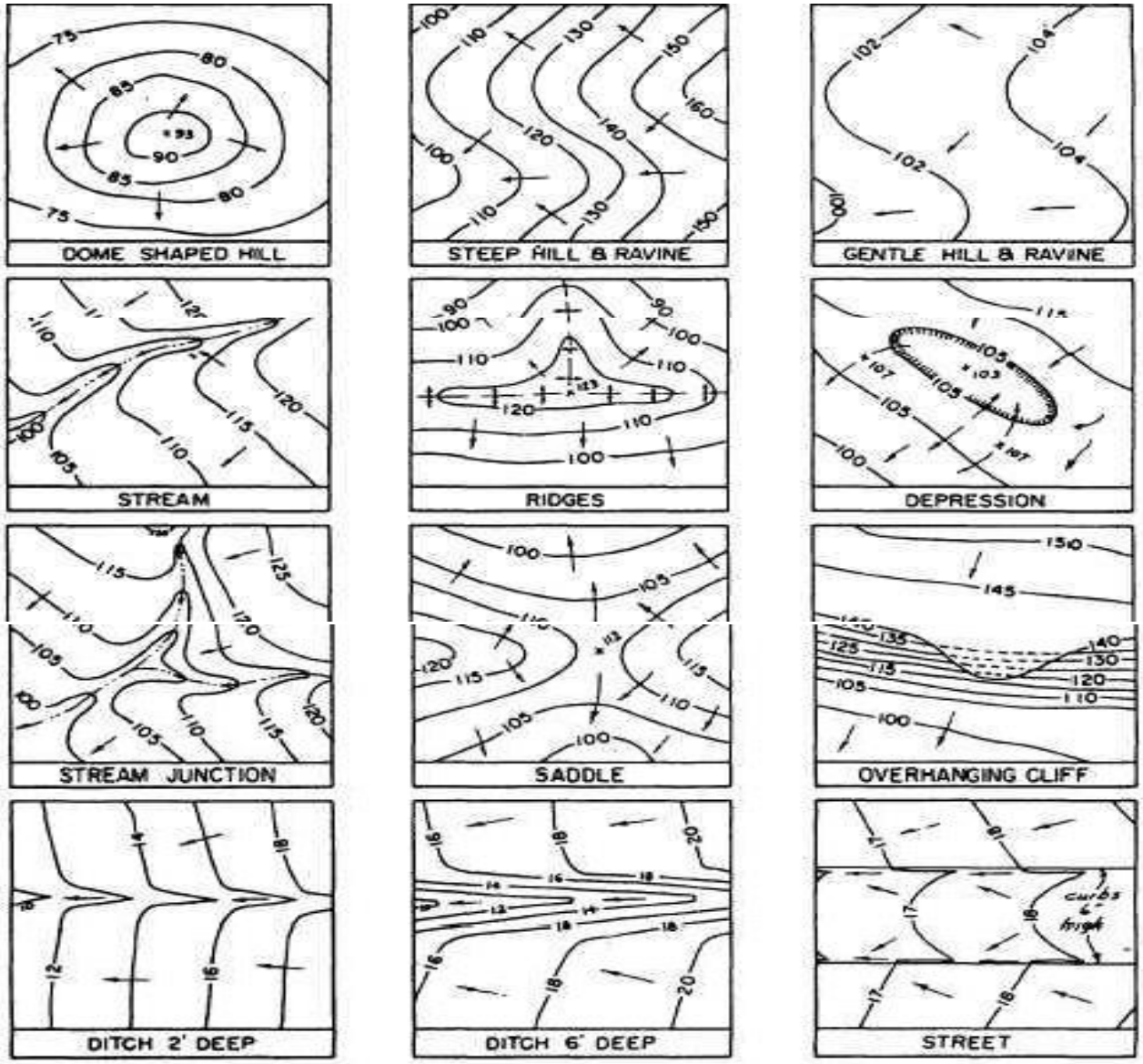
Contour Interval

- *The vertical distance between any two consecutive contours is known as contour interval*



Characteristics of contour lines

- *A series of contour lines with higher value inside indicate a hill*
- *A series of contour lines with lower value inside the loop always indicate depression*
- *Close contour lines indicate steep slope*
- *Wide contour lines indicate flatter slope*
- *Contour lines never cross each other except in case of overhanging cliff.*
- *All points on a contour lines have equal elevation*


DOME SHAPED HILL
STEEP HILL & RAVINE
GENTLE HILL & RAVINE
STREAM
RIDGES
DEPRESSION
STREAM JUNCTION
SADDLE
OVERHANGING CLIFF
DITCH 2' DEEP
DITCH 6' DEEP
STREET

Uses of Contours

- *The nature of ground surface of a region can be known*
- *Contour map helps in locating proper site for bridges, dams, reservoirs etc.*
- *Capacity of a reservoir can be calculated with the help of contour map*
- *The quantity of cutting and filling can be determined from contour maps.*
- *Routes for roads, railways, canals etc can be traced.*

Errors in Levelling

- *The following are the different sources of Errors*
- ***Personal Error***
  - *The Instruments may not be leveled*
  - *The focusing of eye piece and objective glass may not be perfect*
  - *The parallax may not be eliminated*
  - *The position of staff may have changed*
  - *Entry and recording in the field book may not be correct*
  - *The staff may not be fully extended, may not be held vertical.*

- ***Instrumental Error:***
  - *The Permanent adjustment of the instrument may not be perfect. That is the line of collimation may not be horizontal line*
  - *The internal arrangement of focusing tube may not be correct*
  - *The graduation of the staff may not be perfect*

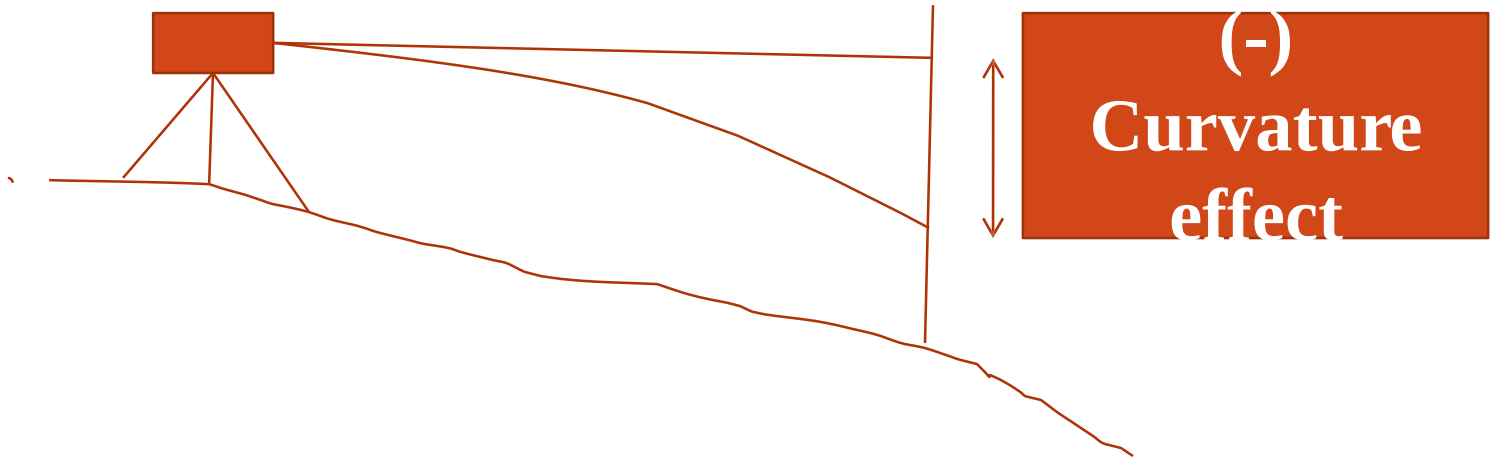
- ***Errors due to Natural Causes:***

  - *The Curvature of the Earth may affect the staff readings when the distance of sight is long.*
  - *The effect of refraction may cause a wrong staff reading*
  - *There are some errors in staff readings due to high velocity wind.*

Curvature Correction

- For long sights the curvature of earth can effect staff readings. The line of sight is horizontal but the level line is curved and parallel to the mean spheroidal surface of the earth. The vertical distance between the line of sight and level line at particular place is called the curvature correction
- The effect of curvature is to cause the object sighted to appear lower than they really are.
- Curvature correction is always Subtractive (-)
- True staff reading= (Observed staff reading- $0.0785\ D^2$) m
- Where D= distance in Km.

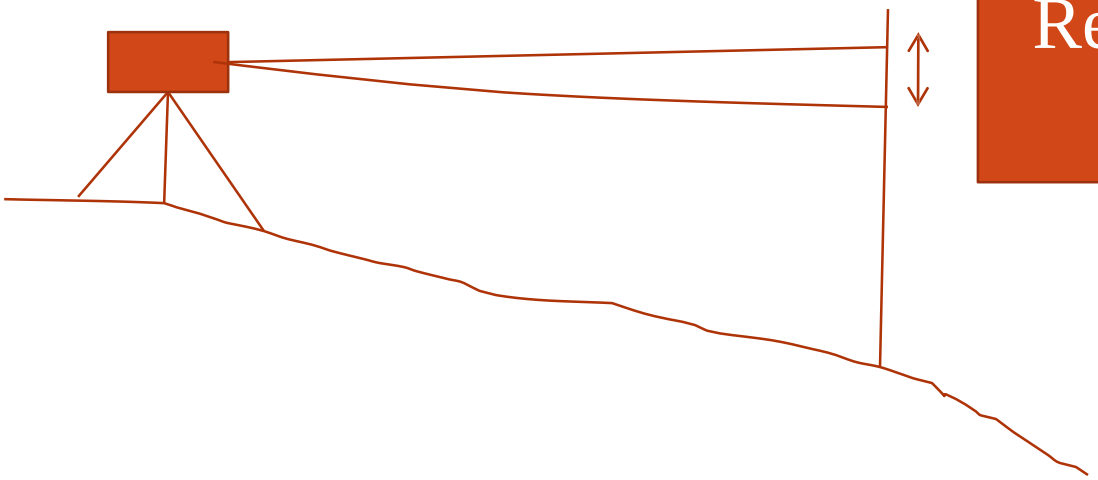
Curvature Correction



Refraction

- The ray of light pass through layers of air of different densities and refract or bent down. The effect of refraction is to make the object appear higher then they really are. Refraction varies considerably with climate conditions.
- However it is taken as
- $Cr = 0.0112\ D^2\ m\ (+)$
- Refraction is always additive
- True staff reading= Observed staff reading + Refraction correction.

Refraction



(+)
Refraction
effect

GPS Surveying

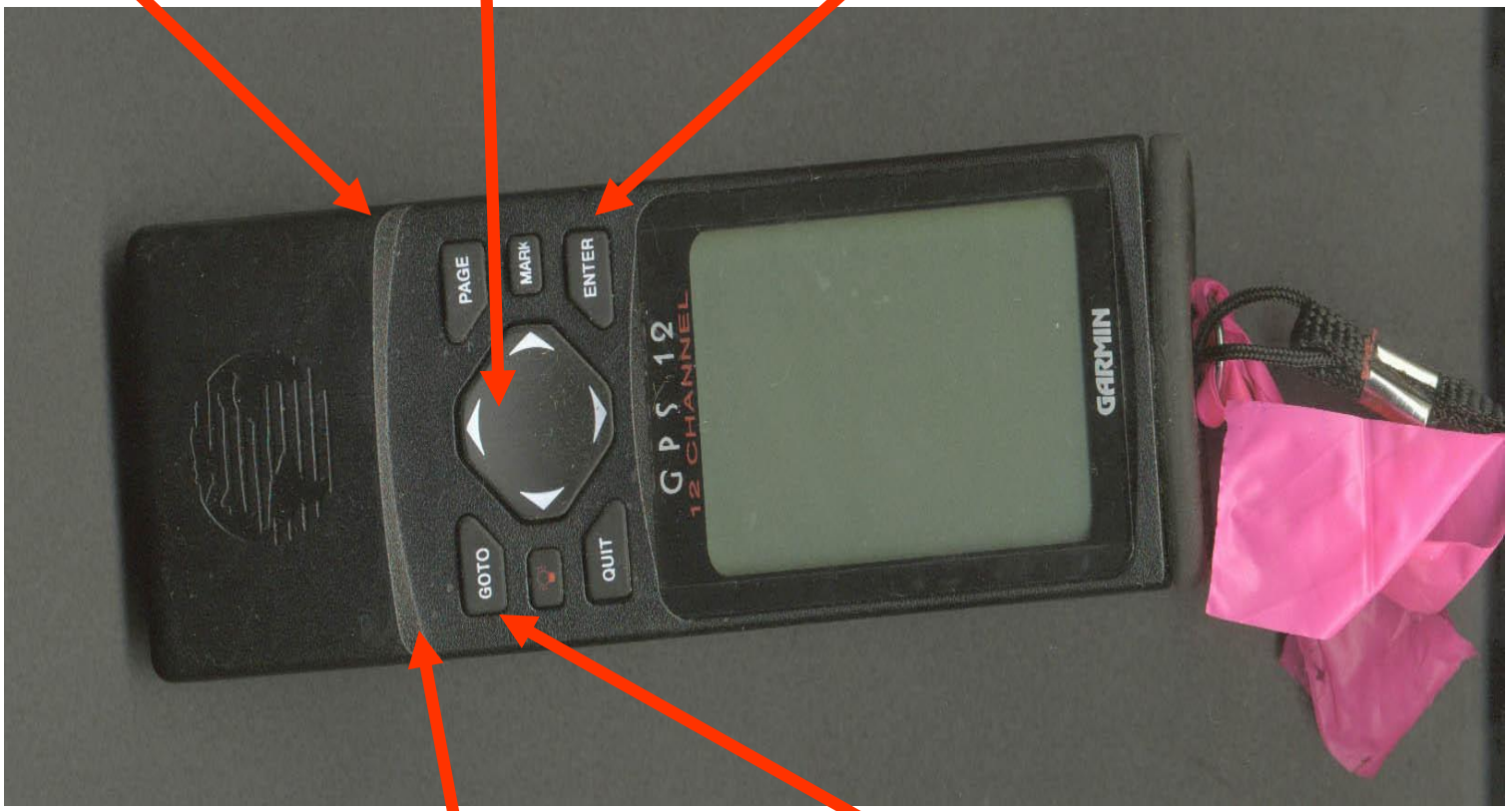
- GPS -- how it works
- GPS -- Garmin 12

The Garmin 12 GPS

Change windows

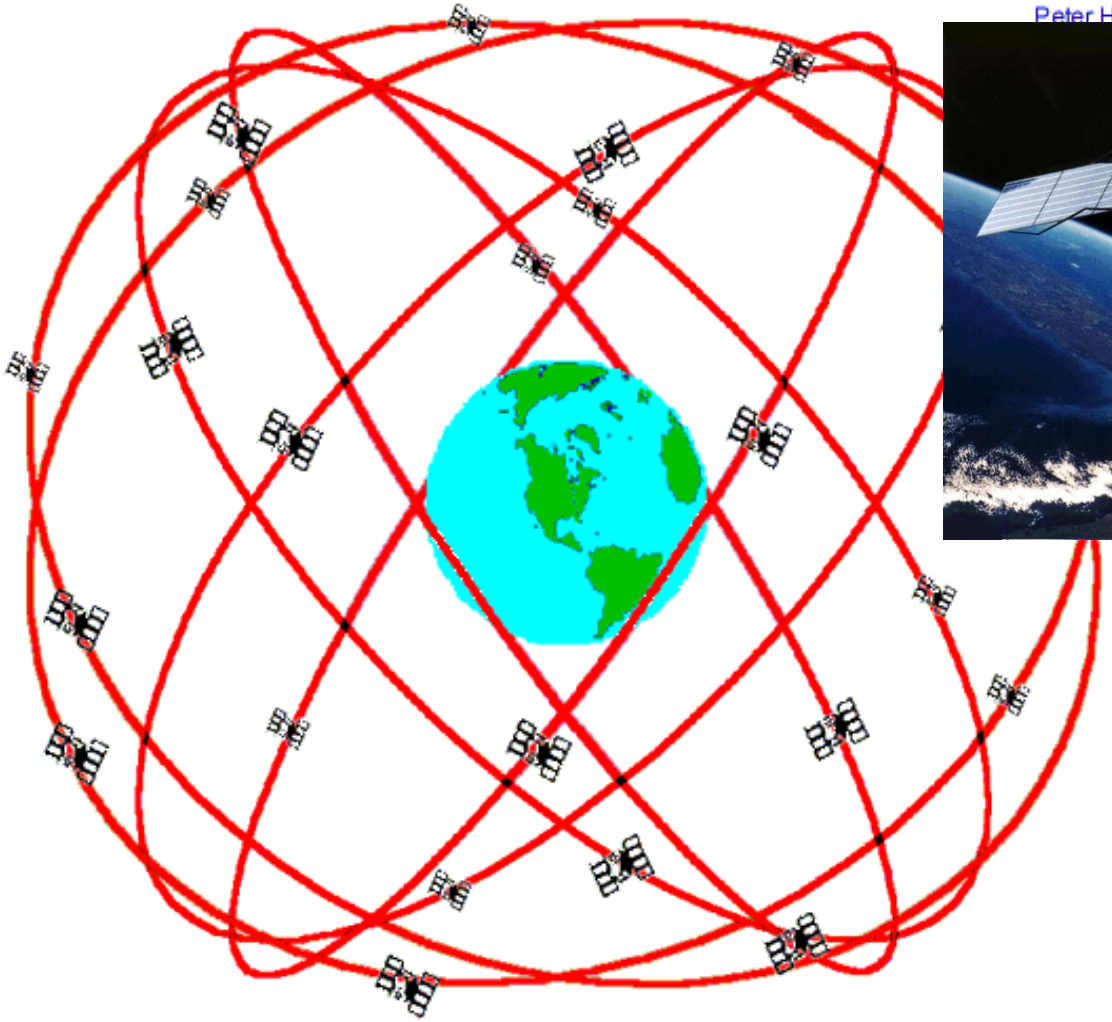
Use to scroll and for keying

Confirm



Get back to a point

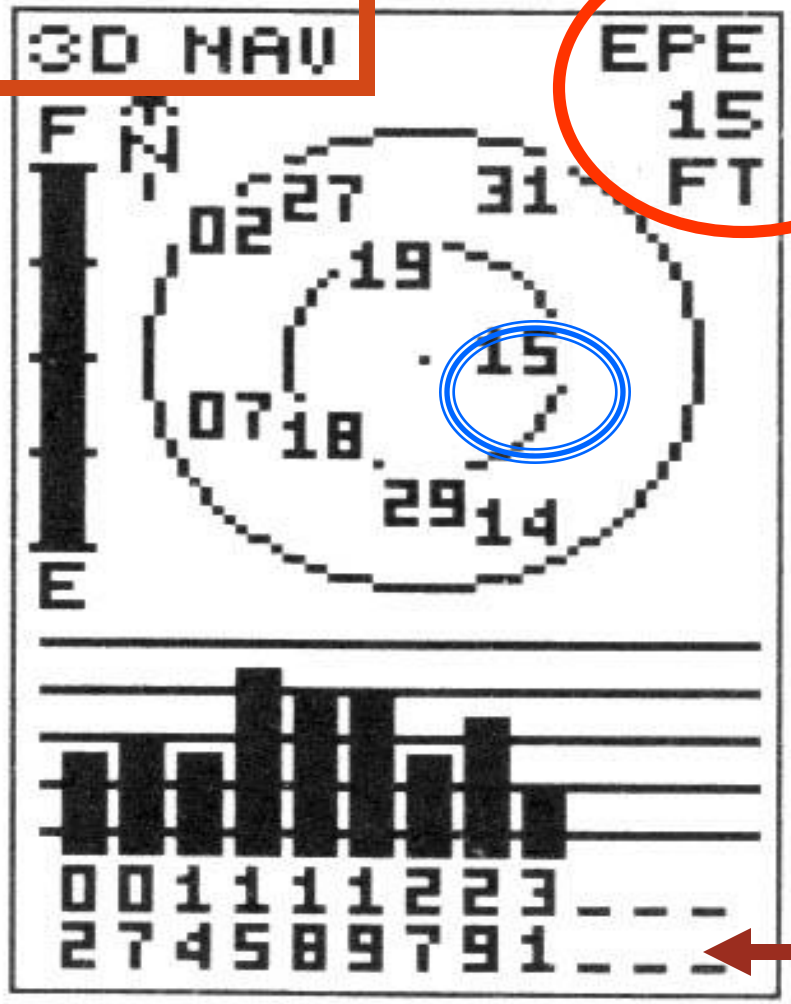
TURN ON



Peter H. Dana 9/22/98

GPS Nominal Constellation
24 Satellites in 6 Orbital Planes
4 Satellites in each Plane
20,200 km Altitudes, 55 Degree Inclination

Trilateration and a 4th for timing



Satellite Page

First page up….

4 important pieces of data

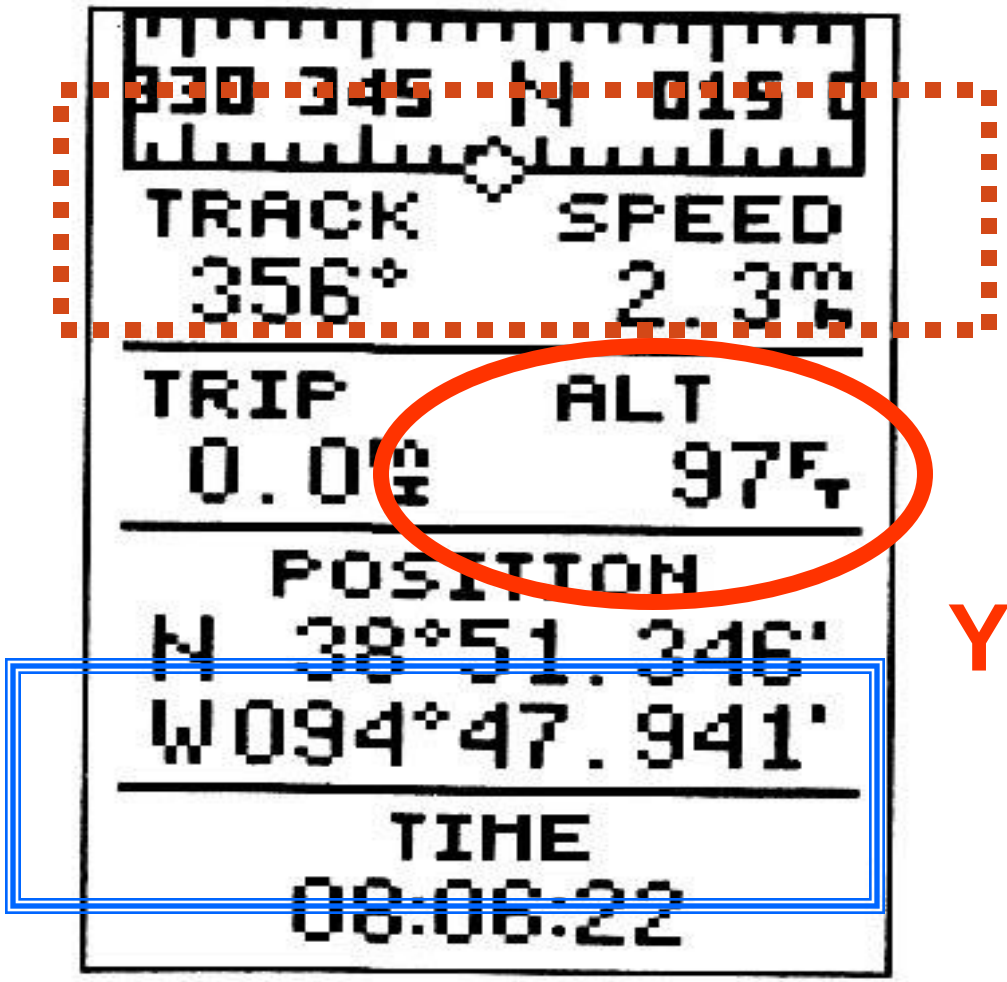
The satillite

It’s signal

Nav

Error

Once you have a fix



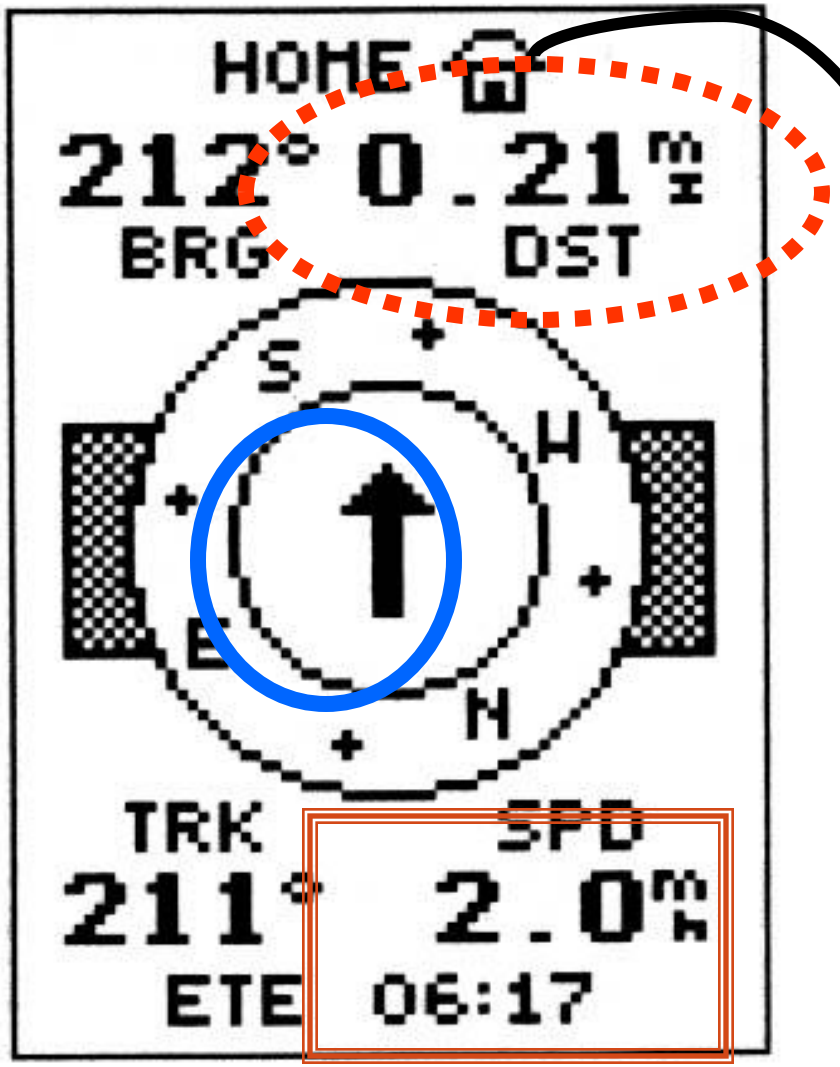
Position Page

Where you are

Your elevation (flaky)

Are you moving?

Are you late?



Compass Page

Getting back to where you started

Hit GOTO

Pick a Waypoint

Follow the arrow

Monitor Speed

Check Distance

GPS Accuracy

Non-corrected *5-30 m*

Beacon-corrected *1 m*

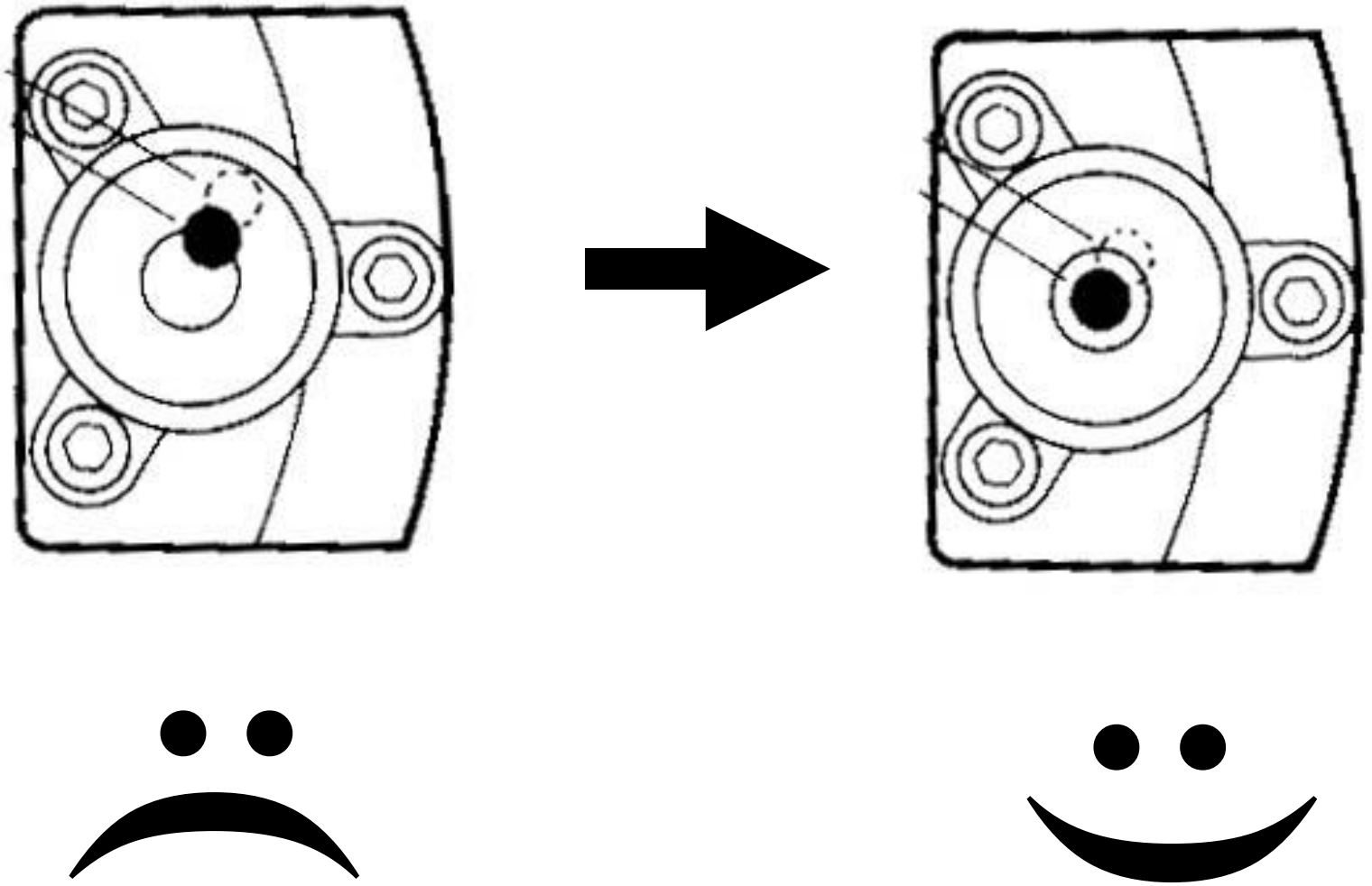
Radio-corrected *cms*

Post-processed *dm to m*

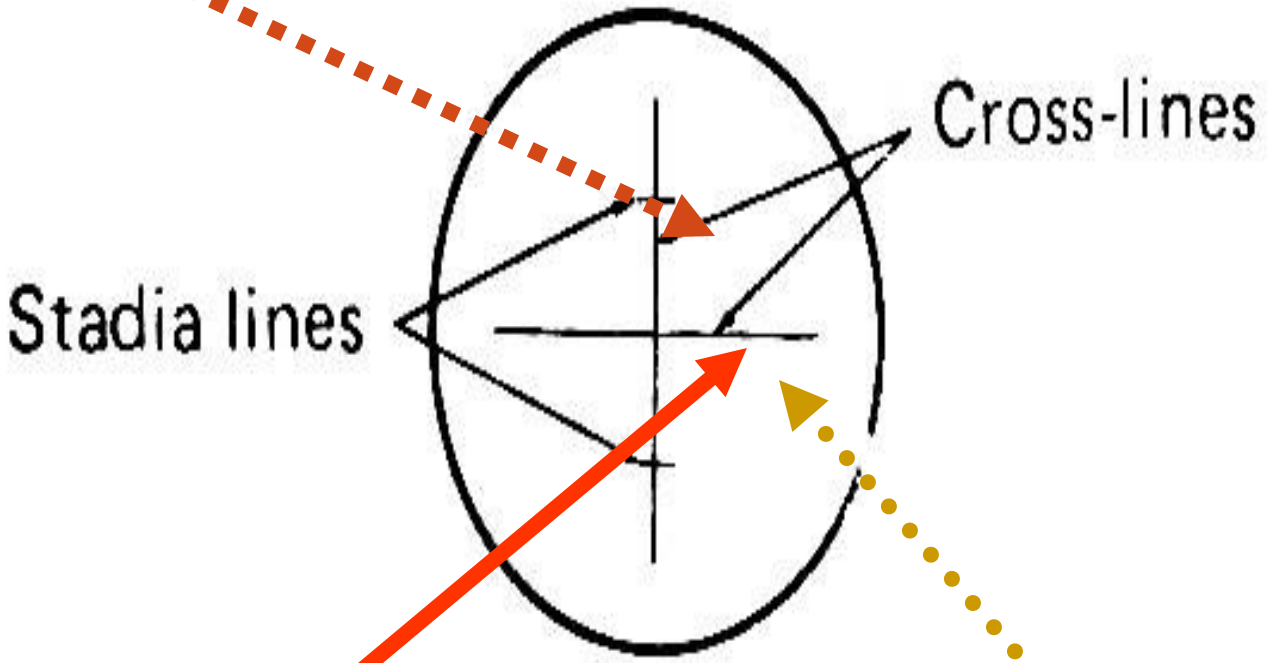
Differential GPS for precision surveying of river terraces and alluvial fans

Crash Course in Surveying With an Auto Level:

First thing first: Gotta level the it



TOP = DISTANCE



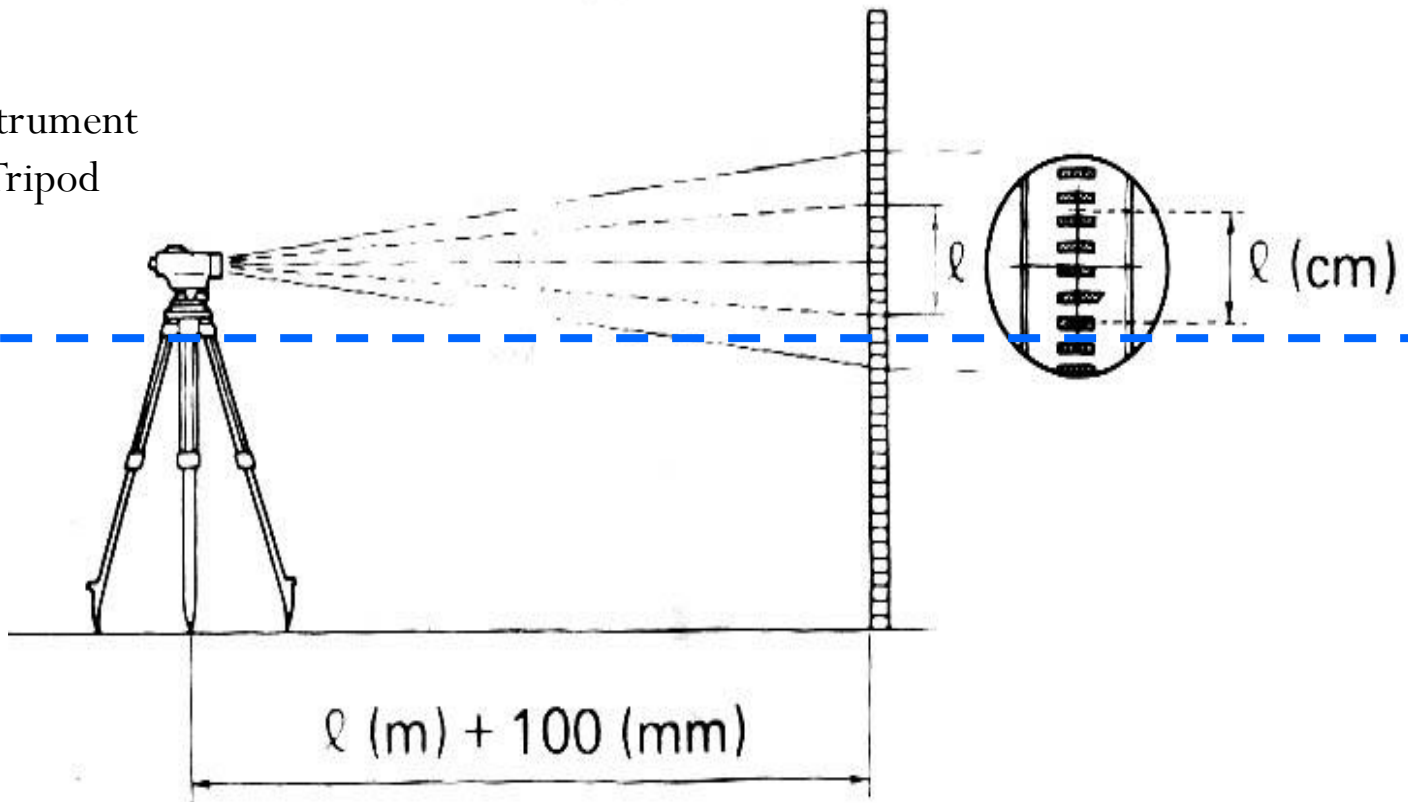
BOTTOM = DISTANCE

CENTER LINE - ELEVATION Δ

The Auto Level:

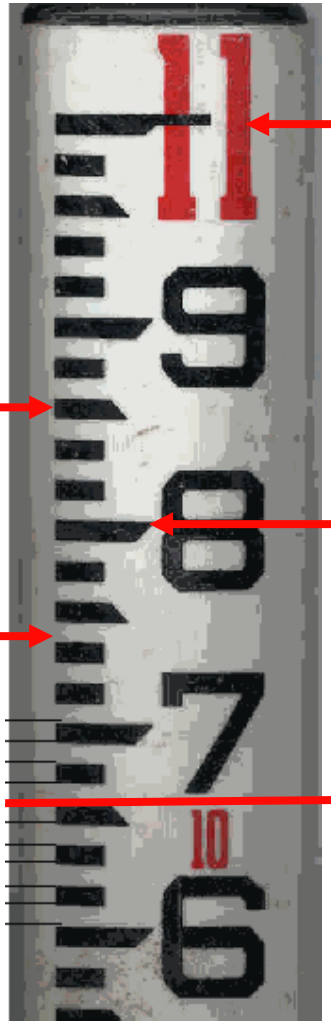
The Stadia Rod
Or Surveyor's Staff

The Instrument
And Tripod



= l (m) * 100 (m)

How to read the Stadia Rod:



11 meters on the dot

Each Black Rectangle = 1 cm

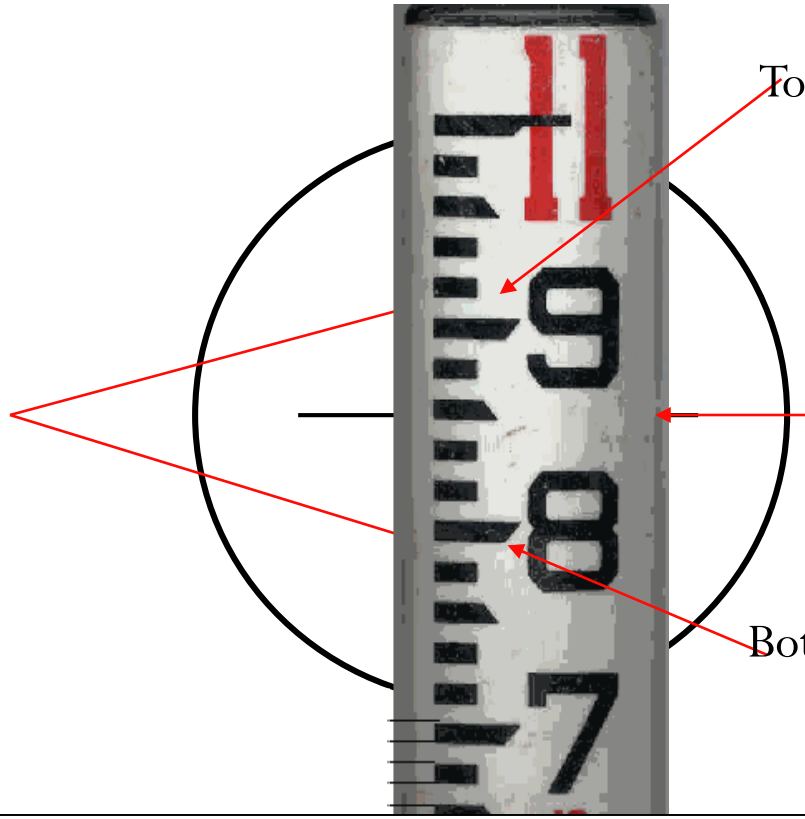
10.8 meters on the dot

Same for Each white one

So what's this height?

10.66 meters

What you'll see through the eyepiece:



Top Stadia = 10.91 m

Stadia Lines

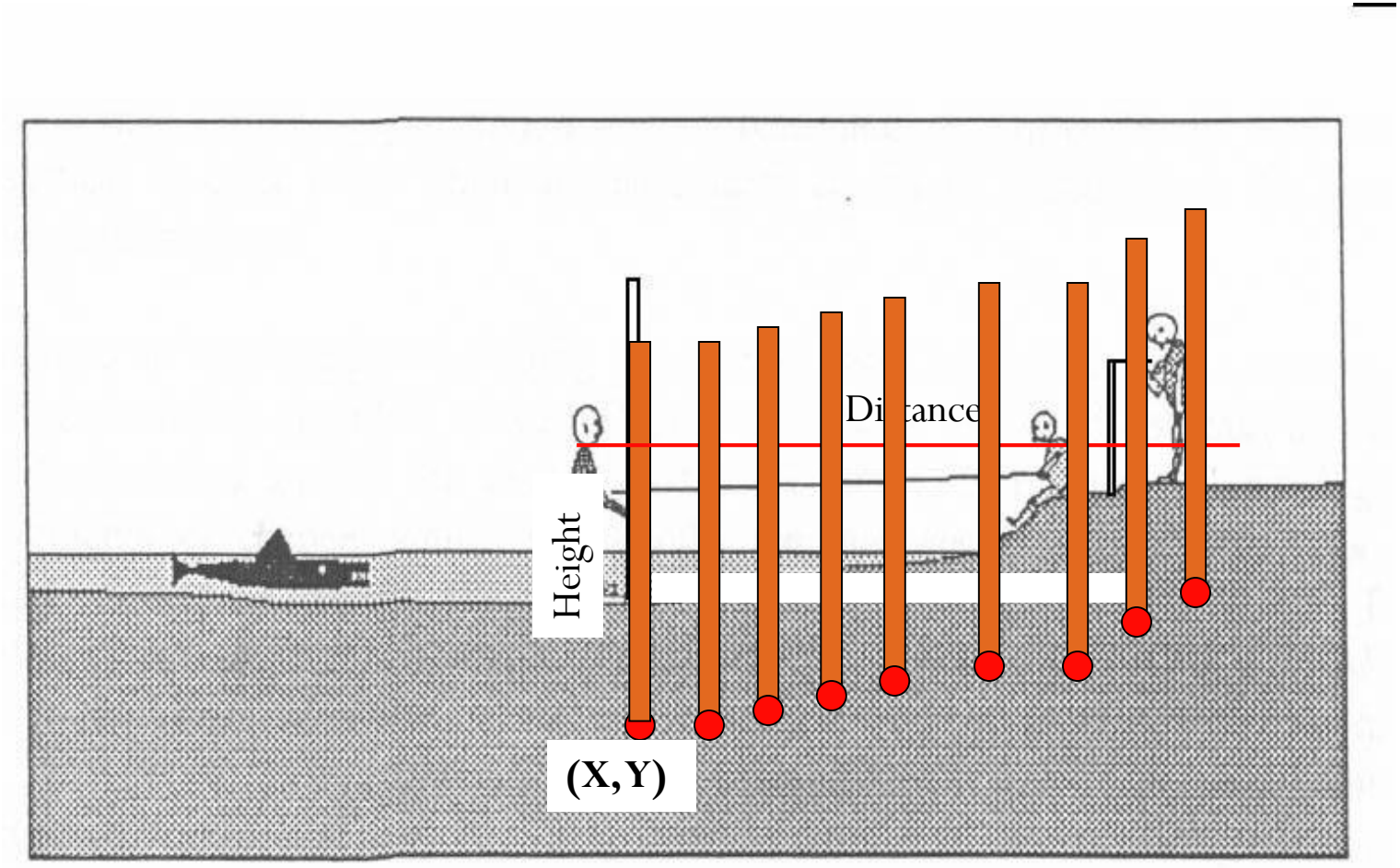
Height = 10.85 m

Bottom Stadia = 10.79 m

To Get Distance Away:

1) (Top - Bottom Stadia) = **0.12 m**
2) Multiply difference by 100: Distance = **12 meters**

For your X-section, be sure to get any Major changes in slope



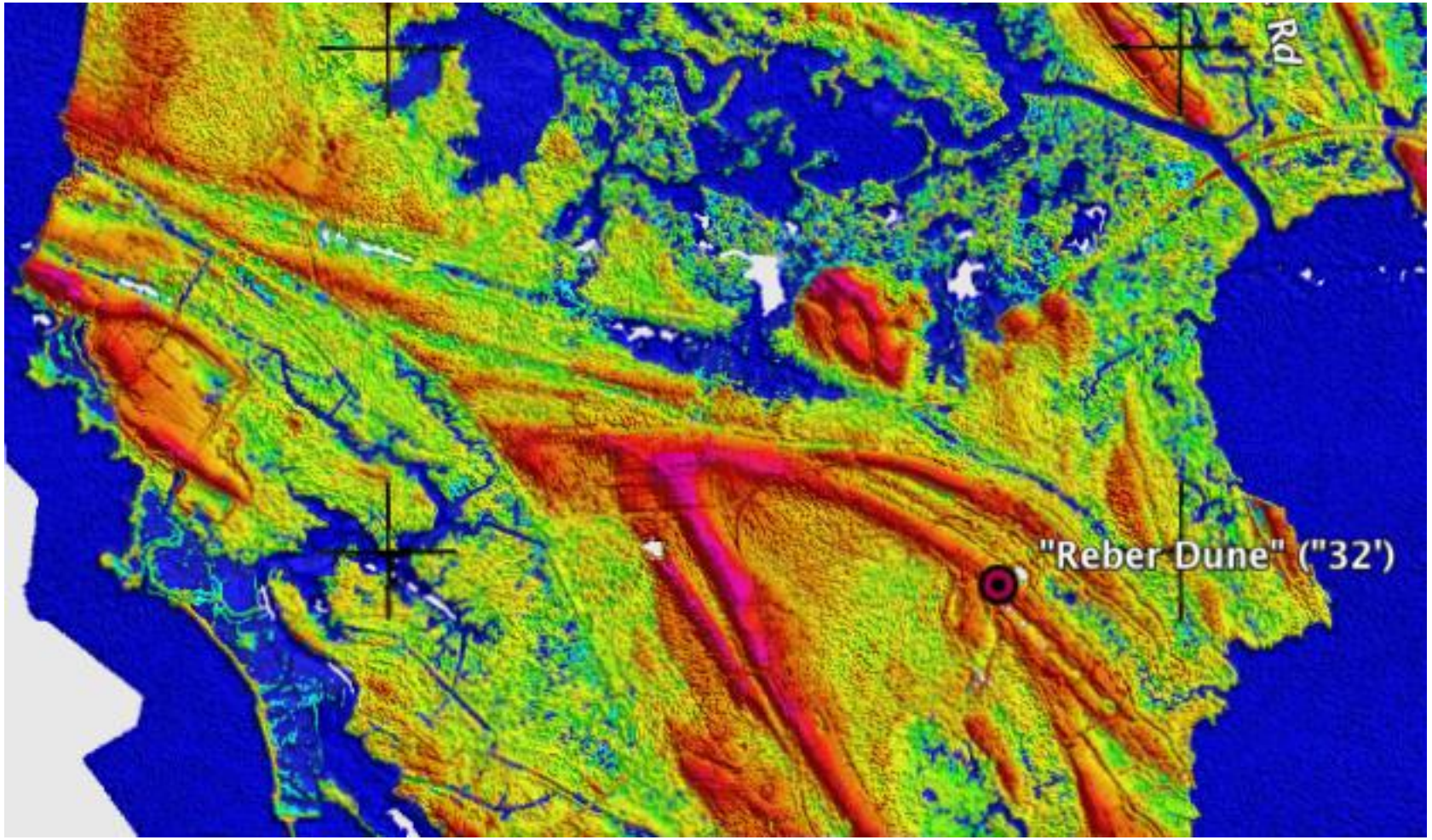
How to collect the data:

Data Collection Sheet For Auto Level Measurements:

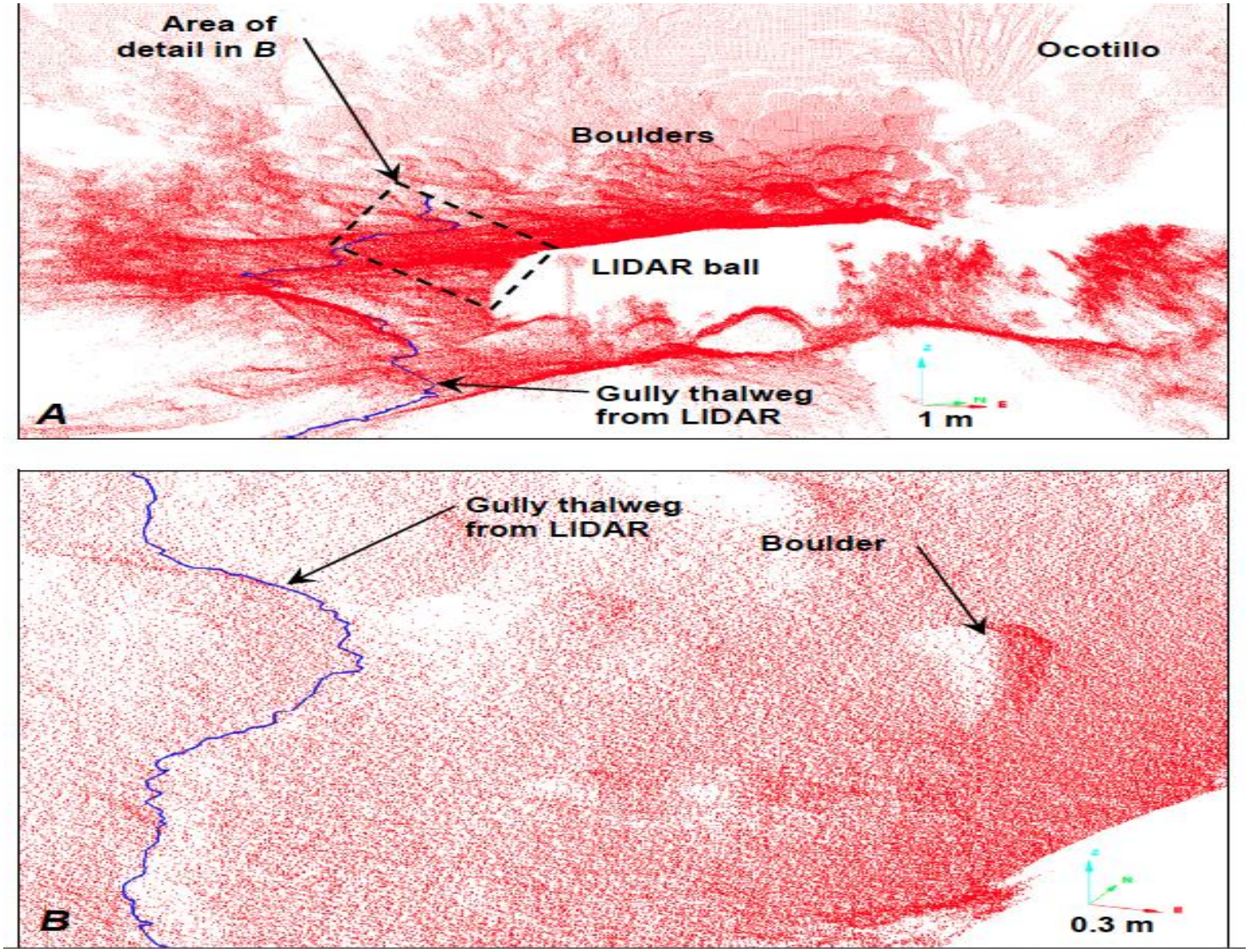
* The Instrument height is the distance from the ground to the eyepiece of the auto level. You need to measure this.
** All Heights (Y-coords) are relative the to ground below the tripod. Anything above your feet is Positive, anything lower is negative

	Distance From Instrument (X):					Height of Point (Y):				
Point #	TS Top Stadia Reads: (meters)		BS Bottom Stadia Reads: (meters)	Diff Top minus Bottom (meters)	X-Coord Distance From Inst. (meters)	IH* Instrument Height (meters)		CL Centerline Reads: (meters)		Y-Coord** Elevation Change (meters)
Ex Pt 1	1.61	-	1.39 =	0.22 x 100 =	22.00	1.3	-	1.50	=	-0.20
Ex Pt 2	1.63	-	1.37 =	0.26 x 100 =	26.00	1.3	-	1.63	=	-0.33

NOTE: When shooting features off your line, you will also need a bearing


Rd
"Reber Dune" ("32')

Side-Scan LiDAR: GeoArcheology


Area of
detail in B
Ocotillo
Boulders
LIDAR ball
Gully thalweg
from LIDAR
A
1 m
Gully thalweg
from LIDAR
Boulder
B
0.3 m

"Project North" is at the white house, And that is BM1

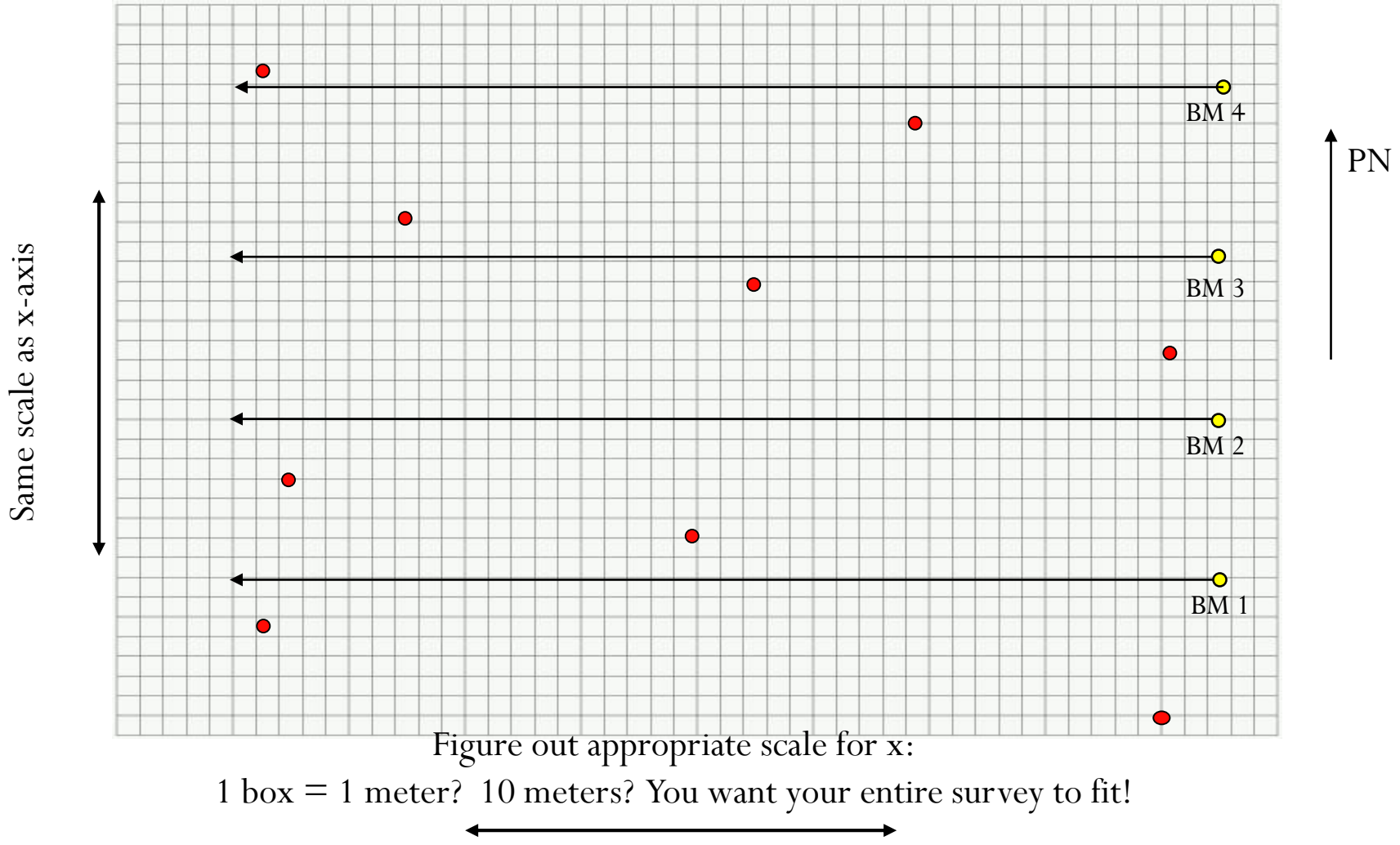


Figure out appropriate scale for x:

1 box = 1 meter? 10 meters? You want your entire survey to fit!