

# CVG 2171 – Surveying and Measurements

## Assignment # 3 – Distance Measurement

### SOLUTIONS

#### Problem 1

A steel tape when standardized at 68°F and supported throughout its entire length under a tension of 12 lb was found to be 100.012 ft. long. The tape has a cross-sectional area of 0.0078 in<sup>2</sup> and weighs 0.0266 lb/ft. In the field this tape was used to measure a line from A to B in six segments. It was held horizontal, supported at the ends and the middle point only each time it was used with a constant tension of 17 lb. These segments were recorded as such: 100.000 ft., 100.000 ft., 100.000 ft., 100.000 ft., 100.000 ft., and 82.366 ft.

What is the actual distance between A and B after corrections for systematic errors have been applied if the temperature of the tape at the time of measurement was 55°F? Coefficient of thermal expansion and contraction of steel is 0.0000065 /ft./°F and its modulus of elasticity is 29x10<sup>6</sup> lb/in<sup>2</sup>.

#### *Step 1: Identify Corrections*

##### 1. Length

$$C_l = \left(\frac{l-l'}{l'}\right)L = \left(\frac{100.012-100.000}{100.00}\right)(582.366) = 0.070 \text{ ft.}$$

##### 2. Temperature

$$C_t = k(T_1 - T)L = (0.00000645)(55 - 68)(582.366) = -0.049 \text{ ft.}$$

##### 3. Pull

$$C_p = (P_1 - P) \frac{L}{AE} = (17 - 12) \frac{582.366}{(0.0078)(29,000,000)} = 0.013 \text{ ft.}$$

##### 4. Sag

$$C_{s1} = -\frac{w^2 L_s^3}{24P_1^2} = -\frac{(0.0266)^2 \left(\frac{100.00}{2}\right)^3}{24(17)^2} \times 10 = -0.128 \text{ ft.}$$

$$C_{s2} = -\frac{w^2 L_s^3}{24P_1^2} = -\frac{(0.0266)^2 \left(\frac{82.366}{2}\right)^3}{24(17)^2} \times 2 = -0.014 \text{ ft.}$$

*Step 2: Sum of Corrections*

$$\sum C = C_l + C_t + C_p + C_s = 0.070 - 0.049 + 0.013 - 0.128 - 0.014 = -0.108 \text{ ft.}$$

*Step 3: Adjust Recorded Distance*

$$\text{corrected length} = \text{measured distance} + \sum C = 582.366 + (-0.108) = 582.258 \text{ ft.}$$

## Problem 2

A 100 ft. tape of cross-sectional area 0.0025 in<sup>2</sup>, weight 2.3 lb, and standardized at 68°F is 99.992 ft. between end marks when supported throughout under a 12 lb pull. What is the true horizontal length of a recorded distance AB for the given conditions:

Recorded Distance AB (ft.)	94.23
Average Temperature (°F)	75
Means of Support	Ends Only
Tension (lb)	25

### *Step 1: Identify Corrections*

#### 1. Length

$$C_l = \left(\frac{l-l'}{l'}\right)L = \left(\frac{99.992-100}{100}\right)(94.23) = -0.008 \text{ ft.}$$

#### 2. Temperature

$$C_t = k(T_1 - T)L = (0.00000645)(75 - 68)(94.23) = 0.004 \text{ ft.}$$

#### 3. Pull

$$C_p = (P_1 - P) \frac{L}{AE} = (25 - 12) \frac{94.23}{(0.0025)(29,000,000)} = 0.017 \text{ ft.}$$

#### 4. Sag

$$C_s = -\frac{w^2 L_s^3}{24P_1^2} = -\frac{\left(\frac{2.31}{100}\right)^2 (94.23)^3}{24(25)^2} = -0.030 \text{ ft.}$$

### *Step 2: Sum of Corrections*

$$\sum C = C_l + C_t + C_p + C_s = -0.008 + 0.004 + 0.017 - 0.030 = -0.017 \text{ ft.}$$

### *Step 3: Adjust Recorded Distance*

$$\text{corrected length} = \text{measured distance} + \sum C = 94.23 + (-0.017) = 94.213 \text{ ft.}$$

### Problem 3

A 30 m steel tape measure 29.991m when standardized fully supported under a 5.500 kg pull at a temperature of 20°C. The tape weighed 1.22 kg and had a cross-sectional area of 0.016 cm<sup>2</sup>. What is the corrected horizontal length of a recorded distance AB for the given conditions:

Recorded Distance AB (m)	28.056
Average Temperature (°C)	18
Means of Support	Throughout
Tension (kg)	8.3

#### *Step 1: Identify Corrections*

##### 1. Length

$$C_l = \left(\frac{l-l'}{l'}\right)L = \left(\frac{29.991-30}{30}\right)(28.056) = -0.008 \text{ m}$$

##### 2. Temperature

$$C_t = k(T_1 - T)L = (0.0000116)(18 - 20)(28.056) = -0.0006 \text{ m}$$

##### 3. Pull

$$C_p = (P_1 - P) \frac{L}{AE} = (8.3 - 5.5) \frac{28.056}{(0.016)(2,000,000)} = 0.0024 \text{ m}$$

#### *Step 2: Sum of Corrections*

$$\sum C = C_l + C_t + C_p = -0.008 - 0.0006 + 0.0024 = -0.0062 \text{ m}$$

#### *Step 3: Adjust Recorded Distance*

$$\text{corrected length} = \text{measured distance} + \sum C = 28.056 + (-0.0062) = 28.049 \text{ m}$$

#### Problem 4

Determine the horizontal length of CD that must be laid out to achieve the required true horizontal distance CD. Assume a 100 ft. steel tape will be used, with cross-sectional area 0.0025 in<sup>2</sup>, weight 2.4 lb, and standardized at 68°F to be 100.008 ft. between end marks when supported throughout with a 12 lb pull.

Required Horizontal Distance CD (ft.)	68.78
Average Temperature (°F)	91
Means of Support	Throughout
Tension (lb)	18

#### *Step 1: Identify Corrections*

##### 1. Length

$$C_l = \left(\frac{l-l'}{l'}\right)L = \left(\frac{100.008-100}{100}\right)(68.78) = 0.006 \text{ ft.}$$

##### 2. Temperature

$$C_t = k(T_1 - T)L = (0.00000645)(91 - 68)(68.78) = 0.010 \text{ ft.}$$

##### 3. Pull

$$C_p = (P_1 - P) \frac{L}{AE} = (18 - 12) \frac{68.78}{(0.0025)(29,000,000)} = 0.006 \text{ ft.}$$

#### *Step 2: Sum of Corrections*

$$\sum C = C_l + C_t + C_p = 0.006 + 0.010 + 0.006 = 0.022 \text{ ft.}$$

#### *Step 3: Adjust Required Distance*

$$\text{corrected length} = \text{measured distance} - \sum C = 68.78 - (0.022) = 68.758 \text{ ft.}$$

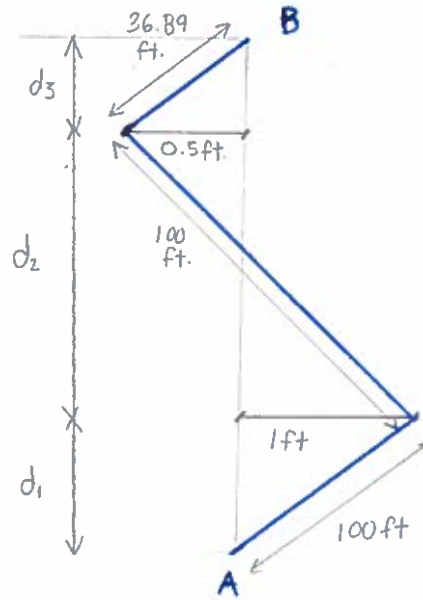
**Problem 5**

When measuring a distance AB, the first taping pin was placed 1.0 ft. to the right of line AB and the second pin set 0.5 ft. left of line AB. The recorded distance was 236.89 ft. Calculate the corrected distance. Assume three taped segments, the first two 100 ft. each.

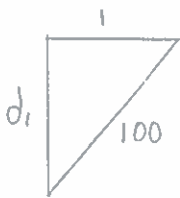
Recorded Distance : 236.89 ft.

1  $c^2 = a^2 + b^2$

2  $a^2 = c^2 - b^2$



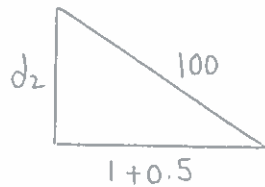
$d_1$



$$d_1 = \sqrt{100^2 - 1^2}$$

$$= 99.995 \text{ ft.}$$

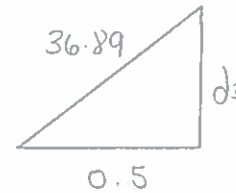
$d_2$



$$d_2 = \sqrt{100^2 - (1+0.5)^2}$$

$$= 99.989 \text{ ft.}$$

$d_3$



$$d_3 = \sqrt{36.89^2 - 0.5^2}$$

$$= 36.8866 \text{ ft.}$$

$$\therefore \text{Corrected distance} = d_{\text{Tot}} = d_1 + d_2 + d_3$$

$$= 99.995 + 99.989 + 36.8866$$

$$= \underline{236.87 \text{ ft.}}$$

Ans.