Distance Definition:

- The *horizontal* distance between two points.
- In ground surveys even though many angles may be read, the length of at least one line must be measured to supplement the angles in locating points.

Measurement Techniques:

- Pacing
- Taping
- EDM (electronic distance measurement)
- GPS (global positioning system)

Units:

- English system is foot
- Metric system is meter
- Other units commonly used in surveying are inch, foot, mile, etc.
PACING

• Pacing is one of the most valuable things learned in surveying, since it has practical applications for everybody and requires no equipment.

• Distances obtained by pacing are sufficiently accurate for many purposes in:
  ♦ Surveying
  ♦ Engineering
  ♦ Geology
  ♦ Forestry
  ♦ Military field sketching

• It is also used to detect careless mistakes that may occur in making distance measurements by more accurate methods.

• Pacing consists of counting the number of steps, or paces, in a required distance.
• Pacing is best done:
  ♦ by walking with natural steps back and forth over a measured level course at least 100 m long, and
  ♦ dividing the known distance by the average number of steps.

Example

A person counted 88 paces by walking along 60.00 m know length on level ground and 111 paces of unknown distance \( AB \). What is the pace length and the length of \( AB \)?

Solution

\[ \text{Pace length} = \frac{60.00}{88} = 0.6818 \text{ m/pace} \]

\[ \text{Length of } AB = 0.6818 \times 111 = 75.6798 \approx 75.680 \text{ m} \]
Measurement of horizontal distances by taping consists of applying the known length of a graduated tape directly to a line for a number of times.
TAPING

Taping Equipment and Accessories

Tapes

Range poles

Hand level

Chaining pins

Plumb bobs
TAPING …

Procedure:

♦ Clear line and mark at both ends, and at intermediate points where necessary.

♦ Lay out tape on ground making sure there are no kinks

♦ Apply tension (10-25 lbs)

♦ The 30 m end of the tape is held over the rear point by the rear tapeperson, while the forward tapeperson, holding the zero end.

♦ For accurate results the tape must be straight and the two ends held at the same elevation.
TAPING …

Procedure:

♦ Use plum-bob
  ♦ Weeds, brush, obstacles, and surface irregularities may make it undesirable to lay a tape on the ground.
  ♦ In those cases, the tape is held above the ground in horizontal position.
  ♦ Mark each end point on the tape by placing the plumb-bob string over the proper tape graduation.

♦ Marking tape lengths
  ♦ The forward tapeperson places a pin exactly opposite the ZERO mark of the tape and calls “stuck” and signals that the point is OK.
  ♦ The rare tapeperson pulls up the rear pin, and then move a head.
  ♦ The process of measuring 30 m lengths is repeated until a partial tape length is needed at the end of the line.

♦ Read the tape
Normal Tape:

- Shows cms and all divisions between whole meters.
- There are two common styles of graduations on surveyor’s tapes.
- It is necessary to identify the type being used before starting.

**“Adding” Tape**

Distance = 87 + 0.68 = 87.68

**“Subtracting” Tape**

Distance = 88 - 0.32 = 87.68
TAPPING ON STEEP SLOPES

"Breaking Tape"

Keep 100 ft/m (larger end) ahead in route surveys when not using reel tape
SLOPE MEASUREMENTS

\[ H = L \cos \alpha \]

\[ H = \sqrt{L^2 - d^2} \]
There are three fundamental sources of error in taping:

1. Instrumental errors
   - Defect in manufacture or repair
   - Error as a result of kinks

2. Natural errors
   - Effects of temperature, wind, and weight of the tape itself

3. Personal errors
   - Being careless in setting pins, reading the tape or manipulating the equipment.

Read: Section 6-14 Sources of Error in Taping
EDMs measure lengths by indirectly determining the number of full and partial waves of transmitted electromagnetic energy and are required in traveling between the two ends of a line.

\[ V = f\lambda \]

\( V \) is the velocity of electromagnetic energy (m/s)

\( f \) is the modulated frequency of energy (Hz)

\( \lambda \) is the wavelength (m)

\[ V = \frac{c}{n} \]

\( c \) is velocity of electromagnetic energy in vacuum (299,792,458 m/s); \( n \) is the atmospheric index of refraction (vary from 1.0001 to 1.0005)
In principle, the distance ($L$) between the EDM instrument and the reflector would be expressed as:

$$L = \frac{n\lambda + p}{2}$$

where $n$ is the number of full wavelengths, and $p$ the length of the fractional part.
LAB : DISTANCE MEASUREMENT

Pace calibration

100 m

Taping, Pacing, and EDM

EDM Instrument

Reflector

G
G-5
G-3
G-1
A
B
D
F

G-6
G-4
G-2