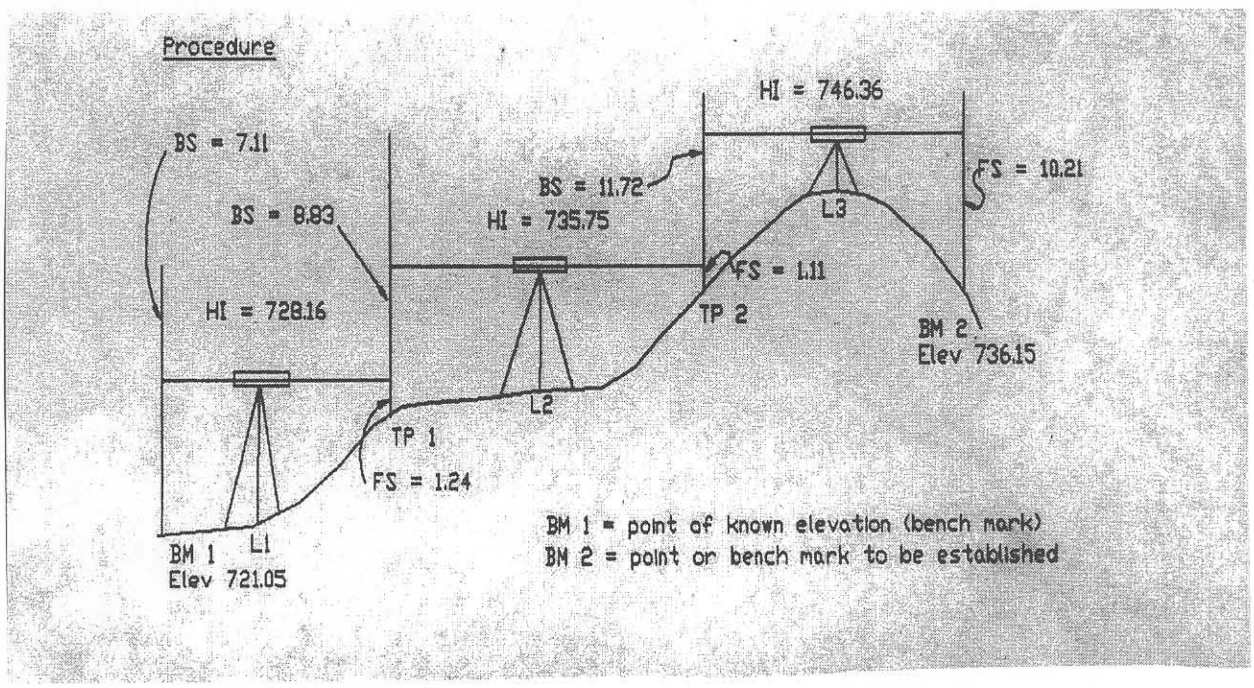
SCORES COMPETITION
MARSHALL UNIVERSITY

Engineering Measurements

Information and Definitions

Differential leveling is the operation of determining the elevations of points some distance apart. Differential leveling requires a series of set-ups of the instrument along the general route and, for each set-up, a rod reading back to a point of known elevation and forward to a point of unknown elevation.



Backsight (BS)—a rod reading taken on a point of known elevation, as a bench mark or a turning point. It sometimes is called a plus (+) sight.

Foresight (FS)—a rod reading taken on a point the elevation of which is to be determined. It sometimes is called a minus (-) sight.

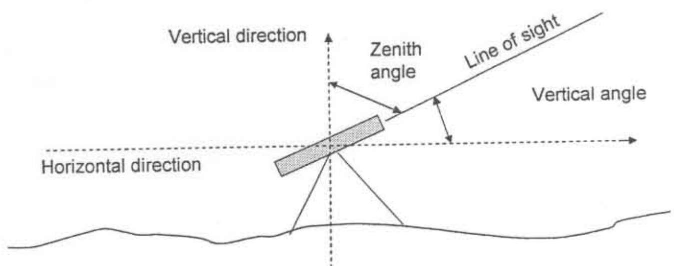
Height of instrument (HI)—the elevation of the line of sight of the telescope when the instrument is leveled.

Bench mark (BM)—a definite point on an object, the elevation and location of which are known. There are two types: permanent bench marks (PBM) and temporary bench marks (TBM).

Turning point (TP)—an intervening point between two bench marks upon which point foresight and backsight rod readings are taken. It can be a pin, a plate, or any stable object such as a rock, a railroad, a street curb, etc.

A **vertical angle** is the difference in direction between two intersecting lines measured in a vertical plane. In surveying, it is commonly taken to be the angle above and below a horizontal plane through the point of observation.

1. **Elevation angle**—a vertical angle in which the line of sight is directed upward (positive angle).
2. **Depression angle**—a vertical angle in which the line of sight is directed downward (negative angle).
3. **Zenith angle**—the angle measured from a vertical line to the point in question. It is the complement of the vertical angle.



A **horizontal distance** is the distance measured along a horizontal line. Usually, in surveying, horizontal distances are the distances reported. However, sometimes measurements along a slope are made, and these slope distances must be converted to horizontal distances by using trigonometry. See the drawing below for an illustration of *horizontal distance*, *slope distance*, and *vertical distance*.

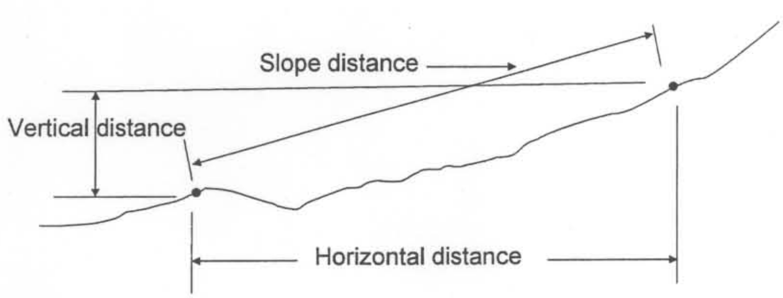
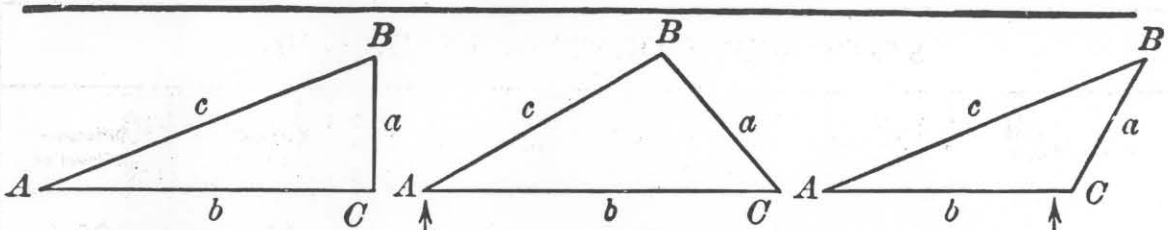


TABLE III. TRIGONOMETRIC FORMULAE



Right Triangle — Oblique Triangles

Solution of Right Triangles

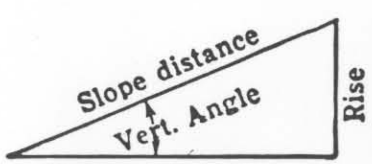
For Angle A. $\sin = \frac{a}{c}$, $\cos = \frac{b}{c}$, $\tan = \frac{a}{b}$, $\cot = \frac{b}{a}$, $\sec = \frac{c}{b}$, $\operatorname{cosec} = \frac{c}{a}$

Given	Required	
a, b	A, B, c	$\tan A = \frac{a}{b} = \cot B,\ c = \sqrt{a^2+b^2} = a\sqrt{1+\frac{b^2}{a^2}}$
a, c	A, B, b	$\sin A = \frac{a}{c} = \cos B,\ b = \sqrt{(c+a)(c-a)} = c\sqrt{1-\frac{a^2}{c^2}}$
A, a	B, b, c	$B = 90° - A,\ b = a \cot A,\ c = \frac{a}{\sin A.}$
A, b	B, a, c	$B = 90° - A,\ a = b \tan A,\ c = \frac{b}{\cos A.}$
A, c	B, a, b	$B = 90° - A,\ a = c \sin A,\ b = c \cos A,$

Solution of Oblique Triangles

Given	Required	
A, B, a	b, c, C	$b = \frac{a \sin B}{\sin A},\ C = 180° - (A+B),\ c = \frac{a \sin C}{\sin A}$
A, a, b	B, c, C	$\sin B = \frac{b \sin A}{a},\ C = 180° - (A+B),\ c = \frac{a \sin C}{\sin A}$
a, b, C	A, B, c	$A+B = 180° - C,\ \tan \frac{1}{2}(A-B) = \frac{(a-b)\tan\frac{1}{2}(A+B)}{a+b},\ c = \frac{a \sin C}{\sin A}$
a, b, c	A, B, C	$s = \frac{a+b+c}{2},\ \sin\frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{bc}},\ \sin\frac{1}{2}B = \sqrt{\frac{(s-a)(s-c)}{ac}},\ C = 180° - (A+B)$
a, b, c	Area	$s = \frac{a+b+c}{2}$, area $= \sqrt{s(s-a)(s-b)(s-c)}$
A, b, c	Area	area $= \frac{bc \sin A}{2}$
A, B, C, a	Area	area $= \frac{a^2 \sin B \sin C}{2 \sin A}$

REDUCTION TO HORIZONTAL



Horizontal distance

Horizontal distance = Slope distance multiplied by the cosine of the vertical angle. Thus: slope distance = 319.4 ft. Vert. angle = 5° 10′. From Table. IV. cos 5° 10′ = .9959. Horizontal distance = 319.4 × .9959 = 318.09 ft.

Horizontal distance also = Slope distance minus slope distance times (1 − cosine of vertical angle). With the same figures as in the preceding example, the following result is obtained. Cosine 5° 10′ = .9959. 1 − .9959 = .0041. 319.4 × .0041 = 1.31. 319.4 − 1.31 = 318.09 ft.

When the rise is known, the horizontal distance is approximately:—the slope distance less the square of the rise divided by twice the slope distance. Thus: rise = 14 ft.. slope distance = 302.6 ft. Horizontal distance $= 302.6 - \frac{14 \times 14}{2 \times 302.6} = 302.6 - 0.32 = 302.28$ ft.

Angle	Sin
° ′	
0	0
10	.0029
20	.0058
30	.0087
40	.0116
50	.0145
1	.0175
10	.0204
20	.0233
30	.0262
40	.0291
50	.0320
2	.0349
10	.0378
20	.0407
30	.0436
40	.0465
50	.0494
3	.0523
10	.0552
20	.0581
30	.0610
40	.0640
50	.0669
4	.0698
10	.0727
20	.0756
30	.0785
40	.0814
50	.0843
5	.0872
10	.0901
20	.0929
30	.0958
40	.0987
50	.1016
6	.1045
10	.1074
20	.1103
30	.1132
40	.1161
50	.1190
7	.1219
10	.1248
20	.1276
30	.1305
40	.1334
50	.1363
	Cosin