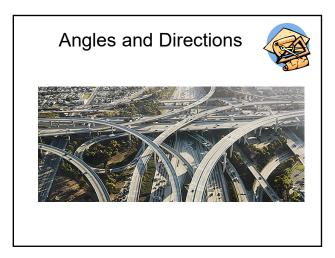


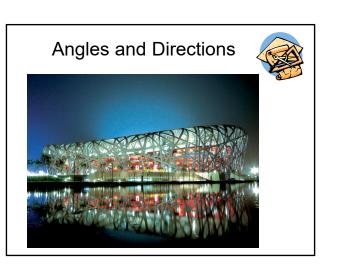


- In planar geometry, an angle is the figure formed by two rays, called the sides of the angle, sharing a common endpoint, called the vertex of the angle.
- ➤ Angle is also used to designate the measure of an angle or a rotation.
- ➤ In the case of a geometric angle, the arc is centered at the vertex and delimited by the sides.











- Surveying is the science and art of measuring distances and angles on or near the earth's surface.
- Surveying is an orderly process of acquiring data relating to the physical characteristics of the earth, particularly the relative position of points and the magnitude of areas.

#### **Angles and Directions**



- Evidence of surveying and recorded information exists from as long ago as five thousand years in China, India, Babylon, and Egypt.
- The word angle comes from the Latin angulus, meaning "a corner."

### **Angles and Directions**



- 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*

# **Angles and Directions**

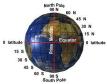


- ➤ The term "meridian" comes from the Latin meridians, meaning "midday."
- The sun crosses a given meridian midway between sunrise and sunset on that meridian.
- The same Latin term gives rise to the terms A.M. (Ante Meridian) and P.M. (Post Meridian) used to disambiguate hours of the day when using the 12hour clock.

## **Angles and Directions**



- 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 latitude gives the position of a point on the meridian.



# **Angles and Directions**

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





- In 1721, Great Britain established its meridian, passing through an early transit circle at the newly established Royal Observatory at Greenwich.
- A prime meridian at the Royal Observatory, Greenwich was established by Sir George Airy in 1851.
- By 1884, over two-thirds of all ships and tonnage used it as the reference meridian on their charts and maps.



## **Angles and Directions**



- Determining latitude is relatively easy. It can be found from the altitude of the sun at noon (i.e., at its highest point) with the aid of a table giving the sun's declination for the day or from many stars at night.
- For longitude, early ocean navigators had to rely on dead reckoning.
- > This was inaccurate on long voyages out of sight of land, and these voyages sometimes ended in tragedy.

# **Angles and Directions**



- Determining longitude at sea was also much more complicated than on land.
- A stable surface to work from, a comfortable location to live in while performing the work, and the ability to repeat determinations over time made various astronomical techniques possible on land (such as the observation of eclipses) that were unfortunately impractical at sea.
- Whatever could be discovered from solving the problem at sea would only improve the determination of longitude on land

# **Angles and Directions**



- 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 (\$1.4M) was offered for a method of determining longitude to an accuracy of half a degree of a great circle.
- Half a degree is sixty nautical miles. Learned astronomers tackled this problem enthusiastically, and they were held in high regard by their contemporaries.

# **Angles and Directions**



- The longitude problem was eventually solved by a workingclass 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 that solved the problem of establishing a ship's East-West position or longitude at sea.

# **Angles and Directions**



- Constructed between 1730 and 1735, 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.









- > There are 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 the observer's position
  - Assumed arbitrary direction taken for convenience

#### Angles and Directions



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.

Sexagesimal (base-sixty) is a numeral system with sixty as the base. It originated with the ancient Sumerians in the 2,000s BC, was transmitted to the Babylonians, and is still used in modified form for measuring time, angles, and geographic coordinates.

# **Angles and Directions**



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.

The number 60, a highly composite number, has twelve factors—1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60—of which 2, 3, and 5 are prime. With so many factors, many fractions of sexagesimal numbers are simple. For example, an hour can be divided into segments of 30 minutes, 20 minutes, 15 minutes, etc. Sixty is the smallest number divisible by every number from 1 to 6.

### **Angles and Directions**



#### **Babylonian mathematics**

Sexagesimal, as used in ancient Mesopotamia, was not a pure base 60 system because it didn't use 60 distinct symbols for its digits.

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<b>777</b> 3	<b>1777</b> 13	<b>(1777</b> 23	<b>(((7))</b> 33	<b>45 777</b> 43	<b>154 117</b> 53
<b>\$</b> 4	<b>178</b> 14	<b>(137</b> 24	<b># 7</b> 34	<b>15 58</b> 44	<b>154 5</b> 9 54
<b>777</b> 5	<b>∜∰</b> 15	<b>∜</b> ₩ 25	<b>##</b> 35	<b>45</b> 7 45	<b>124 P</b> 55
₩ 6	<b>∜</b> ₩ 16	<b>44</b>	₩₩ 36	<b>₹</b> \$\$ 46	<b>1124 887</b> 56
7	<b>₹₩</b> 17	<b>∜₩</b> 27	<b>## 37</b>	<b>47</b>	<b>12</b> 57
₩ 8	<b>₹₩</b> 18	<b>∜₩</b> 28	₩₩ 38	<b>42</b> ## 48	<b>₹₹</b> 58
<b>#</b> 9	<b>4</b> ## 19	<b>代群</b> 29	<b>##</b> 39	₩# 49	<b>**</b> 59
<b>4</b> 10	44 20	464 30	40	₩ 50	

## **Angles and Directions**



#### Other historical usages

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

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 **milliradians** 

#### 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 handspan at arm's length.

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



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

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

# **Angles and Directions**



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

**Radian** - There are  $2\pi$  radians in a circle (1 radian =  $57.2958^{\circ}$  or  $57^{\circ}17'45''$ )



### **Angles and Directions**



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

**Mil** - is defined as a thousandth of a radian (0.001 radian).

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-sumūt meaning "the ways," plural of as-samt. "the way, direction."
- 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

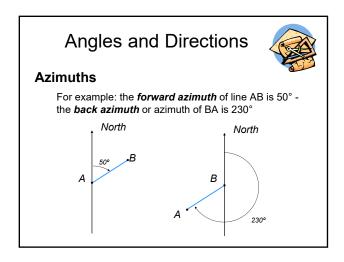
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## **Angles and Directions**



#### **Azimuths**

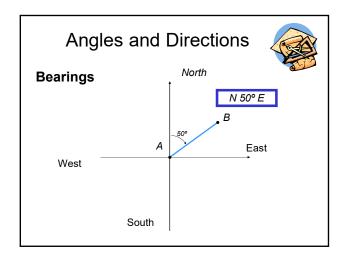
- Every line has two azimuths (forward and back), and their values differ by 180°
- Azimuth is referred to as astronomic, magnetic, or assumed meridian

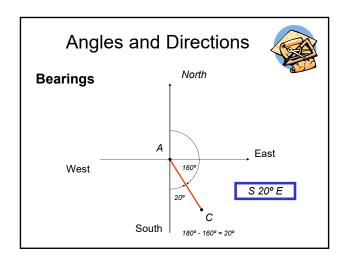


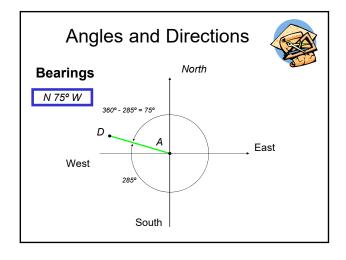


#### **Bearings**

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







# **Angles and Directions**



#### **Bearings**

- ➤ It is convent 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 azimuth
- However, with the advent of computers and calculators, surveyors are also using azimuth today.

