



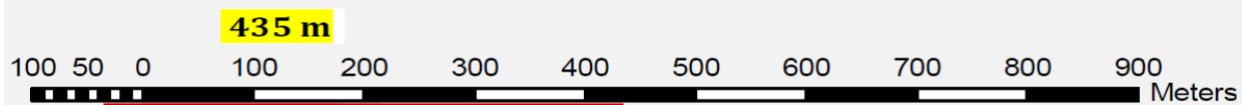
## Scale

the ratio of the length of a feature on a map to the true length of the feature. Choice of scale depends on the purpose, size, and required precision of the finished map.

$$\text{Scale} = \frac{\text{Distance on map}}{\text{Distance on ground}}$$

Map scales are given in three ways:

- (1) by ratio or representative fraction, such as 1:2000 or 1>2000;
- (2) by an equivalence scale, for example, 1 in. = 200 ft; and
- (3) by graphically using either a bar scale.



### Example 1

if the distance between points a and b on map =25 cm and the distance between points a and b on ground =500 m. what is the map scale?

### Solution

$$\text{Scale} = \frac{\text{distance on map}}{\text{distance on ground}} = \frac{25}{500 \times 100} = \frac{1}{\frac{50000}{25}} = \frac{1}{2000}$$

### Example 2

A 2500 m<sup>2</sup> land area is drawn with a scale of  $\frac{1}{1000}$  what is the area of the land on the map?

بما ان المقياس  $\frac{1}{1000}$  فان 1 سنتيمترا على الخارطة يقابل 10 امتار على الطبيعة و كذلك 1 سم<sup>2</sup> على الخارطة 10X10 م<sup>2</sup> على الطبيعة.

$$\text{area of the land on the map} = \frac{2500}{10 \times 10} = 25 \text{ cm}^2$$

**Example 3**

The measured distance between two point on the ground is 258 m.  
what is the distance if want to be drawn on the map with scale of  $\frac{1}{2500}$

$$\text{Scale} = \frac{\text{distance on map}}{\text{distance on ground}}$$

$$\frac{1}{2500} = \frac{\text{distance on map}}{258}$$

$$\text{distance on map} = \frac{258}{2500} = 0.1032 \text{ m} = 10.32 \text{ cm}$$

**Errors**

Error: is the difference between an observed value for a quantity and its true value:

Error = Measured Value - True Value

$$E = X_m - X_t$$

Where

E is the Error in an observation,

$X_m$  the observed value

$X_t$  the true value.

**Types of Errors**

1- Systematic Errors

2- Random Errors

**Sources of Errors**

1- Natural Errors

Natural errors are caused by variations in wind, temperature, humidity, atmospheric pressure, atmospheric refraction, gravity, and magnetic declination. An example is a steel tape whose length varies with changes in temperature.



## 2- Instrumental Errors

Instrumental errors result from any imperfection in the construction or adjustment of instruments and from the movement of individual parts.

## 3- Personal Errors

Personal errors arise principally from limitations of the human senses of sight and touch.

## Measurements of Horizontal Distances

Type of measurements

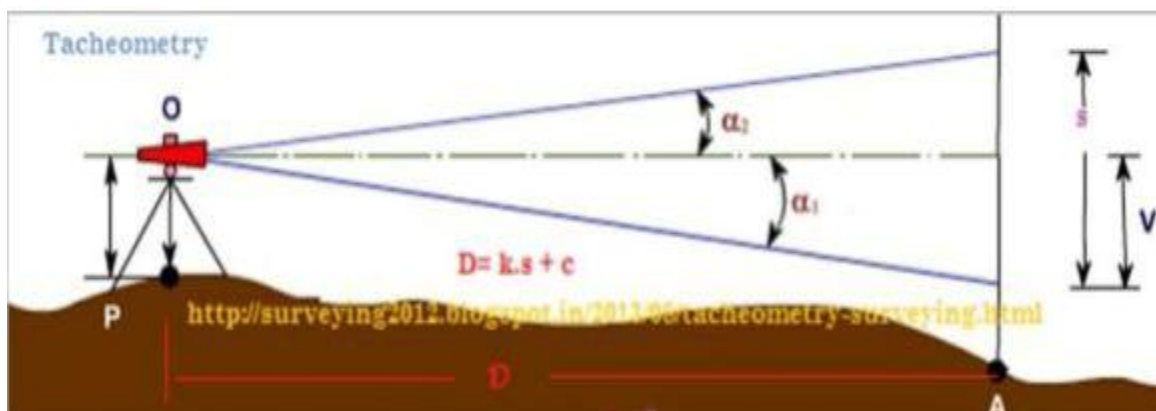
There are two main methods of determining the distance between points

### 1-Direct Measurements

In this method, distances are actually measured on the surface using measurement instruments. These measurements are used for plane terrain.

### 2-Indirect Measurements

Calculations are made to measure distances as in tacheometry and triangulation (or chain) surveying. These measurements are used for slope terrain.



## Distance Measurements by Measuring Tape

### Types of measuring tape

Depending on materials used, tapes are classified as:

1- Cloth tapes	2- Metallic tape	3- Steel tape
		

## **Errors in Taping**

### 1- Incorrect tape length

$$\text{total correction } C_d = C_a * \frac{\text{Measured distance (D)}}{\text{nominal tape length (L}_n\text{)}}$$

where

$C_a$ : correction per tape length, m,

$C_a$  = actual tape length (L') - nominal tape length (L<sub>n</sub>)

Corrected distance ( $\bar{D}$ ) =  $D + C_d$



*Example* A distance of 220.450 m was measured with a steel band of nominal length 30 m. On standardization the tape was found to be 30.003 m. Calculate the correct measured distance, assuming the error is evenly distributed throughout the tape.

$$C_a = \text{actual tape length } (L') - \text{nominal tape length } (L_n)$$

$$= 30.003 - 30 = 0.003 \text{ m}$$

$$\text{total correction } C_d = C_a * \frac{\text{Measured distance } (D)}{\text{nominal tape length } (L_n)}$$

$$= 0.003 * \frac{220.45}{30} = 0.022 \text{ m}$$

$$\text{Corrected distance } (\bar{D}) = D + C_d$$

$$= 220.45 + 0.022 = 220.472 \text{ m}$$

## 2- Variation of temperature

Tapes are usually standardized at 20°C. Any variation above or below this value will cause the tape to expand or contract, giving rise to systematic errors.

$$C_t = D \alpha (T - T_s)$$

where

$\alpha$ : Coefficient of thermal expansion of the material of tape, /°C,

$T$ : Mean temperature during measurement, °C,

$T_s$ : Temperature at which tape is standardized, °C, (20°C)

$D$ : total distance measured, m, and

$C_t$ : total correction due to temperature, m.

$$\text{Corrected distance } (D') = D + C_t$$



Example/A 30-m band standardized at 20°C was found to be 30.003 m. At what temperature is the tape exactly 30 m? Coefficient of expansion of steel = 0.000 011/°C?

$$C_t = D \alpha (T - T_s)$$

$$-0.003 = 30 * 0.000011 (T - 20)$$

$$T = 11^\circ\text{C}$$

### 3- Variation in tension

if the tension force that is used for pulling the tape is greater than the standard, tension errors exist which can be found by using the following formula:

$$C_p = \frac{(P - P_s) * D}{AE}$$

where

$E$ : Young's modulus of the material of tape,  $\text{N/cm}^2$ ,

$A$ : Cross-sectional area of the tape,  $\text{cm}^2$ ,

$P$ : Pull applied during measurement, N,

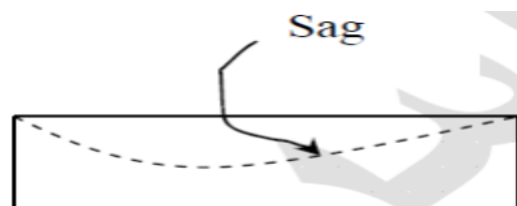
$P_s$ : Standard pull, N,

$D$ : total distance measured, m, and

$C_p$ : total correction due to pull, m.

$$\text{Corrected distance (D')} = D + C_p$$

### 4- Sag correction





$$C_g = \frac{1}{24} \left( \frac{W}{P} \right)^2 L$$

$w$ : weight of tape per span length, N,

$P$ : Pull applied during measurement, N,

$L$ : length measured between two support, m, and

$C_s$  : total correction due to sag, m.

- This correction is always negative (-ve).

$$\text{Corrected distance } (D') = D - C_s$$

**Example.** A base line was measured by tape suspended in catenary under a pull of 145 N, the mean temperature being 14°C. The lengths of various segments of the tape and the difference in level of the two ends of a segment are given in Table

Bay/Span	Length (m)	Difference in level (m)
1	29.988	+ 0.346
2	29.895	– 0.214
3	29.838	+ 0.309
4	29.910	– 0.106

If the tape was standardized on the flat under a pull of 95 N at 18°C determine the correct length of the line.

Take Cross-sectional area of the tape = 3.35 mm<sup>2</sup>

Mass of the tape = 0.025 kg/m

Coefficient of linear expansion =  $0.9 \times 10^{-6}$  per °C Young 's modulus =  $14.8 \times 104$  MN/m<sup>2</sup>

**Solution:**

It is given that

$$P_0 = 95 \text{ N}, P = 145 \text{ N}$$

$$t_0 = 18^\circ\text{C}, t_m = 14^\circ\text{C}$$

$$A = 3.35 \text{ mm}^2, \alpha = 0.9 \times 10^{-6} \text{ per } ^\circ\text{C}$$

$$w = mg = 0.025 \times 9.81 \text{ kg/m}$$

$$E = 14.8 \times 10^4 \text{ MN/m}^2 = \frac{14.8 \times 10^4 \times 10^6}{10^6} \text{ N/mm}^2 = 14.8 \times 10^4 \text{ N/mm}^2$$

$$H = 51.76 \text{ m}, R = 6370 \text{ km}$$

$$\text{Total length of the tape } L = 29.988 + 29.895 + 29.838 + 29.910 = 119.631 \text{ m}$$

**Temperature correction**

$$c_t = \alpha(t_m - t_0)L$$

$$= 0.9 \times 10^{-6} \times (14 - 18) \times 119.631 = -0.0004 \text{ m}$$

**Pull correction**

$$c_p = \frac{(P - P_0)}{AE} L$$

$$= \frac{(145 - 95) \times 119.631}{3.35 \times 14.8 \times 10^4} = 0.0121 \text{ m}$$





## Sag correction

$$\begin{aligned}c_g &= -\frac{1}{24}\left(\frac{W}{P}\right)^2 L \\&= -\left[\frac{1}{24}\left(\frac{wl_1}{P}\right)^2 l_1 + \frac{1}{24}\left(\frac{wl_2}{P}\right)^2 l_2 + \frac{1}{24}\left(\frac{wl_3}{P}\right)^2 l_3 + \frac{1}{24}\left(\frac{wl_4}{P}\right)^2 l_4\right] \\&= -\frac{w^2}{24P^2} (l_1^3 + l_2^3 + l_3^3 + l_4^3) \\&= -\frac{(0.025 \times 9.81)^2}{24 \times 145^2} (29.988^3 + 29.895^3 + 29.838^3 + 29.910^3) \\&= -0.0128 \text{ m}\end{aligned}$$