Distance Measurement

Introduction

- Distance is one of the most basic engineering measurements
- Early measurements were made in terms of the dimensions of the body

Cubits - the distance between the tip of your middle finger and the elbow

Typically, to measure cords and textiles

(another measure was 24 digits or 6 palms)

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Distance Measurement

Introduction

- The English word "cubit" comes from the Latin noun *cubitus,* "elbow."
- The Bible tells us the length of Noah's Ark was 300 cubits, its width 50 cubits, and its height 30 cubits.

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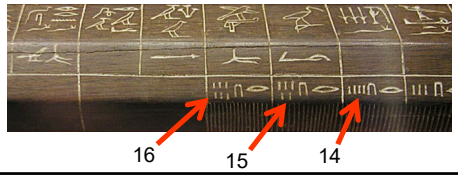
Distance Measurement

Introduction

A very old wooden rule - Royal Egyptian Cubit



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Distance Measurement

Introduction

Fathom - distance between the tips of your middle finger when your arms are outstretched (~6 feet)

The name originates from the Danish "faedn," meaning "outstretched arms."

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Distance Measurement

Introduction

- It is customary, when burying the dead, to inter the corpse at a fathom's depth, or six feet under.
- A burial at sea requires a minimum of six fathoms of water.
- This is the origin of the phrase "to deep six" as meaning to discard, or dispose of

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Distance Measurement

Introduction

Foot - distance from the tip of a man's big toe to the heel

Rod - the sum of the lengths of the left feet of 16 men (16.5 - 24 ft.)

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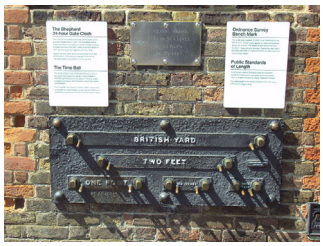
Distance Measurement

Introduction



Imperial measurement standards, Royal Observatory, Greenwich

Determination of the rod, using the length of the left foot of 16 randomly chosen people coming from church service.

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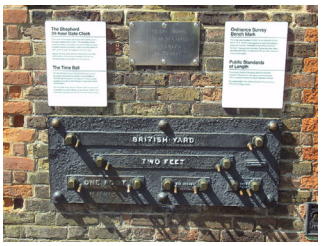
Distance Measurement

Introduction



Imperial measurement standards, Royal Observatory, Greenwich

A yard was originally the length of a man's belt or girdle, as it was called. In the 12th century, King Henry I of England fixed the yard as the distance from his nose to the thumb of his outstretched arm.

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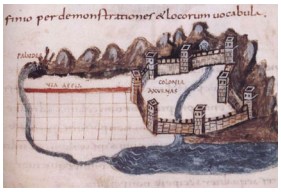
Distance Measurement

Introduction

- The Roman pace (Latin: *passus*) was a Roman unit of length.
- It was the distance of a full stride from the position of one heel where it raised off the ground to where it set down again at the end of the step: two steps, one by each foot.



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Distance Measurement

Introduction

- Under Marcus Vipsanius Agrippa, it was standardized as the distance of two steps (*gradūs*) or five Roman feet (pedes), about 1.48 meters or 4 feet 10 inches.
- There were 1,000 paces in the Roman mile, which was named after that distance as the *mille passus* or *passuum*.

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Distance Measurement

Pacing

- The ability to ***pace*** distance is very useful
- A person can determine their ***pace*** by counting the number of paces necessary to walk a distance that has been previously measured
- A ***pace*** is defined as one step
- A ***stride*** is considered two steps

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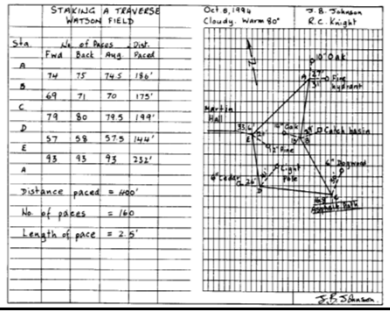
Distance Measurement

Pacing



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Distance Measurement

Measuring Wheels

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Distance Measurement

Taping or Chaining

- For centuries engineers have measured distances with ropes, lines, or cords
- The term ***chaining*** is a carry–over from the time when the Gunter chain was used (1600's)
- Gunter's chain was designed and introduced in 1620 by English clergyman and mathematician Edmund Gunter (1581–1626)

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Distance Measurement

Taping or Chaining

- For centuries engineers have measured distances with ropes, lines, or cords
- The term ***chaining*** is a carry–over from the time when the Gunter chain was used (1600's)
- The 66-foot chain is made of 100 links 7.92 in. long.
- In 1785, the U.S. federal law stated that all government surveys must be done with a Gunter's chain

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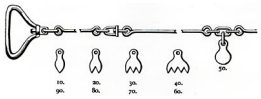
Distance Measurement

Taping or Chaining



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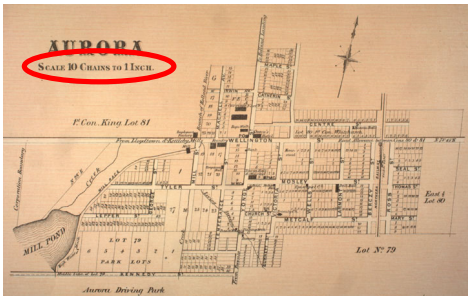
Distance Measurement

Taping or Chaining



A map of Aurora, Ontario, Canada from 1878, indicating a scale of 10 chains to one inch.

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Distance Measurement

Taping or Chaining

- Gunter's Chain lies at the origin of the definition of an **acre**.
- The original acre was an area of land suitable for ploughing with a defined amount of work (e.g., ten furrows long, each furrow being ten chains, permitting rests of an oxen team)
- It measured one chain by one furlong (totaling 10 square chains).
- Early two-lane roads were laid out with a chain, resulting in a 66-ft. right-of-way

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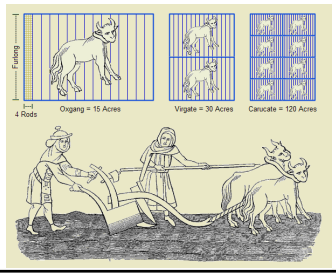
Distance Measurement

Taping or Chaining

- The word *acre* is derived from Old English *æcer* originally meaning "open field",



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Distance Measurement

Taping or Chaining

Tapes are available in lengths up to 1,000 feet; precision of 1/1,000 to 1/5,000 are commonly obtained

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Distance Measurement

Electronic Distance Measurement (EDM)

EDMs are very useful in measuring distances that are difficult to access or long distances

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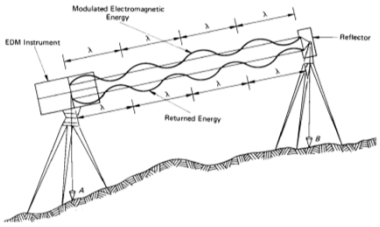
Distance Measurement

Electronic Distance Measurement (EDM)

EDMs measure the time required for a light wave to sent to a target and reflected back



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Distance Measurement

Pacing	1/50 to 1/200	Reconnaissance
Odometer	1/200	Reconnaissance
Taping	1/1,000 to 1/5,000	Land surveys
EDM	±0.04 to 1/300,000	All types of surveying

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Distance Measurement

Taping over Level Ground

- If the taping is done over level ground where there is no underbrush, the tape can rest on the ground
- A taping crew consists of two people: the head tapeperson and the rear tapeperson
- The head tapeperson takes one end of the tape and walks down the line towards the point
- If the distance is more than 100 ft., then the head tapeperson places a taping pin at the 100 ft. interval, and the process is repeated

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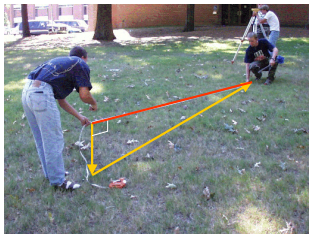
Distance Measurement

Taping over Sloping Ground

If the taping is done over sloping ground where there is no underbrush, the taping must be done in sections, referred to as ***breaking the tape***.



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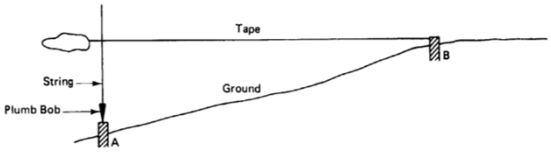
Distance Measurement

Taping over Sloping Ground

Holding the tape more than five feet above the ground is difficult; therefore, slopes greater than 5 ft. per 100 ft. will require runs of less than 100 ft.



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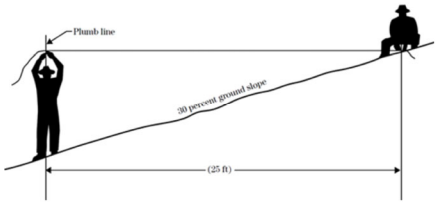
Distance Measurement

Taping over Sloping Ground

Holding the tape more than five feet above the ground is difficult; therefore, slopes greater than 5 ft. per 100 ft. will require runs of less than 100 ft.



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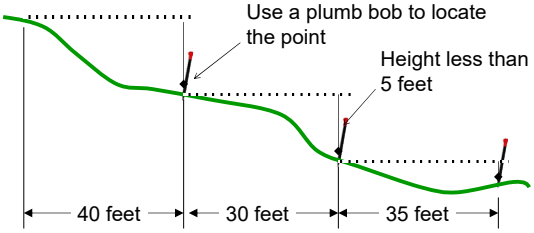
Distance Measurement

Taping over Sloping Ground

Hold the tape level

Use a plumb bob to locate the point

Height less than 5 feet



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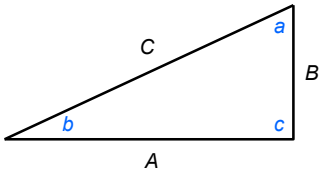
Distance Measurement

Review of Basic Trigonometry

For a right triangle, let's consider the basic trigonometric functions.



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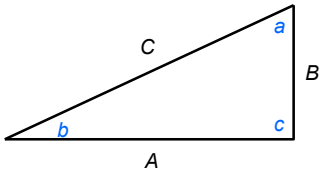
Distance Measurement

Review of Basic Trigonometry

$A^2 + B^2 = C^2$ $a + b + c = 180^\circ$



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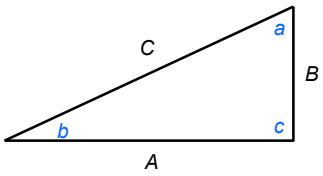
Distance Measurement

Review of Basic Trigonometry

$$\cos(b) = \frac{A}{C} \qquad \sin(b) = \frac{B}{C} \qquad \tan(b) = \frac{B}{A}$$



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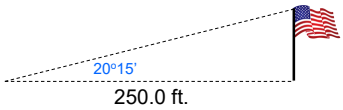
Distance Measurement

Review of Basic Trigonometry

Assuming that the ground is level, a 250.0 ft. length is measured out from the base of the steeple, and a 20°15' vertical angle is determined from that point on the ground to the top of the flagpole.

$$\tan(20.25^\circ) = \frac{h}{250.0\,\text{ft.}} \quad \Rightarrow \quad h = \overline{250.0} \times \tan(20.25^\circ)$$

$$h = 92.2298....\ \text{ft.}$$



$$h = 92.23\,\text{ft.}$$

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Distance Measurements

TopHat Problems

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Distance Measurements

End of Distance Measurements

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