**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 to 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 comes from the Danish faedn, "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.)
**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.

Under Marcus Vipsanius Agrippa, it was standardized as the distance of two steps (gradus) 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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**Surveying - Measuring Distance**

**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
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).

The 66-foot chain is made of 100 links 7.92 in. long. In 1785 U.S. a federal law stated that all government surveys must be done with a Gunter's chain.

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.
The word acre is derived from Old English æcer originally meaning "open field".

Taping or Chaining

- Distance Measurement

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

Electronic Distance Measurement (EDM)

- Distance Measurement

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

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

Pacing

- Distance Measurement

<table>
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<tr>
<th>Pacing</th>
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<th>Reconnaissance</th>
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Odometer

- Distance Measurement

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<th>1/200</th>
<th>Reconnaissance</th>
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Taping

- Distance Measurement

<table>
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<tr>
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<th>1/1,000 to 1/5,000</th>
<th>Land surveys</th>
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EDM

- Distance Measurement

<table>
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<tr>
<th>EDM</th>
<th>±0.04 to 1/300,000</th>
<th>All types of surveying</th>
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</thead>
</table>

Taping over Level Ground

- Distance Measurement

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 places a taping pin at the 100-ft. interval and the process is repeated.
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*.

Hold 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.

Hold the tape level

Use a plumb bob to locate the point

Height less than 5 feet

40 feet

30 feet

35 feet

Review of Basic Trigonometry

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

\[
A^2 + B^2 = C^2 \\
a + b + c = 180^
\]

\[
cos(b) = \frac{A}{C} \\
sin(b) = \frac{B}{C} \\
tan(b) = \frac{B}{A}
\]
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.

\[
\tan(20.25') = \frac{h}{250.0 \text{ ft.}} \Rightarrow h = 250.0 \times \tan(20.25')
\]

\[h = 92.2298\ldots \text{ ft.} \]

\[h = 92.23 \text{ ft.}\]