Surveying is the science and art of measuring distances and angles on or near the surface of the earth.

Surveying is an orderly process of acquiring data relating to the physical characteristics of the earth and in particular the relative position of points and the magnitude of areas.
Evidence of surveying and recorded information exists from as long ago as five thousand years in places such as China, India, Babylon and Egypt.

The word *angle* comes from the Latin word *angulus*, meaning "a corner".

In surveying, the direction of a line is described by the horizontal angle that it makes with a reference line.

This reference line is called a **meridian**.

The term "meridian" comes from the Latin *meridies*, meaning "midday".

The sun crosses a given meridian midway between the times of sunrise and sunset on that meridian.

The same Latin term gives rise to the terms A.M. (Ante Meridian) and P.M. (Post Meridian) used to disambiguate hours of the day when using the 12-hour clock.

A **meridian** (or *line of longitude*) is an imaginary arc on the Earth's surface from the North Pole to the South Pole that connects all locations running along it with a given longitude.

The position of a point on the meridian is given by the latitude.

The meridian that passes through Greenwich, England, establishes the meaning of zero degrees of longitude, or the Prime Meridian.

In July of 1714, during the reign of Queen Anne, the Longitude Act was passed in response to the Merchants and Seamen petition presented to Westminster Palace in May of 1714.

A prize of £20,000 was offered for a method of determining longitude to an accuracy of half a degree of a great circle.

Half a degree being sixty nautical miles. This problem was tackled enthusiastically by learned astronomers, who were held in high regard by their contemporaries.
The longitude problem was eventually solved by a working class joiner from Lincolnshire with little formal education.

John Harrison (24 March 1693 – 24 March 1776) was a self-educated English clockmaker.

He invented the marine chronometer, a long-sought device in solving the problem of establishing the East-West position or longitude of a ship at sea.

H1 is essentially a portable version of Harrison's precision wooden clocks. It is spring-driven and only runs for one day. The moving parts are controlled and counterbalanced by springs so that, unlike a pendulum clock, H1 is independent of the direction of gravity.

Three types of meridians:
- Astronomic - direction determined from the shape of the earth and gravity; also called geodetic north
- Magnetic - direction taken by a magnetic needle at observer’s position
- Assumed - arbitrary direction taken for convenience

Methods for expressing the magnitude of plane angles are: sexagesimal, centesimal, radians, and mils.

Sexagesimal System - The circumference of circles is divided into 360 parts (degrees); each degree is further divided into minutes and seconds.

Babylonian mathematics

Clay tablets from the ancient Sumerians in Mesopotamia include sexagesimal representations of numbers, suggesting that the sexagesimal system was in use as early as 3000 BC.
Other historical usages

- By the 17th century it became common to denote the integer part of sexagesimal numbers by a superscripted zero, and the various fractional parts by one or more accent marks.
- John Wallis, in his *Mathesis universalis*, generalized this notation to include higher multiples of 60, giving as an example the number:

\[ 49^\prime\prime\prime, 36^\prime\prime, 25^\prime, 15^\prime, 15^\prime\prime, 25^\prime\prime\prime, 36^\prime\prime\prime, 49^\prime\prime\prime \]

where the numbers to the left are multiplied by higher powers of 60, the numbers to the right are divided by powers of 60, and the number marked with the superscripted zero is multiplied by 1.

Angles and Directions

Methods for expressing the magnitude of plane angles are: **sexagesimal**, **centesimal**, **radians**, and **mils**

- **Centesimal System** - The circumference of circles is divided into 400 parts called **gon** (previously called **grads**)

- **Radian** - There are 2\(\pi\) radians in a circle

  \(1\) radian = 57.2958° or 57°17′45″

Angles and Directions

- **Mil** - The circumference of a circle is divided into 6,400 parts (used in military science)

  The practical form of this that is easy to remember is: 1 mil at 1 km = 1 meter.

Angles and Directions

- **Azimuths**
  - A common term used for designating the direction of a line is the **azimuth**
  - From the Arabic as-simt, from as (the) + simt (way)
  - The azimuth of a line is defined as the clockwise angle from the north end or south end of the reference meridian.
  - Azimuths are usually measured from the north end of the meridian.

Approximations

- 1° is approximately the width of a little finger at arm's length.
- 10° is approximately the width of a closed fist at arm's length.
- 20° is approximately the width of a hands at arm's length.

These measurements clearly depend on the individual subject, and the above should be treated as rough approximations only.
Angles and Directions

Azimuths

- Every line has two azimuths (forward and back) and their values differ by 180°.
- Azimuths are referred to as astronomic, magnetic, or assumed meridians.

For example: the forward azimuth of line AB is 50°, and the back azimuth or azimuth of BA is 230°.

Bearings

- Another method of describing the direction of a line is giving its bearing.
- The bearing of a line is defined as the smallest angle that the line makes with the reference meridian.
- A bearing cannot be greater than 90° (bearings are measured in relation to the north or south end of the meridian - NE, NW, SE, or SW).

It is convenient to say: N90°E is due East, S90°W is due West.

Until the last few decades, American surveyors favored the use of bearings over azimuths.

However, with the advent of computers and calculators, surveyors generally use azimuths today instead of bearings.
A **traverse** is a series of successive straight lines that are connected together.

A traverse is **closed** such as in a boundary survey or **open** as for a highway.

An **exterior angle** is one that is not enclosed by the sides of a closed traverse.

An **interior angle** is one enclosed by sides of a closed traverse.

An **angle to the right** is the clockwise angle between the preceding line and the next line of the traverse.

A **deflection angle** is the angle between the preceding line and the present one.

**Traverse Computations**

If the **bearing** or **azimuth** of one side of traverse has been determined and the angles between the sides have been measured, the **bearings** or **azimuths** of the other sides can be computed.

One technique to solve most of these problems is to use the deflection angles.
Traverse and Angles

Example - From the traverse shown below compute the azimuth and bearing of side BC

A

D

C

B

N 30° 35' E

85° 14'

Traverse and Angles

North

Deflection angle = 180° - 85°14' = 94°46'

Azimuth BC = 30°35' + 94°46' = 125°21'

Bearing BC = S 54°39' E

Traverse and Angles

Example - Compute the interior angle at B

A

B

S 75° 15' E

C

D

N 62° 20' E

62°20'

75°15'

Interior ABC = 62°20' + 75°15' = 137°35'

Traverse and Angles

Example - Compute the interior angle at B

A

B

S 75° 15' E

C

D

N 62° 20' E

62°20'

75°15'

Interior ABC = 62°20' + 75°15' = 137°35'

Angles and Directions

Compute Bearings Given the Azimuth

End of Angles

Any Questions?