Learning Objectives - L1

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1. Define Geomatics
2. Understand the general relation between the fields of geomatics
3. Define Survey and its importance
4. Know General Types of Surveying
5. Know the Specific Types of Survey
6. Know How Distance is Measured
7. Know How Angles are Measured
8. Understand Cartesian Coordinates
9. Know How Elevation is Measured
10. Know How Terrain is Model
11. Know How a Cross-Section is Made

Reading Assignment

- Ch 1 of Textbook
- Basics of Geomatics (in folders file)

Homework Assignment

1. Using internet searches, find information about the following devices:
   a. **Survey digital level**
   b. **Total station theodolite.**
   c. Write a summary of their use (1/2 page total for each device (minimum - singled space).
   d. You can also include photos, but these should be placed after your summary. Remember to reference your sources. (30 points.)

Definition of Geomatics

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Geomatics is defined as a systemic, multidisciplinary, integrated approach to selecting the instruments and the appropriate techniques for collecting, storing, integrating, modeling, analyzing, retrieving at will, transforming, displaying, and distributing spatially georeferenced data from different sources with well-defined accuracy characteristics and continuity in a digital format.

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Geomatics is a relatively new term that is now commonly
being applied to encompass the areas of practice formerly identified as surveying. The name has gained widespread acceptance in the United States, as well as in other English-speaking countries of the world, especially in Canada, the United Kingdom, and Australia. In the United States, the Surveying Engineering Division of The American Society of Civil Engineers changed its name to the Geomatics Division. Many college and university programs in the United States that were formerly identified as "Surveying" or "Surveying Engineering" are now called "Geomatics" or "Geomatics Engineering."

Textbook - 13th Edition

Relationship of Elements of Geomatics

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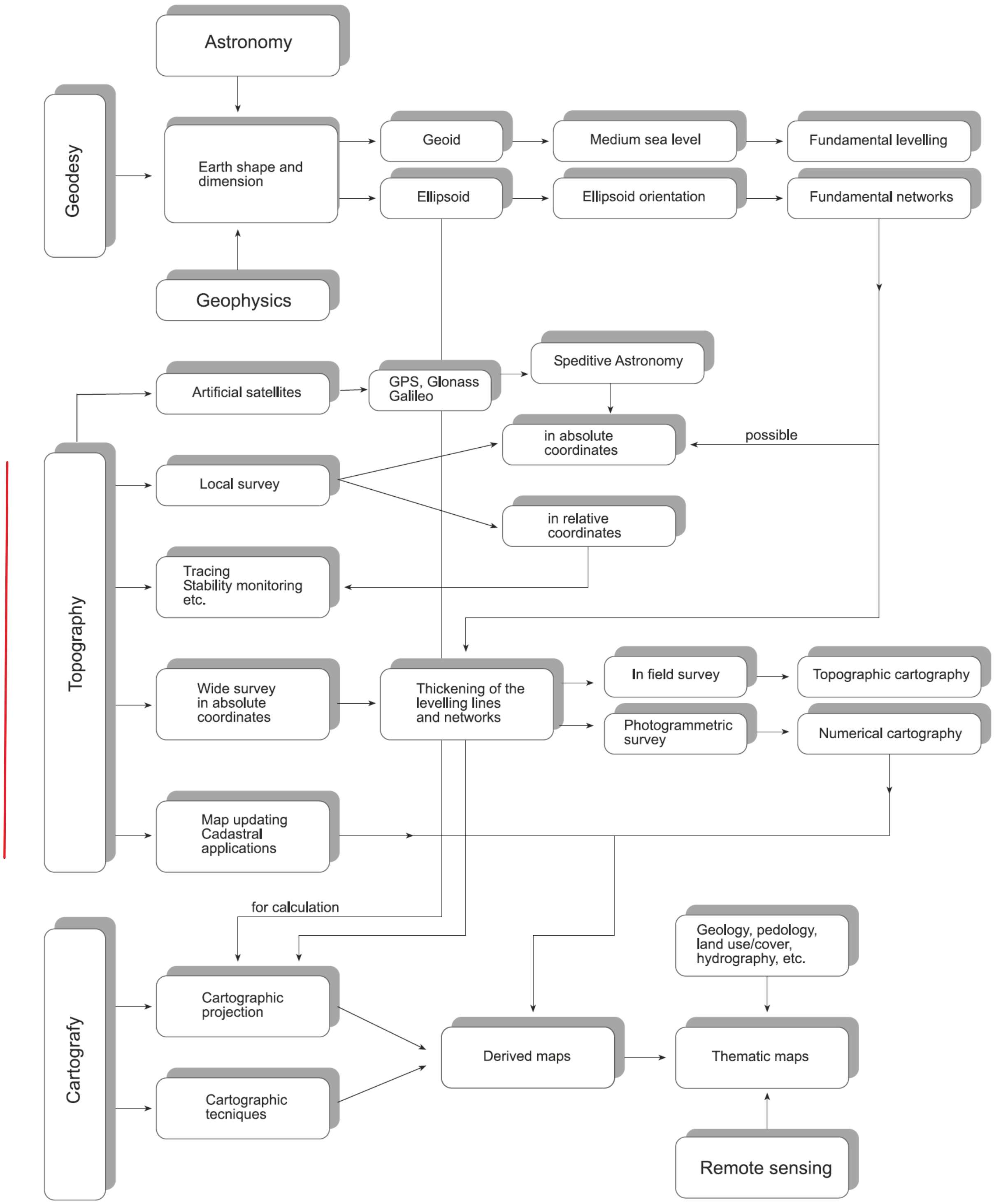

Definition and Importance

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Definition of Surveying

- Surveying has to do with the determination of the relative spatial location of points on or near the surface of the earth.
- It is the art of measuring horizontal and vertical distances between objects, of measuring angles between lines, of determining the direction of lines, and of establishing points by predetermined angular and linear measurements.
- Along with the actual survey measurements are the mathematical calculations.
- Distances, angles, directions, locations, elevations, areas, and volumes are thus determined from the data of the survey.
- Survey data is portrayed graphically by the construction of maps, profiles, cross sections, and diagrams.

Importance of Surveying

Land surveying is basically an **art and science of mapping and measuring land**. The entire scope of profession is wide; it actually boils down to calculate where the **land boundaries are situated**. This is very important as without this service, there would not have been r**ailroads, skyscrapers** could not have been erected and neither any individual could have put fences around their yards for not intruding others land.

History of Surveying

The University of Duhok

- The Early Days Of Surveying
  - 2700 BC by Egyptian

    Great Pyramid by using basic geometry.
  - 1400 B.C by Egyptian

    land division into plots for the purpose of taxation.
  - Romans were the Next

    an official land surveyor was employed by the empire

History of Geomatics (cont.)

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- The Early Days Of Surveying
  - 120 B.C
    - Greeks developed the science of geometry and were using it for precise land division.
    - Greeks developed the first piece of surveying equipment (Diopter).
    - Greeks standardized procedures for conducting surveys.

History of Geomatics (cont.)

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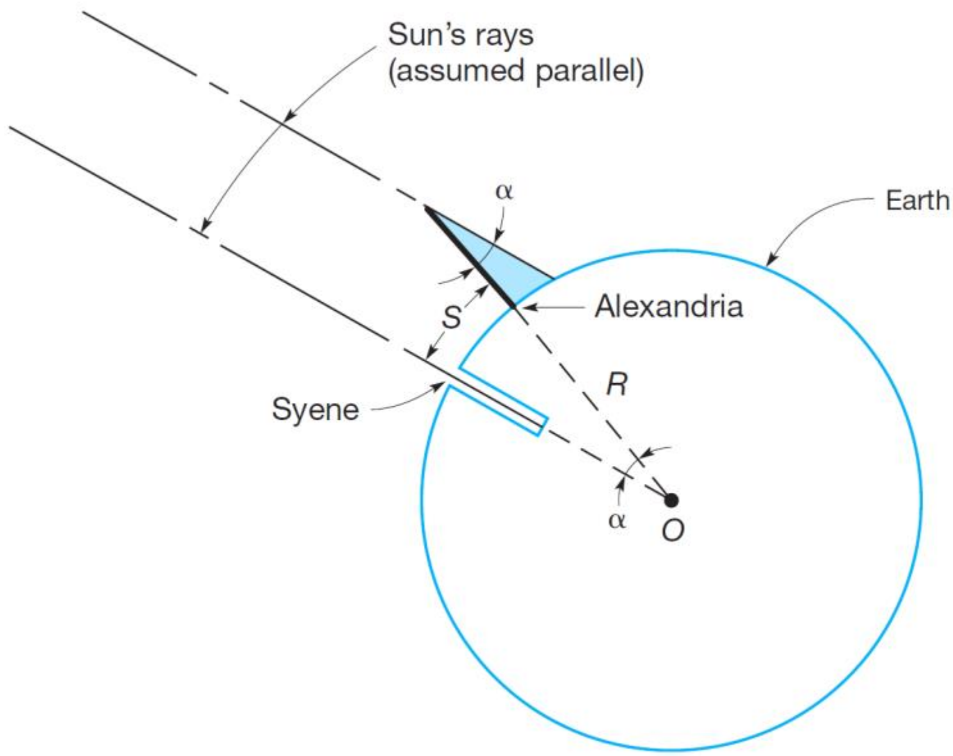
Eratosthenes measurement of the circumference of the earth



Eratosthenes had concluded that the Egyptian cities of Alexandria and Syene were located approximately on the same meridian, and he had also observed that at noon on the summer solstice, the sun was directly over-head at Syene. (This was apparent because at that time of that day, the image of the sun could be seen reflecting from the bottom of a deep vertical well there.) He reasoned that at that moment, the sun, Syene, and Alexandria were in a common meridian plane, and if he could measure the arc length between the two cities, and the angle it subtended at the Earth's center, he could compute the Earth's circumference. He determined the angle by measuring the length of the shadow cast at Alexandria from a vertical staff of known length. The arc length was found from multiplying the number of caravan days between Syene and Alexandria by the average daily distance traveled.

History of Geomatics (cont.)

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- The Early Days Of Surveying
  - 1800 A.D.
  - Beginning of the industrial revolution.
    - "exact boundaries" importance.
    - demand for public improvements (i.e. railroads, canals, roads).
    - More accurate instruments were developed.
    - Science of Geodetic and Plane surveying were developed.

Historical Survey Equipment

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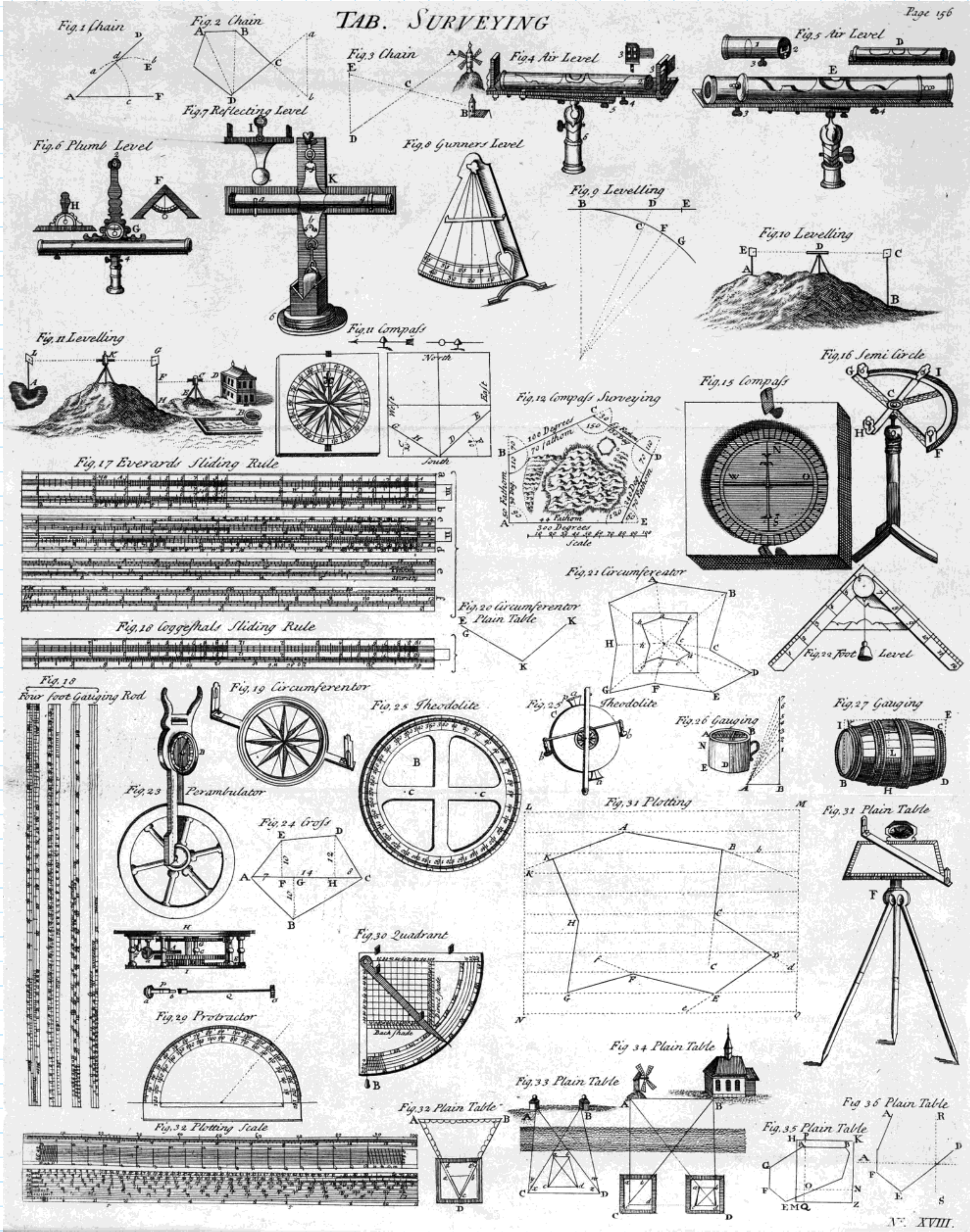

https://en.wikipedia.org/wiki/Surveying

Historical Survey Equipment (cont.)

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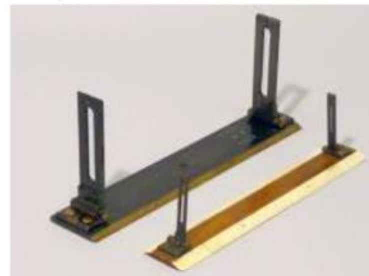
- Chain
- Compass
- Plane table
- Barometer
- Alidade



History of Geomatics (cont.)

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- Survey Today
  - To map the earth above and below the sea.
  - Prepare navigational maps (land, air, sea).
  - Establish boundaries of public and private lands.
  - Develop data bases for natural resource management.
  - Development of engineering data for
    - Bridge construction.
    - Roads.
    - Buildings.
    - Land development.

Modern Survey Equipment

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Surveying equipment. Clockwise from upper left: optical theodolite, robotic total station, RTK GPS base station, optical level.

https://en.wikipedia.org/wiki/Surveying

General Types of Surveying

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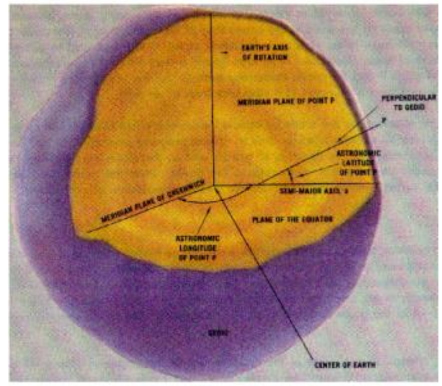
Types of Surveying

Geodetic Surveying:

The type of surveying that takes into account the true shape of the earth. These surveys are of high precision and extend over large areas.



Plane Surveying:

The type of surveying in which the mean surface of the earth is considered as a plane, or in which its spheroidal shape is neglected, with regard to horizontal distances and directions.

Specific Types of Surveying

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- Control Survey: Made to establish the horizontal and vertical positions of arbitrary points.

- Boundary Survey: Made to determine the length and direction of land lines and to establish the position of these lines on the ground.

- Topographic Survey: Made to gather data to produce a topographic map showing the configuration of the terrain and the location of natural and man-made objects.

- Hydrographic Survey: The survey of bodies of water made for the purpose of navigation, water supply, or sub-aqueous construction.

- Mining Survey: Made to control, locate and map underground and surface works related to mining operations.

- Construction Survey: Made to lay out, locate and monitor public and private engineering works.

- Route Survey: Refers to those control, topographic, and construction surveys necessary for the location and construction of highways, railroads, canals, transmission lines, and pipelines.

- Photogrammetric Survey: Made to utilize the principles of aerial photogrammetry, in which measurements made on photographs are used to determine the positions of photographed objects.

- Astronomical survey: generally involve imaging or "mapping" of regions of the sky
using telescopes.

Purposes of Surveying

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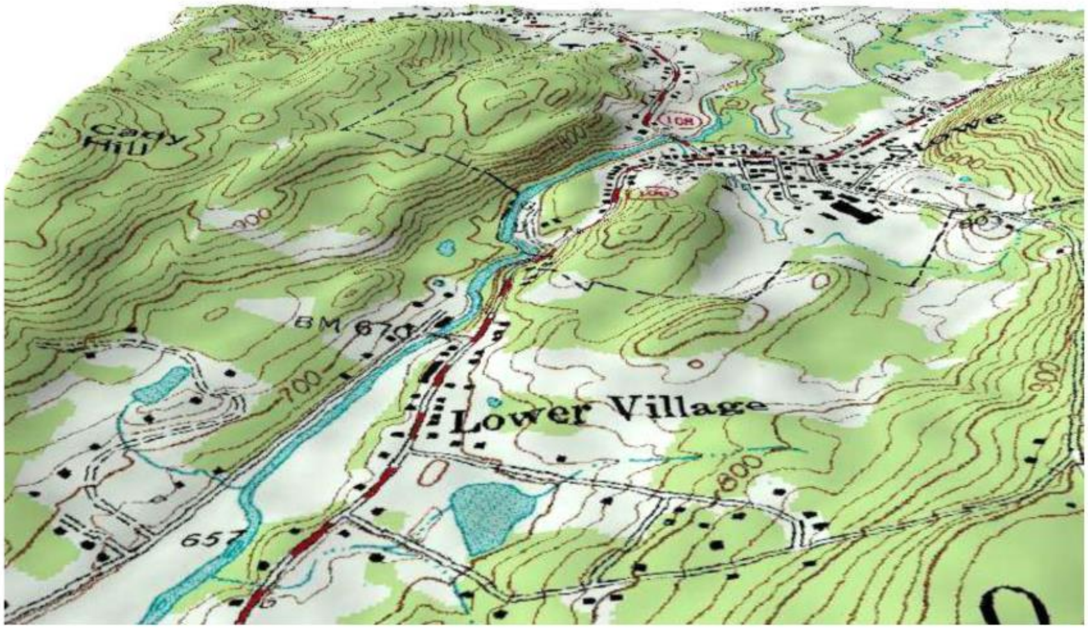
- To prepare a topographical maps.



Show both natural and man-made features

Purposes of Surveying (cont.)

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- To prepare the engineering detailed plans and sections of roads and other structures.

Purposes of Surveying (cont.)

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- To determine the required areas and volumes of a land.

Purposes of Surveying (cont.)

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- To ensure that the construction takes place in the correct relative and absolute position on the ground.

Purposes of Surveying (cont.)

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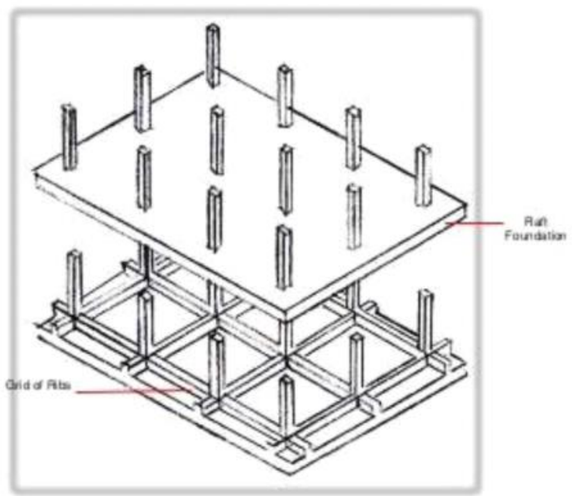
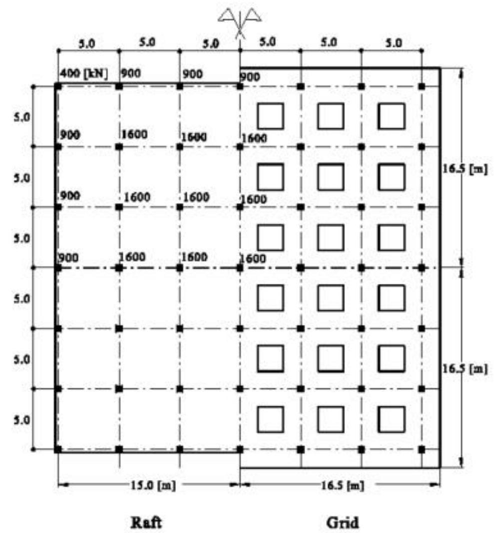
- To record the final position of the construction, including any design changes.





Purposes of Surveying (cont.)

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- To provide permanent and temporary control points.

Purposes of Surveying (cont.)

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- To prepare a map of a country of detailed out location of cities, towns, villages and major roads.

Purposes of Surveying (cont.)

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- To record archeological, crimes scenes

Location of Objects

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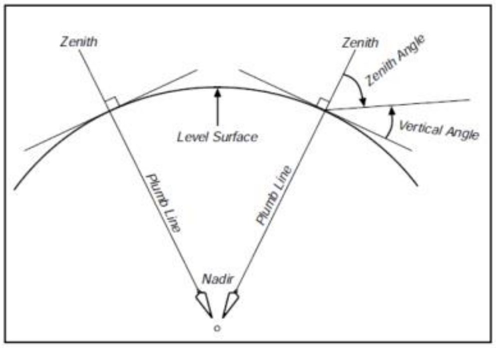
Angle Measuring

Measuring distances alone in surveying does not establish the location of an object. We need to locate the object in 3 dimensions. To accomplish that we need:

1. *Horizontal length (distance)*
2. *Difference in height (elevation)*
3. *Angular direction.*



An angle is defined as the difference in direction between two convergent lines. A horizontal angle is formed by the directions to two objects in a horizontal plane. A vertical angle is formed by two intersecting lines in a vertical plane, one of these lines horizontal. A zenith angle is the complementary angle to the vertical angle and is formed by two intersecting lines in a vertical plane, one of these lines directed toward the zenith.

Distance Measurement

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DDM or Direct distance measurement – This is mainly done by chaining or taping.

ODM or Optical distance measurement – This measurement is conducted by tacheometry, horizontal subtense method or telemetric method. These are carried out with the help of optical wedge attachments.

EDM or Electromagnetic distance measurement – The method of direct distance measurement cannot be implemented in difficult terrains. When large amount of inconsistency in the terrain or large obstructions exist, this method is avoided.

From <https://theconstructor.org/surveying/electronic-distance-measurement-instrument/6576/>

Distance Measuring (Chaining surveying)

English mathematician Edmund Gunter (1581-1626) gave to the world not only the words cosine and cotangent, and the discovery of magnetic variation, but the measuring device called the Gunter's chain shown below. Edmund also gave us the acre which is 10 square chains.

The Gunter's chain is 1/80th of a mile or 66 feet long. It is composed of 100 links, with a link being 0.66 feet or 7.92 inches long. Each link is a steel rod bent into a tight loop on each end and connected to the next link with a small steel ring.

Starting in the early 1900's surveyors started using steel tapes to measure distances. These devices are still called "chains" to this day.

Distance Measurement - Automated

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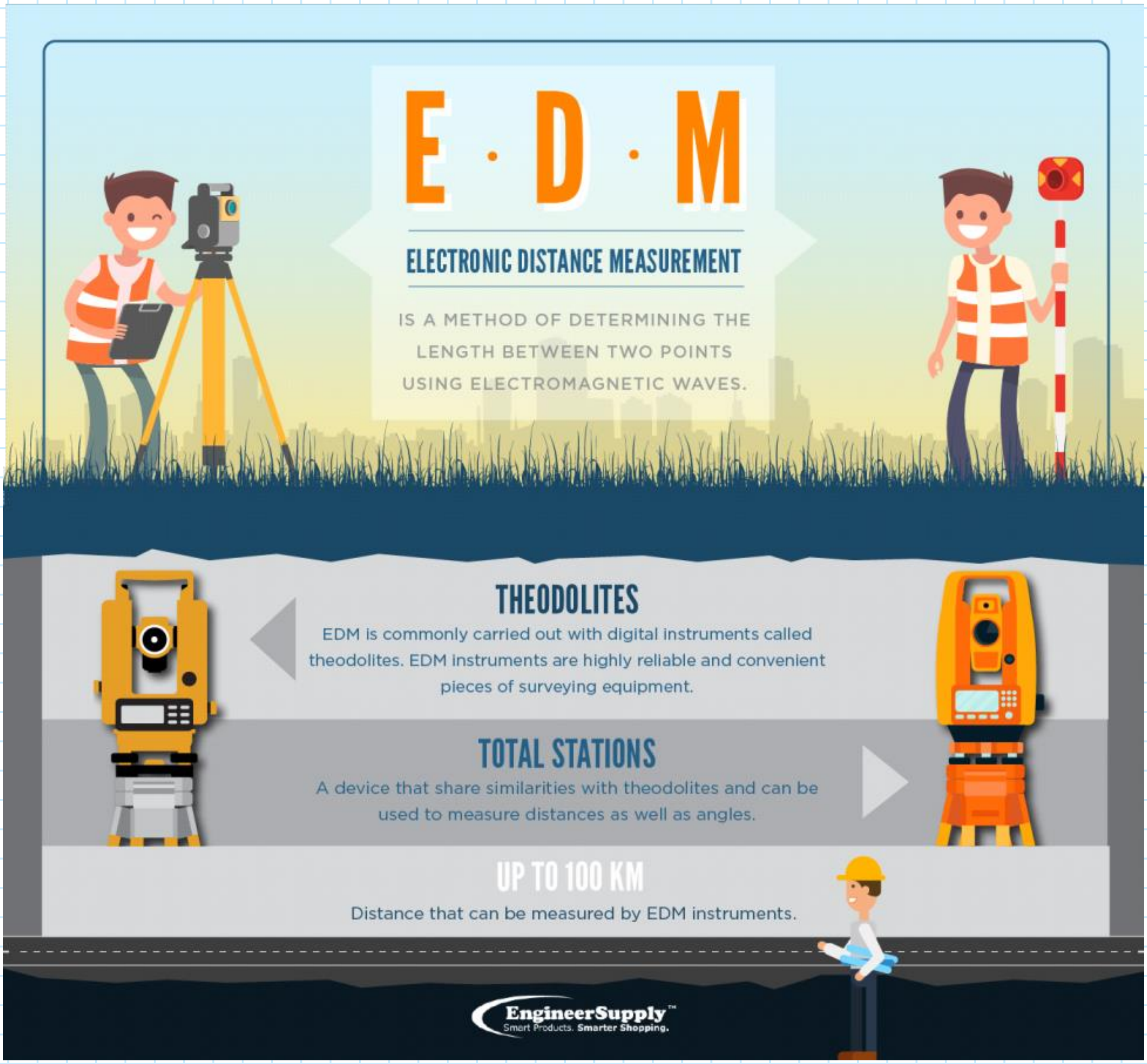

https://www.engineersupply.com/EDM.aspx

For more information (see also)

https://theconstructor.org/surveying/electronic-distance-measurement-instrument/6576/

Angle Measurement

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A Theodolite is a precision surveying instrument; consisting of an alidade with a telescope and an accurately graduated circle; and equipped with the necessary levels and optical-reading circles. The glass horizontal and vertical circles, optical-reading system, and all mechanical parts are enclosed in an alidade section along with 3 leveling screws contained in a detachable base or tribrach.

A Transit is a surveying instrument having a horizontal circle divided into degrees, minutes, and seconds. It has a vertical circle or arc. Transits are used to measure horizontal and vertical angles. The graduated circles (plates) are on the outside of the instrument and angles have to be read by using a vernier.

Azimuth and Bearing Practice

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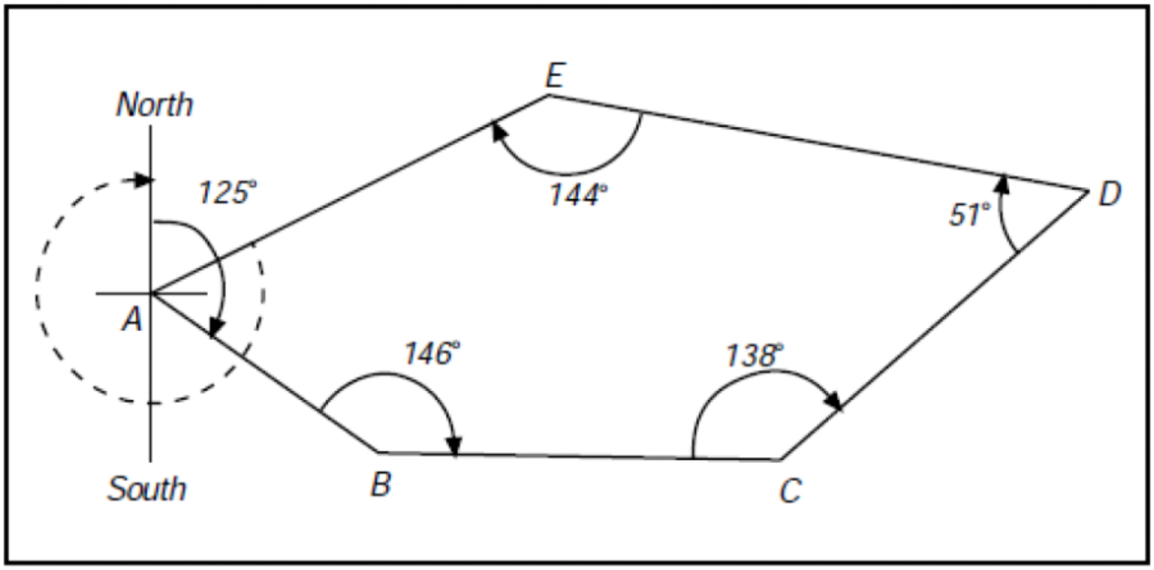

Line	Bearing	Azimuth
A – B	S 55° E	125°
B – C	S 89° E	91°
C – D	N 49° E	49°
D – E	N 80° W	280°
E – A	S 64° W	244°

Bearing and Azimuths

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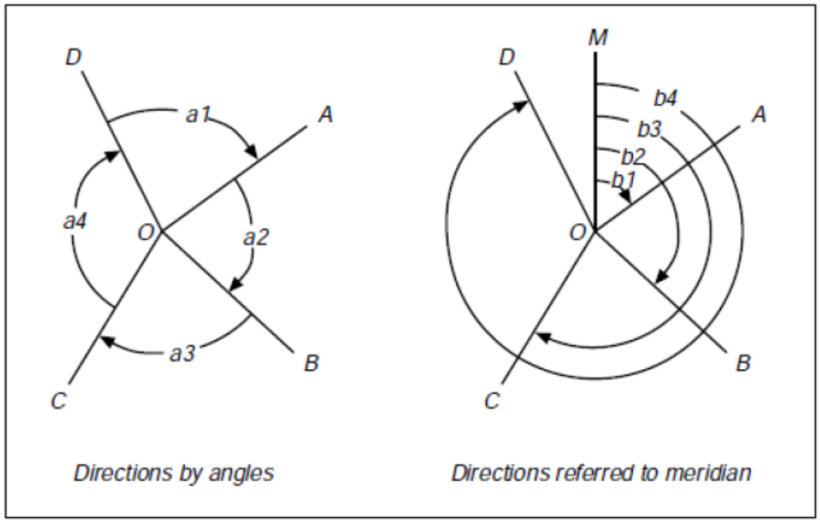
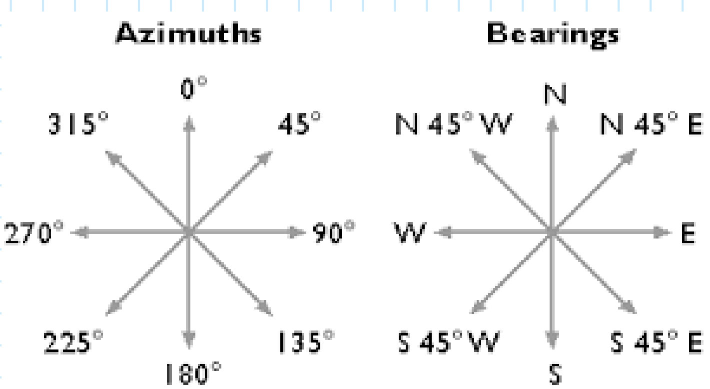
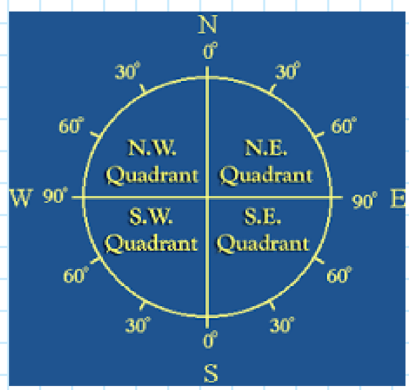
The Relative directions of lines connecting survey points may be obtained in a variety of ways. The figure below on the left shows lines intersecting at a point. The direction of any line with respect to an adjacent line is given by the horizontal angle between the 2 lines and the direction of rotation. The figure on the right shows the same system of lines but with all the angles measured from a line of reference (O-M). The direction of any line with respect to the line of reference is given by the angle between the lines and its direction of rotation.



Bearings





Altitude and Azimuth

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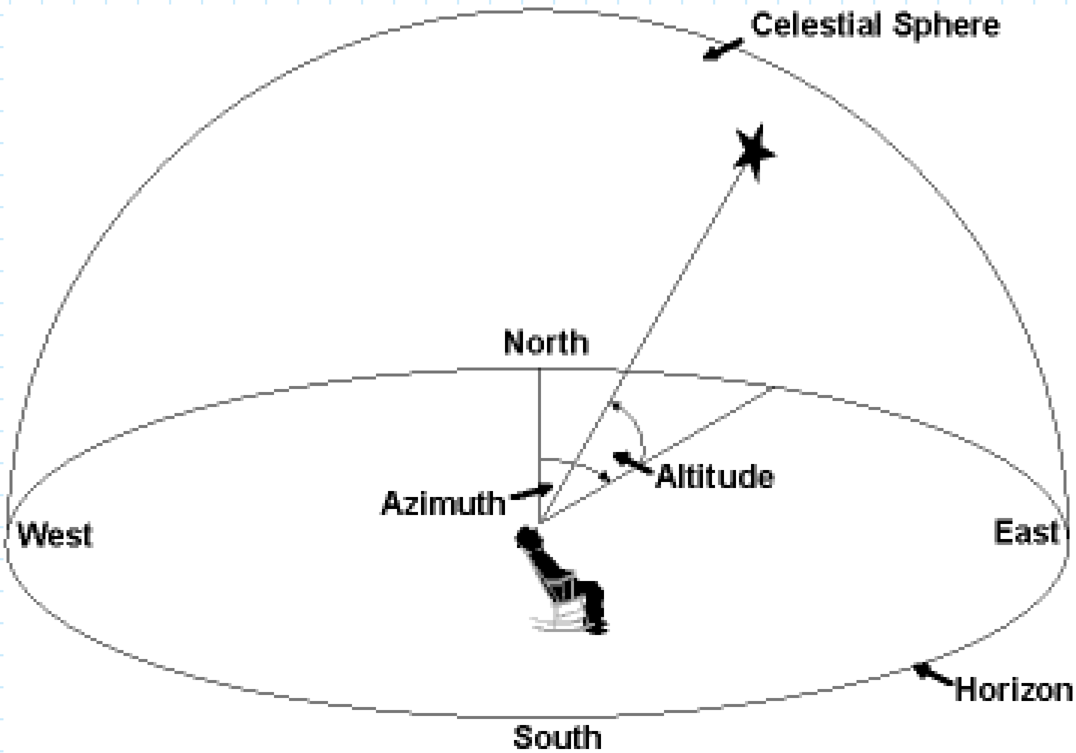

Latitude and Longitude

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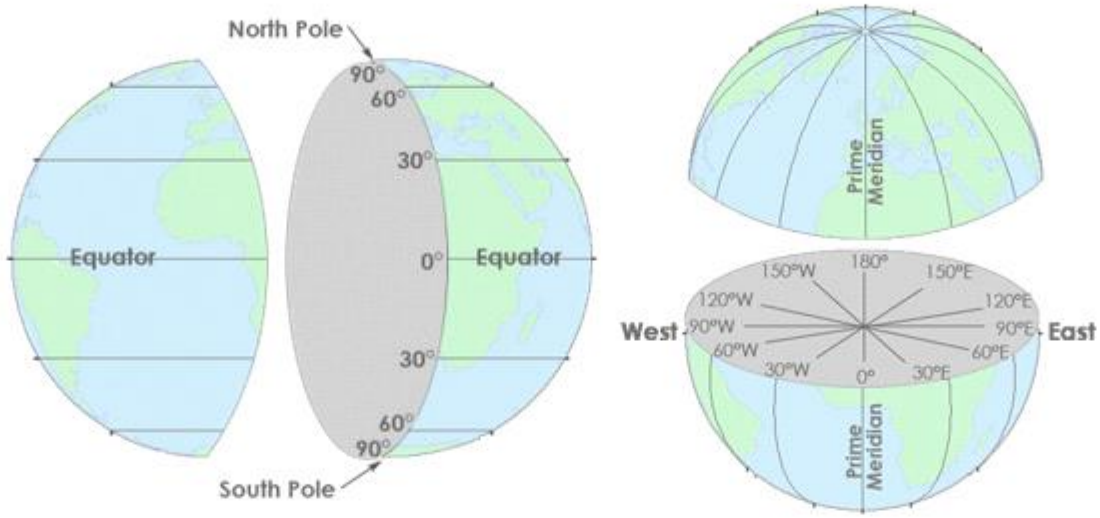

https://gisgeography.com/latitude-longitude-coordinates/

Astronomical or True Meridians

A plane passing through a point on the surface of the earth and containing the earth's axis of rotation defines the astronomical or true meridian at that point. Astronomical meridians are determined by observing the position of the sun or a star. For a given point on the earth, its direction is always the same and therefore directions referred to the astronomical or true meridian remain unchanged. This makes it a good line of reference. Astronomical or true meridians on the surface of the earth are lines of geographic longitude and they converge toward each other at the poles. The amount of convergence between meridians depends on the distance from the equator and the longitude between the meridians.

Cartesian Coordinates

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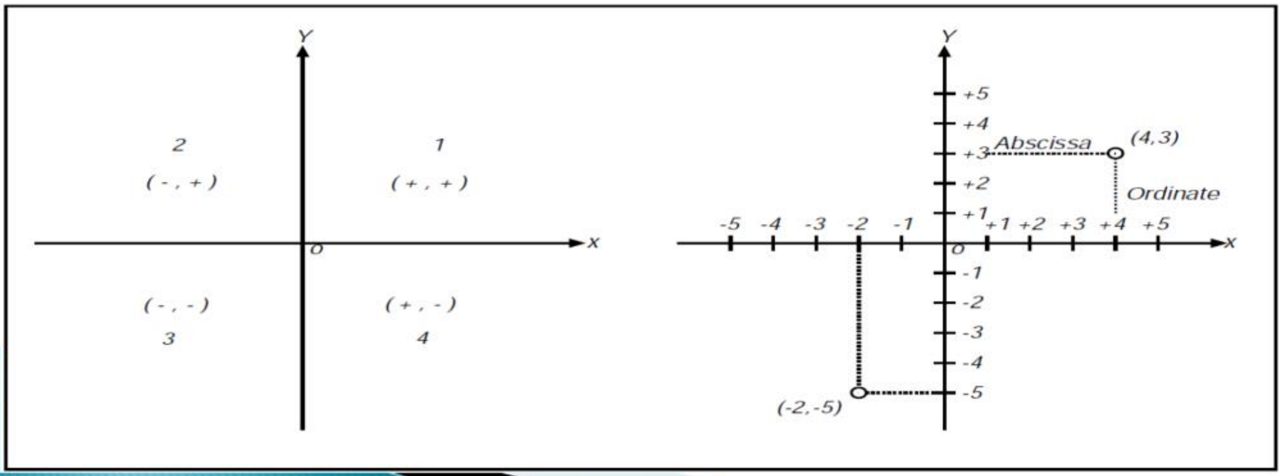
Co-ordinates

In Surveying, one of the primary functions is to describe or establish the positions of points on the surface of the earth. One of the many ways to accomplish this is by using coordinates to provide an address for the point. Modern surveying techniques rely heavily on 3 dimensional coordinates.

Rectangular Coordinate System (or Cartesian Plane)

In the right of figure, is what is described as a rectangular coordinate system. A vertical directed line (y-axis) crosses the horizontal directed line (x-axis) at the origin point. This system uses an ordered pair of coordinates to locate a point. The coordinates are always expressed as (x,y).

The x and y axes divide the plane into four parts, numbered in a counter-clockwise direction as shown in the left of figure 33. Signs of the coordinates of points in each quadrant are also shown in this figure.
Note: In surveying, the quadrants are numbered clockwise starting with the upper right quadrant and the normal way of denoting coordinates (in the United States) is the opposite (y,x) or more appropriately North, East.



Coordinate Geometry

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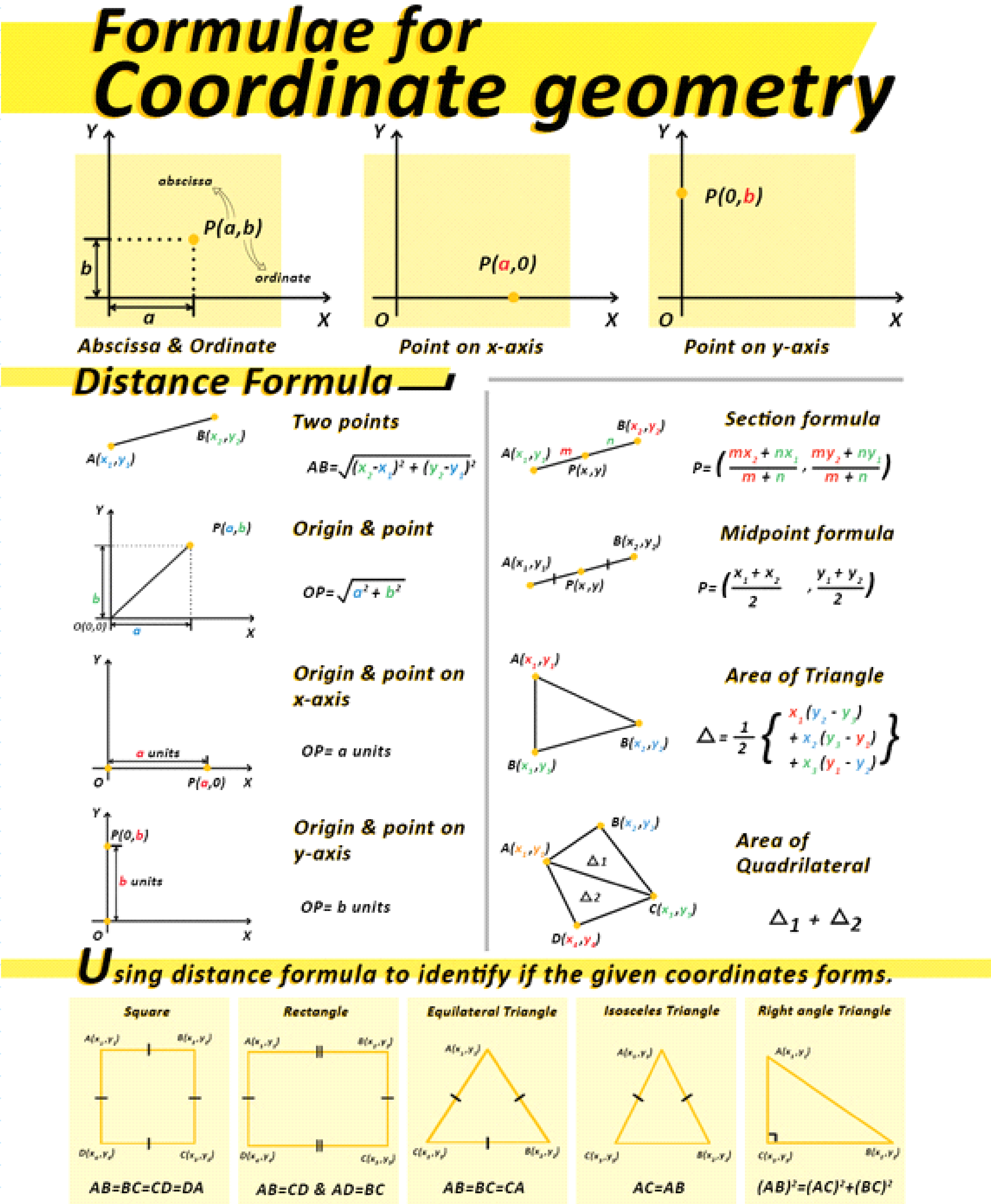

Polar Coordinates

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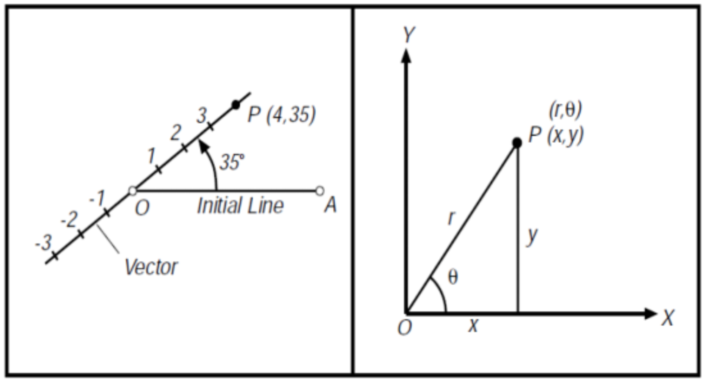
Polar Coordinates

Another way of describing the position of point P is by its distance r from a fixed point O and the angle θ that makes with a fixed indefinite line oa (the initial line). The ordered pair of numbers (r,θ) are called the polar coordinates of P. r is the radius vector of P and θ its vectorial angle.

Note: (r,θ), (r, θ + 360°), (-r, θ + 180°) represent the same point.

Transformation of Polar and Rectangular coordinates:

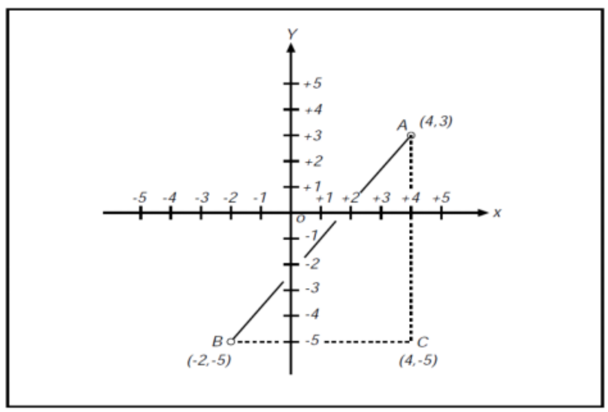
1. $x = r\cos\theta$ $y = r\sin\theta$ (if θ and r are known)
2. $r = \sqrt{x^2 + y^2}$ $\theta = \tan^{-1}\left(\frac{y}{x}\right)$ (if x and y are known)



Measuring distance between coordinates

When determining the distance between any two points in a rectangular coordinate system, the pythagorean theorem may be used. In the figure below, the distance between A and B can be computed in the following way :

$AB = \sqrt{[4-(-2)]^2+[3-(-5)]^2}$ $AB = \sqrt{[4+2)]^2+[3+5)]^2}$ $AB = 10$



Area from Coordinates

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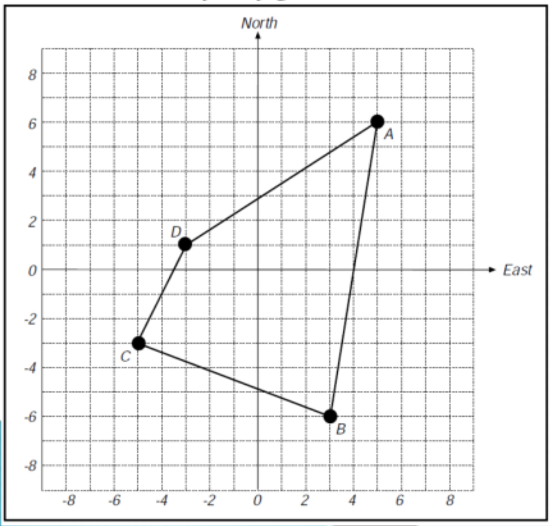
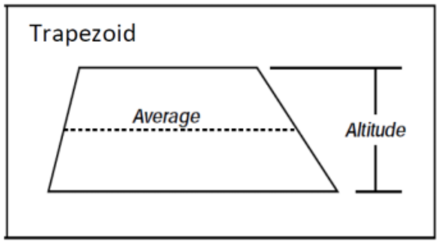
Measuring the Area by Coordinates

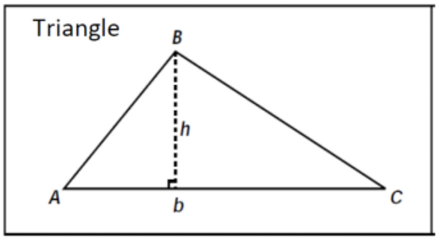
Area of a trapezoid: one-half the sum of the bases times the altitude.
Area of a triangle: one-half the product of the base and the altitude.

The area enclosed within a figure can be computed by coordinates. This is done by forming trapezoids and determining their areas. Trapezoids are formed by the abscissas of the corners. Ordinates at the corners provide the altitudes of the trapezoids. A sketch of the figure will aid in the computations.

1. *Find the latitude and departure between points.*
2. *Find the area of the figure.*







Answers

	Latitude	Departure
A-B	-12	-2
B-C	3	-8
C-D	4	2
D-A	5	8

Area	62 Square Units

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Traverses

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Traverse

A Traverse is a succession of straight lines along or through the area to be surveyed. The directions and lengths of these lines are determined by measurements taken in the field.

A traverse is currently the most common of several possible methods for establishing a series or network of monuments with known positions on the ground. Such monuments are referred to as horizontal control points and collectively, they comprise the horizontal control for the project.

In the past, triangulation networks have served as horizontal control for larger areas, sometimes covering several states. They have been replaced recently in many places by GPS networks. (GPS will be discussed in more detail later.) GPS and other methods capitalizing on new technology may eventually replace traversing as a primary means of establishing horizontal control. Meanwhile, most surveys covering relatively small areas will continue to rely on traverses.
Whatever method is employed to establish horizontal control, the result is to assign rectangular coordinates to each control point within the survey. This allows each point to be related to every other point with respect to distance and direction, as well as to permit areas to be calculated when needed.

Types of traverses

There are several types or designs of traverses that can be utilized on any given survey. The terms open and closed are used to describe certain characteristics of a traverse. If not specified, they are assumed to refer to the mathematical rather than geometrical properties of the traverse.
A Geometrically Closed Traverse creates a closed geometrical shape, such as the first two examples in Figure A. The traverse ends on one of two points, either the on same point from which it began or on the initial backsight. The first two traverses in Figure A are geometrically closed.

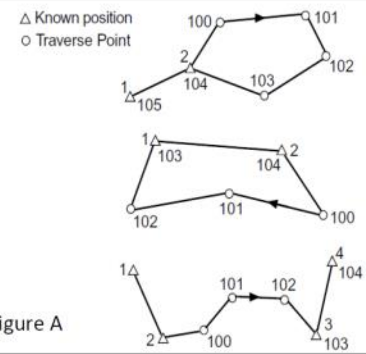

Figure A

Traverses (cont.)

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Procedure for running a traverse

To begin any traverse, a ***known point*** *must be occupied. (To occupy a point means to set up and level the transit or theodolite, directly over a monument on the ground representing that point.) Next, a direction must be established. This can be done by sighting with the instrument a second known point, or any definite object, which is in a known direction from the occupied point. The object that the instrument is pointed to in order to establish a direction is known as a backsight. Possible examples would be another monument on the ground, a radio tower or water tank on a distant hill, or anything with a known direction from the occupied point. A celestial body such as Polaris or the sun could also be used to establish an initial direction.*

Once the instrument is occupying a known point, for example point number 2, and the telescope has been pointed toward the backsight, perhaps toward point number 1, then an angle and a distance is measured to the first unknown point. An unknown point being measured to is called a foresight. With this data, the position of this point (lets call it point number 100) can be determined.

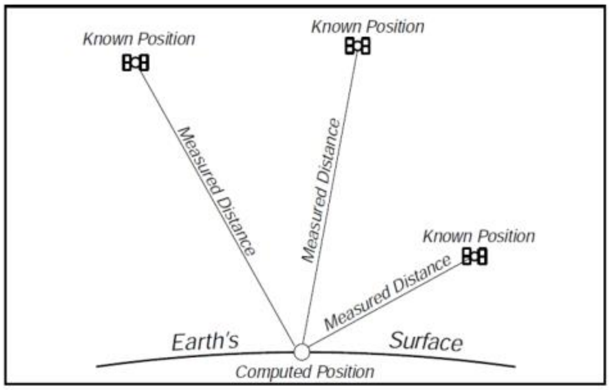
The next step is to move the instrument ahead to the former foresight and duplicate the entire process.

How satellite distance is measured

The Global Positioning System (GPS) is a navigational or positioning system developed by the United States Department of Defense. It was designed as a fast positioning system for 24 hour a day, three dimensional coverage worldwide.
It is based on a constellation of 21 active and 3 spare satellites orbiting 10,900 miles above the earth. The GPS (NAVSTAR) satellites have an orbital period of 12 hours and are not in geosynchronous orbit (they are not stationary over a point on the earth). They maintain a very precise orbit and their position is known at any given moment in time. This constellation could allow a GPS user access to up to a maximum of 8 satellites anywhere in the world.
GPS provides Point Position (Latitude/Longitude) and Relative Position (Vector). GPS can differentiate between every square meter on the earth's surface thus allowing a new international standard for defining locations and directions.

The Principles of GPS

For centuries man has used the stars to determine his position. The extreme distance from the stars made them look the same from different locations and even with the most sophisticated instruments could not produce a position closer then a mile or two. The GPS system is a constellation of Manmade Stars at an orbit high enough to allow a field of view of several satellites, yet low enough to detect a change in the geometry even if you moved a few feet.
A typical conventional survey establishes positions of unknown points by occupying a known point and measuring to the unknown points. GPS is somewhat the opposite.



We occupy the unknown point and measure to known points. In conventional surveying this is similar to the process of doing a resection, the slight difference is that the targets are 10,900 miles away and travelling at extremely high speeds.

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How Elevations is Measured

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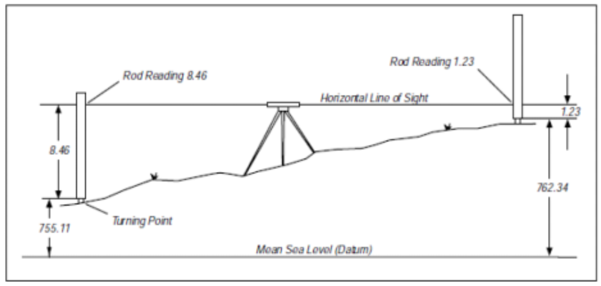
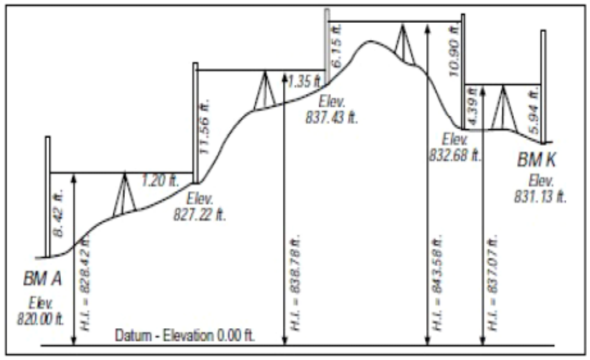
Differential Leveling

Differential leveling is the process used to determine a difference in elevation between two points. A Level is an instrument with a telescope that can be leveled with a spirit bubble. The optical line of sight forms a horizontal plane, which is at the same elevation as the telescope crosshair. By reading a graduated rod held vertically on a point of known elevation (Bench Mark) a difference in elevation can be measured and a height of instrument (H.I.) calculated by adding the rod reading to the elevation of the bench mark. Once the height of instrument is established, rod readings can be taken on subsequent points and their elevations calculated by simply subtracting the readings from the height of instrument.



In the following example, the elevation at BM-A is known, and we need to know the elevation of BM-K. The level is set up at a point near BM-A, and a rod reading taken. The height of instrument (HI) is calculated and a rod reading to a turning point (TP1) is taken. The reading of the foresight is subtracted from the height of instrument to obtain the elevation at TP1. The rod stays at TP1, the level moves ahead and the rod at TP1 now becomes the backsight. This procedure is repeated until the final foresight to BM-K.



How Terrain is Modeled

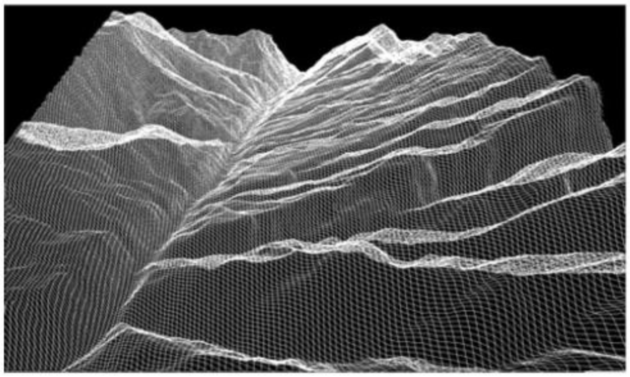
Monday, February 24, 2020 9:39 AM

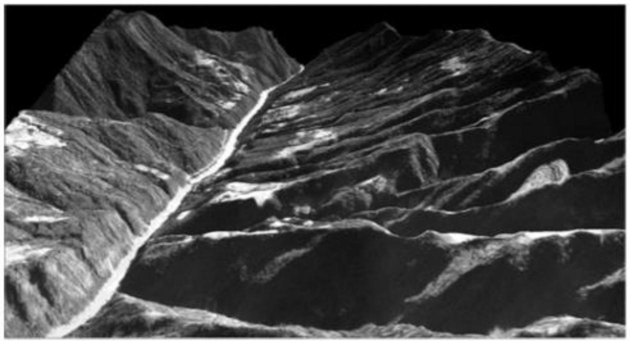
Digital Terrain Models

A digital Terrain Model (DTM) is numerical representation of the configuration of the terrain consisting of a very dense network of points of known X,Y,Z coordinates. Modern surveying and photogrammetric equipment enables rapid three dimensional data acquisition. A computer processes the data into a form from which it can interpolate a three dimensional position anywhere within the model.

Think of a DTM as an electronic lump of clay shaped into a model representing the terrain. If an alignment was draped on the model and a vertical cut made along the line, a side view of the cut line would yield the alignment's original ground profile. If vertical cuts were made at right angles to the alignment at certain prescribed intervals, the side views of the cuts would represent cross sections. If horizontal cuts were made at certain elevation intervals, the cut lines when viewed from above would represent contours.

A DTM forms the basis for modern highway location and design. It is used extensively to extract profiles and cross sections, analyze alternate design alignments, compute earthwork, etc.





generates a "Digital Terrain Model" (DTM) from which it then automatically extracts a regular grid "Digital Elevation Model" (DEM).

Making Cross Sections

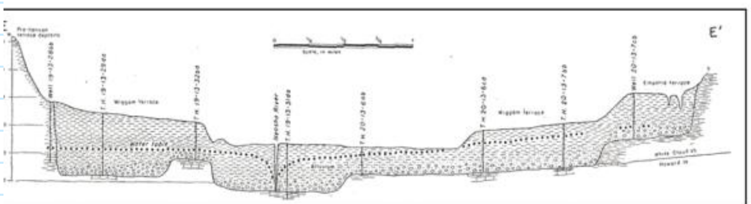
Monday, February 24, 2020 9:39 AM

Cross Sections

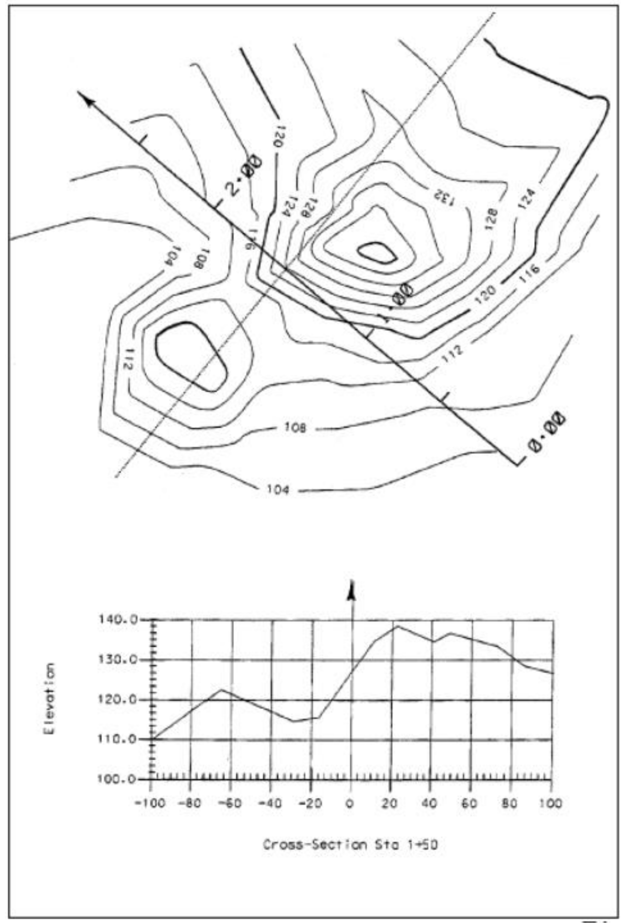
Cross sections are lines 90 degrees perpendicular to the alignment (P-Line, L-Line, centerline of stream, etc.), along which the configuration of the ground is determined by obtaining elevations of points at known distances from the alignment.

Cross sections are used to determine the shape of the ground surface through the alignment corridor. The shape of the ground surface helps the designer pick his horizontal and vertical profile. Once the alignment is picked, earthwork quantities can be calculated. The earthwork quantities will then be used to help evaluate the alignment choice.

In addition to earthwork calculations, cross sections are used in the design of storm sewers, culvert extensions and the size and location of new culverts.



Example of alluvial terraces in a geologic cross section across the Neosho River Valley Taken from O'Connor, 1953



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