Module - 1 :-

Mine - surveying

Surveying : It is an art of science determining the relative positions (or) stations on the surface of the earth by measuring the horizontal and vertical distance, angles and taking details of the position (or) station and by preparing map (or) plan to a suitable scale.

Objective of Surveying :- The object of surveying is to prepare map (or) plan to show the relative positions of the object (or) station on this surface of the earth. The map (or) plan is drawn to some suitable scale.

→ It also shows the boundaries of the state, country and districts. etc.

principle of Surveying :- To locate a new station by taking at least two measurements (linear or angular) from fixed reference points.

→ Always work from whole to the part.

Uses of Surveying :-

i, To prepare a topographical map which shows the hills, village, river, town forest etc.

ii, To prepare a cadastral map showing the boundaries of fields, houses and other properties.

iii, To prepare an engineering map which shows the details of engineering works such as roads, buildings, reservoirs, irrigation canals.

primary divisions of surveying:-

We know that the surface of the earth is spherical. Thus the surface is obviously curved. surveying is primarily divided into two types considering the curve of the earth's surface.

1, plain surveying
2, Geodetic surveying

plain surveying:- plain surveying is that type of surveying in which earth surface is considered as a plane and the curvature of the earth surface is ignored. In such surveying a line joining any two stations is considered to be straight. The triangles 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.

Geodetic surveying:- 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 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 it Carried out for a larger area exceeding 250 km^2.

plane Survey	Geodetic survey
1, In the Curvatu -re of the earth is Considered as aplain	1, In this the Curvatu -re of the earth is Considered as Spherical
2, The Curvature of the earth is ignored.	2, The Curvature of earth is taken into accou -nt.
3, Line joining any two Stations is Considered to be straight.	3, Line joining any two Stations is Considered as Spherical.
4, The triangle formed by any three points is Considered as plain.	4, The triangle formed by any three points is Considered as Spherical.
5, It carried out for a small area of less than 250 km^2.	5, It carried out for a larger area greater than 250 km^2.

Classification of surveying :-

* Surveying may be classified under headings which defined the uses of the resulting maps.

1, Object of survey
2, Classification according to the nature of
3, field of survey
3, Classification according to the methods employed in survey.
4, Classification according to the instruments used.

1, Object of survey Categories :-

a, Geological survey
b, Mine survey
c, Military survey
d, Engineering survey.

2, Nature of field of survey Categories :-

a, Tropographic survey
b, Cadastral survey
c, Astronomical survey

3, Methods of Employed Categories :-

a, Triangulation survey and traversing survey

4, Instruments survey Categories :-

a, Chain survey
b, Compass survey
c, levelling
d, plane table survey

e, Tacheometry Survey
f, photographic Survey
g, ~~photo~~ Aerial Survey
h, EDM Survey

Direct Ranging :-

* The ranging of survey lines by Observation from one end station, which are inter visible is called direct Ranging

* The Direct Ranging is carried out by an eye are line Ranging.

Indirect Ranging :-

* When both end stations are not inter-visible, either due to high ground b/w them are due to long distance b/w the station.

* The indirect ranging in comes into action.

Direct Ranging :-

* A and B are the two stations at the ends of the survey line which distance is required the measure.

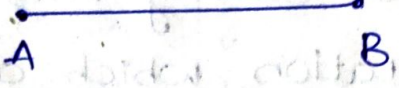
* Ranging rods at station A and B are fixed.

* The Surveyor stands 1.5 - 2m behind the ranging rod at station A, direct the assisstance to fix other ranging rod and mark with arrows.

* The Surveyor standing behind station a give signals. to the assistance to make

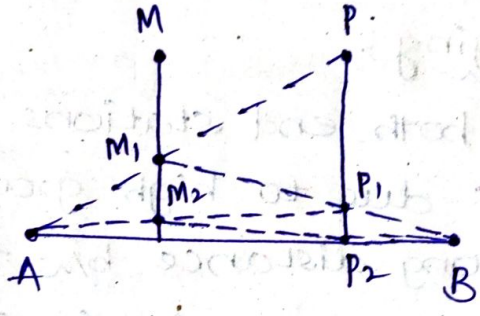
left or right untill the ranging rod (R_1 & R_2) comes in straight line with position A & B.

* The Surveyor as to check they verticality of ranging rods (R_1 & R_2) by siding bottom of the rods.



Direct Ranging.

Indirect Ranging :-



* As shown in the above fig. station A & B are not inter visible due to high level grand in b/w.

* M & P new stations are introduce with ranging rods with approximate equidistance among the four stations.

* 1st station A is observing the position P at M, postion & directed M coming the range at P, so that AMP. are in straight line.

* Now, B observes that M, position & directed P to coming the range at P_1 position so that BP, M, are straight

line.

* Again ranging from A to P_1 position then directed M_1 to coming range at M_2 position so that AM_2P_1 are straight line.

* Similarly way from B station will occupied position M & P are in line with AB.

Errors in Chaining :-

* The difference b/w a measured quantity and the true value of quantity measured is the true error of the measurement.

* Since the true value of the quantity is never known the true error is difficult to be known.

* However the duty of a surveyor is to do measurements so precisely that these should be correct with in certain limits of error.

Sources of Error :-

1, Instrumental Errors
2, Natural Errors
3, Personal Errors.

1, Instrumental Errors :-

The errors which occur due to faulty adjustments or in accuracy in making the instruments are called

instrumental errors.

2, Natural Errors :-

* The errors which araises due to natural effects such as heavy winds, refraction, variation in temparature etc..

3, Personal Errors :-

* The errors which araise due to carelessness of the surveyor - Engineer such as applying unequal tension in the chain, Non- alignment of a chain line not removing parallex or siting the object incorrectly.

Classification of Errors :-

* The chief sources of errors may also be classified under the following Heads.

1, Cumulative error
2, Compensating error
3, Mistakes.

Cumulative error :-

* These are liable to occur in the same direction and tend to accumulate (or) add up as a chaining progress. these errors may be regarded as positive if the measured length is in excess of the true length. Then, if the measured length is less than the true

length it may regarded as negative error.

* Cumulative error is proportional to the true length measured, which seriously effect the accuracy of the work.

Reasons for Cumulative Errors.

1, Incorrect length of a chain
2, Sag on the chain or tape
3, Non-alignment of the chain.
4, Chain (or) Tape not being straight
5, Variation in temparature.

problems :-

1, The length of the line measured by 30 m chain found to be 350 m. Calculate the true length of a line.

i, The chain used 10cm long
ii, The chain used 4cm short.

Sol] Given :-

Chain length = 30m

Measured length = 350 m

Chain used = 10 cm long = 0.1 m

Then, Actual length = ?

$$\text{Actual length of a line} = \frac{\text{Incorrect length}}{\text{Correct length}} \times \text{Measured length}$$

$$\text{Actual length} = \frac{30+0.1}{30} \times 350$$

$$= 351.16 \text{ m}$$

ii,

Given,

Chain length = 30m

Measured length = 350 m

Chain used = 4 cm short

= 0.04 m

Actual length = ?

$$\text{Actual length} = \frac{\text{Incorrect length}}{\text{Correct length}} \times \text{Measured length}$$

$$= \frac{30 - 0.04}{30} \times 350$$

$$= 349.53 \text{ m}$$

2, The length of the line measured with 20 m chain found to be 372m. The true length of the line was known 371 m. Find the error in the chain.

Sol Given data,

The chain length = 20m

Measured length = 372m

True length = 371m

Error = ?

$$\text{Incorrect length} = \frac{\text{Actual length}}{\text{Measured length}} \times \text{correct length}$$

$$= \frac{371}{372} \times 20$$

$$= 19.95 \text{ m}$$

$$\therefore \text{Error} = 20 - 19.95$$

$$= 0.05 \text{ m error.}$$

While Calculating Area :-

Actual area = $\left[\frac{\text{Incorrect length}}{\text{correct length}}\right]^2 \times$ Measured area

While Calculating Volume :-

1, Actual volume = $\left[\frac{\text{Incorrect length}}{\text{correct length}}\right]^3 \times$ Measured length

2, Incorrect length = Correct length ± Error (either shorter (or) longer)

Compensating errors :-

* These are liable to occur in the either direction & have tendency to Compensate the result. Compensating error is proportional to the square root of the length measured. These are not as serious as cumulative errors.

Compensating errors occur due to following Causes :-

a, Incorrect holding of a chain.
b, Incorrect placing of an arrow.
c, Incorrect plumbing
d, Unequal pull applied in the chain

Mistakes :-

Mistakes (or) errors committed due to inexperience Carelessness and poor

judgement of the surveyor / Engineer. If not detected they may seriously effect the final result. These can be avoided by reaching the records in the field itself as the work proceeds.

* Displacement of arrows.
* Mistake in counting the chain length.
* Reading from the wrong end of the chain.
* Wrong Booking.

3. The length of a line measured with 20m chain was found to be 463m. The true length of a line was known to be 467m. Find the error in the chain.

A. Given data:

Chain length = 20m

Measured length = 463m

True length = 467m

Error = ?

$$\text{Incorrect of Chain length} = \frac{\text{Actual length of a line}}{\text{Measured length Of line}} \times \text{Correct length}$$

$$= \frac{467}{463} \times 20$$

$$= 20.17\text{m Error} \qquad L' = L \pm e$$

$\therefore$ Incorrect length = 20 - 20.17

= 0.1727 longer.

Levelling :-

Levelling is a process of finding the differences in vertical heights b/w two (or) more points on the Earth's surface (or) the relative attitudes of a number of points with respect to a given reference line termed as "Datum line". It deals with the measurements in a vertical plane.

principle :-

* The principle of levelling is to obtain a horizontal line of sight from which vertical distances of the points above (or) below of these lines are formed.

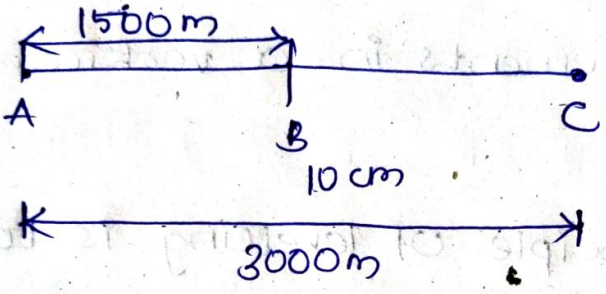
Objective :-

* In connection with mining operations levelling may be employed in following purposes :

1, To determine the depth of the workings below surface.
2, To determine the gradient of roadways through which the mineral may be harled.
3, To determine the height to which water may have to be pumped.
4, To establish contours of the surface and in under ground workings.

4. A 20 m chain was found to be 10cm long after chaining a distance of 1500 m. It was found to be 18cm too long at the end of days work. After chaining a total distance of 3000 m. Find the true distance of the chain was correct before the commencement of the work.

Sol



i, By considering actual length from station A to B.

Given data,

Measured length = 1500m

Chain length = 20m

Error = 10cm long.

$$\text{Actual length} = \frac{\text{Incorrect length of chain}}{\text{Correct length of chain}} \times \text{Measured length of line}$$

$$= \frac{L'}{L} \times ML$$

$$\text{Error} = \frac{0+10}{2} = 5\text{cm}$$

$$= 0.05\text{m}$$

$$L' = 20 + 0.05$$

$$= 20.05\text{m}$$

$$\text{Actual length} = \frac{20.05}{20} \times 1500$$

$$= 1503.75\text{m}$$

ii) By considering find actual length from station B to C.

Given data,

Measured length = 1500 m

Chain length = 20 m

Error = 18 cm long

Average Error b/w stations B & C

$$= \frac{10+18}{2}$$

$$= \frac{28}{2} \text{ 14 cm}$$

$$= 0.14 \text{ m}$$

$$\text{Actual length} = \frac{20.4}{20} \times 1500$$

$$= 1510.5 \text{ m}$$

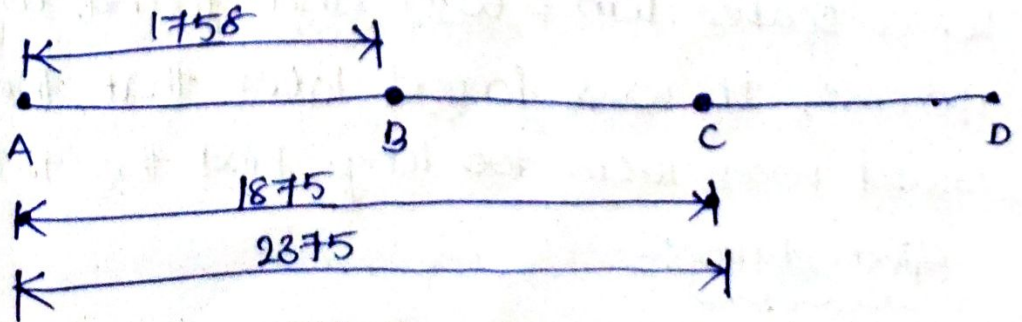
The true length b/w stations A to C is

$$= 1503.75 + 1510.5$$

$$= 3014.25 \text{ m}$$

5. A 30m chain found to be 5cm shorter after chaining a distance of 1758 m. It was found to be 15cm longer after reaching a distance of 1875 m and also it was found 3 cm shorter at the end of days work after reaching 500 m from the previous station.

Sol



i, By considering to find the true length b/w stations A & B.

Measured length = 1758m

Chain length = 30m

Average Error b/w two stations = $\frac{0+5}{2} = 2.5$ cm

Actual length = $\frac{30-0.025}{30} \times 1758$

$= 1756.535$ m

ii, By considering to find the true length b/w C & D stations.

Measured length = 500m

Chain length = 30m

Error b/w C & D = $\frac{15+3}{2} = \frac{18}{2} = 9$ cm

$= 0.09$ m.

Actual length = $\frac{30-0.009}{30} \times 500$

$= 498.5$m.

∴ The Actual distance (or) True distance b/w A & D stations = 1756.535 + 117.39 + 498.5

$= 2372.42$ m.

6. The area Survey by 20m chain was plotted to a scale 1cm = 50m and found to be 140 cm^2. It was found later that the chain used was 10cm too long. Find the true area

Sol Given data:-

L= Chain length = 20m

Scale 1 cm = 50m

Incorrect area = $140 cm^2 \rightarrow m^2$

$= 140 \times 50 \times 50$

$= 350,000 m^2$

10cm too long

True area = ?

Actual area = $\left(\frac{L'}{L}\right)^2 \times$ Measured area

$L' = L + e$ then

$= L + e$ (10 cm = 0.1m)

$= 20 + 0.1$

$\boxed{L' = 20.1 M.}$

Actual area = $\left[\frac{20.1}{20}\right]^2 \times 3,50,000$

$= 353509 m^2$

7. The plan of a old mine surrey plotted to a scale 50m to 1 cm was found to have shrunk so that a line originally 20cm long was 19.4cm. there was also a note on the plan that the 20m chain used was 0.1m too long. If the area of the plan measure now is 150.44 cm^2. Find the true area surrey on the ground.

Sol] Given data

Scale 1cm = 50m

Original length of aline on the plan

$= 19.4$ cm

Incorrect length of aline on the plan

$= 150.44 cm^2$

Chain length = 20 m

too long = 0.1 m.

i, Correct area on the plan

$$= \left[\frac{L'}{L}\right]^2 \times \text{Incorrect area on the plan}$$

$$= \left[\frac{20}{19.4}\right]^2 \times 150.44 \text{ cm}^2$$

$$= 159.88 \text{ cm}^2$$

ii, We know that 1 cm = 50 m

$159.88 \text{ cm}^2 = ?$

$159.88 \times 50 \times 50 = 899700 \text{ m}^2$

$159.88 \text{ cm}^2 = 899700 \text{ m}^2$

Correct area on the ground = 399700 m²

~~Why because, after~~ we ~~found that chain was 0.1m too long~~ Why because after we found that chain was 0.1m too long.

~~Actual~~ area on the ground =

$$\left[\frac{L'}{L}\right]^2 \times \text{Incorrect area on the ground}$$

$L' = L \pm \text{Error}$

$= 20 + 0.1$

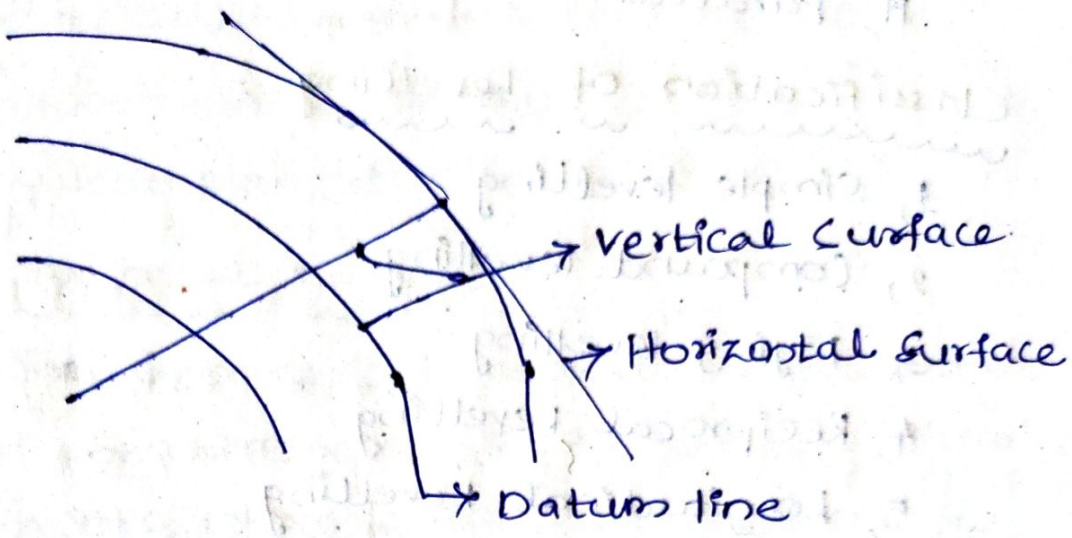
$= 20.1 \text{ m}.$

e = toolong 0.1m.

Actual area on the ground $= \left[\frac{20.1}{20}\right]^2 399700$

$= 403706.9 \text{ m}^2$

Levelling Surrey :-



Important terms used in levelling :-

1, Level Surface
2, Level Line
3, Horizontal line
4, Horizontal surface
5, vertical surface
6, vertical Line
7, Datum Line
8, Mean Sea level (MSL)
9, Reduced level.
10, Bench Marks
11, Fore Sight
12, Back Sight
13, Intermidiate Sight
14, Change point
15, Line Of Collimation
16, Axis of the bubble tube.
17, Height of the instrument

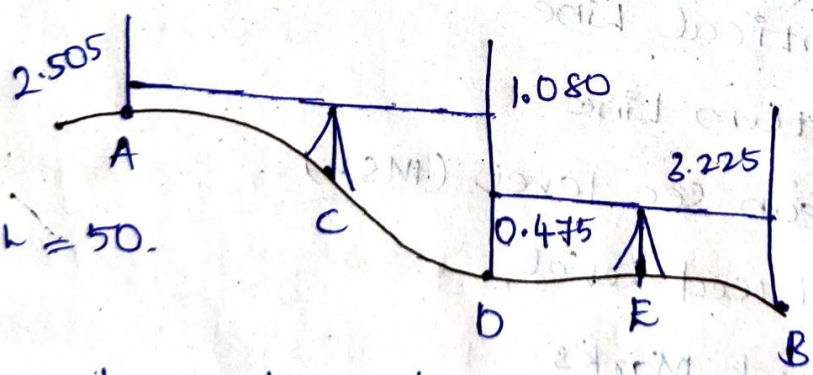
18, Station

19, Parallax.

Classification of levelling :-

1, Simple levelling
2, Compound levelling
3, Flying levelling
4, Reciprocal Levelling
5, Longitudinal Levelling
6, check levelling
7, Cross levelling (or) Cross sectioning
8, precise levelling

Note :- if the F.S. value exceeds, the preceeding back sight value, indicates, the fall b/w those 2 stations.



BS	FS	Rise	Fall	R.L	Dist.	Remarks
2.505				50		St.A
0.475	1.080	1.425		51.42		St.D
	3.225		2.75	48.67		St.B

Methods of Levelling :-

1, Geometrical method
2, Trigonometrical Method
3, physical Method.

1, Geometrical Method :-

The Geometrical method comprices the direct measurement of the vertical distance b/w points whose levels are required & a horizontal line or plane set out by means of spirit level. Normally, it involves the use of a suitably mounted telescope generally a dumpy level, for setting out the horizontal lines, & a graduated staff for measuring the verkical heights & with these instruments the method is capable of giving the highest degree of accuracy. The Dumpy level, however is not suitable for steep gradients but in the absence of angular instrument, the work may be carried out by means of a wooden straight-edge a masons Spirit level & a tape or staff. The Method is also known as Direct Ranging levelling.

2, Trigonometrical Method :-

* The method utilises an angular instrument having a graduated vertical arc to measure vertical angles of a dip or rise, & a chain or steel band to measure distances. Difference of level are then calculated trigonometrically. This Method whilst not as accurate as levelling with a dumpy, engineer's or surveyor's level can be good result & in steep underground roadways, may be the only method available to the surveyor. It is also known as indirect levelling & in a Modified from it is called as Stadia levelling.

3, physical Levelling :-

* In this method, differences of level are deduced from the readings of a Barometer or of boiling point of thermometer The method is based on the fact that the atmospheric pressure varies inversly as the height of any place. The results, however, are approximate only and the method is of little use in mine Surveying.

Errors in Levelling :-

Causes Of Errors :-

The various causes of errors in levelling are —

1, Instrumental errors
2, Errors in Manipulation
3, Errors due to displacement or Settlement of staff and level
4, Errors due to natural causes
5, Errors in reading
6, Errors in Booking

precautions to eliminate errors in levelling :

1, The telescope should be accurately focussed and parallax eliminated
2, The Bubble must always be brought exactly to the centre of its run.
3, If a slide of the staff is drawn out, it must be drawn out fully
4, Fook of the staff should be kept free from dirt
5, Care should be taken in reading and booking of staff readings.

Module - 2 :-

Traversing with compass and Contouring

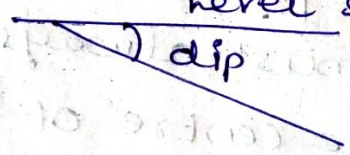
* principle of traversing :-

1, The traversing is the field method which is used for delivering the control of different networks.

2, This also involves the placing of the points in the line access in general conditions. The surveyed points for the base observation.

Dip and declination :-

Dip :- Downwards with reference to level surface.



Declination :- Angle between true meridian and Magnetic meridian.

Magnetic ~~meridian~~ :- Dip :- Declination of magnetic needle with reference of Magnetic meridian.

⇒ Magnetic meridian are two types :-

i, Isoclinecline :-

Same angle Meridian

ii, Aclinic line :-

zero angle meridian this is called Equator line.

iii) Isogonic line :-

Same declination

iv) Agonic lines :-

Zero declination, Magnetic meridian & True meridian coincides.

1, The magnetic declination on a certain date at a given places N 15° 15' W. The magnetic azimuth of a line is 124° 20'. what is the true azimuth of a line

Sol) Given data

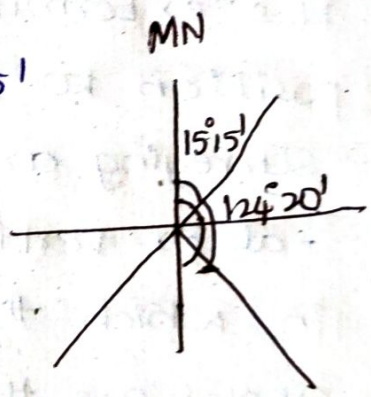
Magnetic Azimuth = 124° 20'

Magnetic declination = 15° 15' W

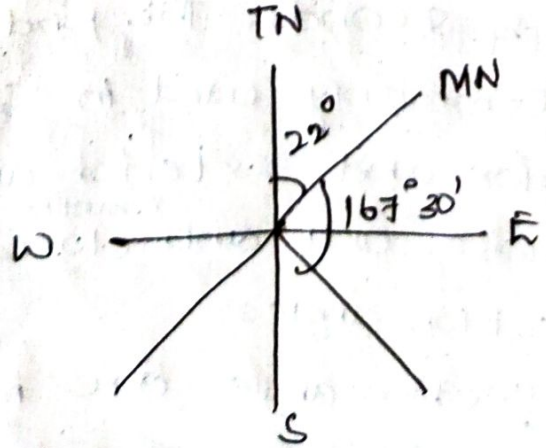
True Azimuth = ?

$\Rightarrow 124° 20' - 15° 15'$

$= 109° 05'$



2, The Magnetic bearing of a line was observed as S 20° 30' E. when the magnetic declination was 22° E. what is true bearing of the line.



Q) Given:-

Magnetic Bearing = S 120° 30' E

Magnetic declination = 22° E

True Bearing = ?

Magnetic azimuth = 180° − 12° 30'

= 167° 30'

True azimuth = 167° 30' + 22°

= 189° 30'

True Bearing = 189° 30' − 180°

= S 9° 30' W.

Angles:- An angle is defined as the amount of turning of a line revolving about one of its extremities in one plane from one position to another angle measured in surveying are classified either as horizontal or vertical depending upon the plane in which they are measured. Horizontal angles are the basic measurements needed for determining bearings and azimuths. The magnitude of an angle is expressed in sexagesimal system in India, i.e. degrees minutes & seconds. The kind of horizontal angles commonly used in surveying are

i, Interior and Exterior angles

ii, Clockwise and anti (counter) clock wise angles

iii, Deflection angles.

* Deflection angles are measured in either clockwise (right) or counter clock wise (left)

from the extension of the backside line to the forward station are always less than 180°.

Bearings:- These represent one system of designating direction of lines. The bearing of a line is the horizontal angle subtended b/w the surface line concerned & some standard line of reference, termed a meridian. The Meridian may be either 1, The geographical or tube meridian, 2, The magnetic meridian 3, An artificial meridian, 4, An assumed (false) Meridian. The bearings may be stated either as a, Quadrant bearings, measured from either end of the meridian according to circumstances (or) b, whole-circle bearings, measured from one end of the meridian.

Azimuth:- The azimuth of a line is its whole circle bearing measured clockwise from the North or zero end of the meridian. The value of such bearing ranges from 0° to 360° The bearing observed with a prismatic compass are the whole circle bearing. The cardinal points of the compass are north, South, East and west and their azimuth are North (0° or 360°), East (90°), South (180°) and west (270°).

Conversion of bearings : WCB into R.B.

Case	W.C.B between	Rules for R.B	Quadrant
I	0° & 90°	R.B = W.C.B	NE
II	90° & 180°	R.B = 180° - W.CB	SE
III	180° & 270°	R.B = W.CB - 180°	SW
IV	270° & 360°	R.B = 360° - W.CB	NW.

R.B into W.C.B :

Case	R.B in quadrant	Rules for W.C.B	W.CB b/w
I	NE	W.C.B = R.B	0° & 90°
II	SE	W.C.B = 180° - R.B	90° & 180°
III	SW	WCB = R.B + 180°	180° & 270°
IV	NW	WCB = 360° - R.B	270° & 360°

Meridians :- The meridian of choosen line of reference from which bearings are measured may be -

1, Geographical (or) True Meridian :- It is the imaginary vertical plane (represented on a plan by a plan line) which passes through the point of observation and also through the North and South Geographical poles.

* The direction of the true meridian at a given place is always constant. The bearing of any line is relation to this meridian is called a true bearing.

2, Magnetic Meridian :- It is the imaginary vertical plane which passes through the

Centre line of magnetic needle freely suspended from its centre at the point of observation and influenced only by the earth's surface magnetic attraction. Its direction is not constant, but varies from moment to moment owing to changes in the earth's magnetic field. The bearing of a line in relation to the magnetic meridian is called magnetic Bearing.

3, Artificial Meridian:- An Artificial Meridian is one laid down b/w two permanant objects and its sometimes used when surveying an isolated area. Usually the relationship of this line to geographical north is found as soon as convenient, but this is not essential so far as the correct relationships of all the lines in the isolated survey is concerned.

4, Assumed or False meridian:- It may be any line in a survey, but usually the first draft. The bearings of all the remaining lines are obtained in relation to this assumed meridian and may be subsequently be converted to geographical (or) Magnetic bearing if the true (or) Magnetic bearing of any one line is known.

Contouring :- The value of a plan or map is highly enhanced if the relative position of the points is represented both horizontally as well as vertically, such maps are known as topographic maps. Topography may be defined (or) represented on a map by hachures (or) hillshading by forming lines.

Contour line :- A contour line is the intersecti of a level surface with surface of ground. It is an imaginary line connecting the points of equal elevation above or below of a given datum. A contour is represented in nature by shore line of a body of still water.

Contour Interval :- The vertical distance b/w of any two consecutive contours is called the contour interval. The contour interval is kept constant for a contour plan, otherwise the general appearance of the plan will be misleading. The horizontal distance b/w two consecutive contours is known as the horizontal equivalent. The horizontal equivalent depends upon the steepeness of the ground.

The following are the proper contour level interval depends upon following Considerations.

i) Nature of the ground

ii) Scale of the plan

iii, purpose and extent of the survey
iv, Time and expenses of field.

Stratum Contours :- These are contour lines drawn on the surface of a bed or coal seam and are the same as strike lines. In case of uniformly sloping bed or seam these lines are equally spaced and may form straight lines if the direction of dip is constant in the area.

Isopachytes :- These are the lines showing equal vertical thickness of strata, say between the floor of two seams. Such lines are obtained by showing the contours of two seams on the same plan in correct relationship to each other If one joints the points where these differences give the same value, a curved line is produced known as Isopachyte line.

Characteristic of contour lines :-

The following are the characteristics of the contour lines.

1, All points in one contour line have the same reduced level.

2, Every contour line closes on itself, either within or beyond the limit of the map.

3, Contour lines are equally spaced when the ground is uniformly sloped and where the ground is plane they are straight and parallel.

4, Contour lines runs close together near the top of the hill, representing very steep ground and wide apart at the flat ground.

5, Contours never split, nor do two Contour run into one, nor cross each other, except in the rare instance of an overhanging cliff.

6, A series of closed Contours on map indicates a depression or a summit according to the lower or higher value values inside them. The depressions between the summits are called saddles.

7, The direction of the steepest slope at a point on contour is at right angles to the Contour.

Uses of Contour lines on mine plans :-

1, Any change in flat or inclined seams. Anticlini-cal or synclinical structures, domes or basins etc. can be easily ascertained from a contour map.

2, A map Contour line is a line of strike and direction and amount of dip can be calculated.

3, Work planning schemes can be drawn up with due regard to the dip can be seam.

4, proper position of shafts, inclines etc can be located as not to be affected by highest flood level.

5, Gradients of proposed road or railway

line at surface or haulage road below ground can be determined.

6, Static pumping head can be determined at any point.

7, Layout of stowing pipe range can be planned.

8, Area liable to flooding can be seen at a glance and proper drainage scheme can be drawn up.

9, Inter visibility of two stations can be ascertained from a contour map.

10, Thickness of coal seam can be determined from stratum contours or underground levels and surface contour lines. Isopachytes can be found out for use in quarry works.

11, Quantity of earth work can be computed.

12, Capacity of reservoir can be determined.

Methods of contouring :-

In general, there are mainly two field measurements of determining contours :-

a, Direct Method

b, Indirect Method.

a, Direct Method :-

1, By selecting a long main line and then taking cross-sections at suitable intervals.

2, By radial line method.

3, Use of plane table in conjunction with levelling operation.

b) Indirect levelling

i) Square method

ii) Cross-section method

iii) Tacheometric Method.