Online Surveying FE 208
Lectures 12

Leveling

Learning Objectives for this Lecture

1. **Know the definitions for leveling terminology**
2. **Understand the effects of curvature and refraction on an image**
3. **Be familiar with the different types of leveling procedures**
4. **Be able to calculate elevation differences using the profile leveling method**
5. **Be able to write correct leveling note format for profile leveling**

Leveling and Elevations

Definitions:

Leveling- The process of finding elevations of points, or of the differences of elevation between points.

Level surface – A *curved* surface that at every point is perpendicular to the local plumb line.

Horizontal line - A line in a horizontal plane

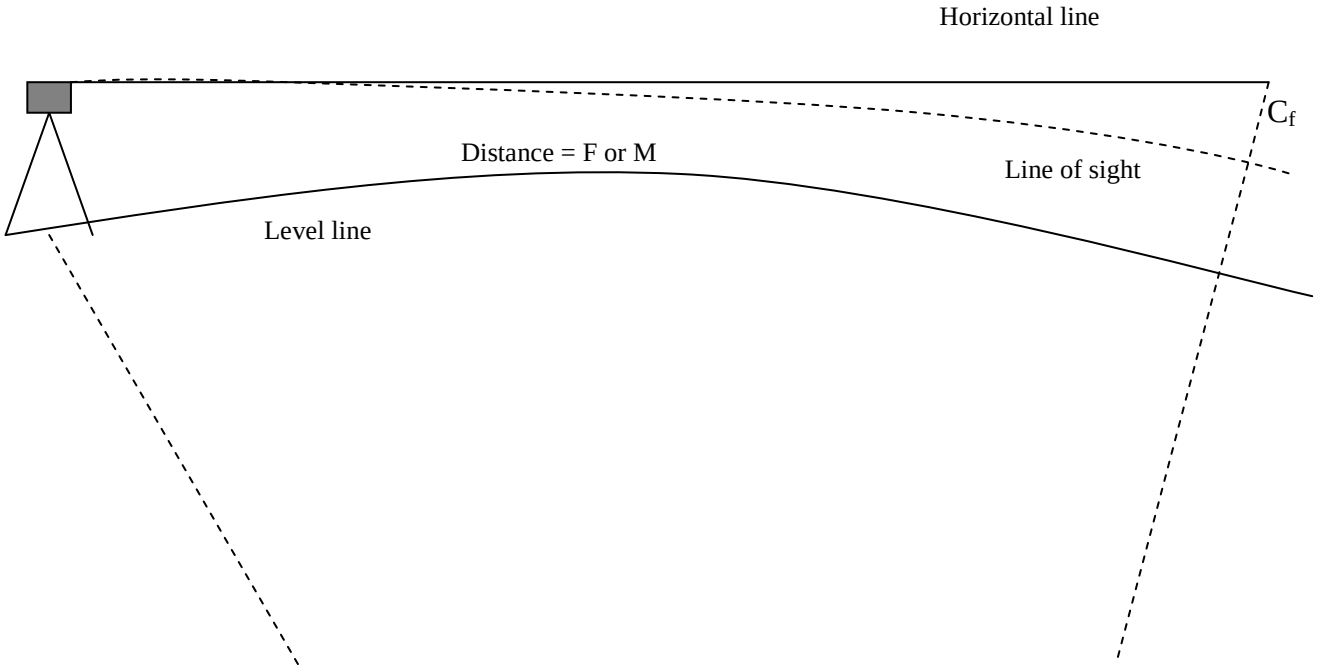
Vertical datum – Any level surface to which elevations are referred (for example mean sea level).

Bench mark – A relatively permanent object having a marked point with known elevation.

Vertical control – A series of benchmarks established throughout an area.

Line of Sight

Curvature of the earth. If a level sight was set on a level rod one mile away from a point on the earth, the reading would be greater than the actual by 2/3 of a foot.



Curvature

The line of sight is refracted downward approximately 1/7 of the deflection between the horizontal and the level lines.

The effects of curvature on line of sight can be expressed as:

$$C_f = 0.667M^2 = 0.0239F^2$$

Where: M = distance in miles
F = distance in thousands of feet

C_f = Line departure in feet

Refraction

Refraction causes the reverse of curvature, in other words, objects appear higher than they really are.

Refraction: Light passing through the atmosphere is ***bent*** so that in reading a rod, the reading is less than the actual. This offsets the earth's curvature by about 14%.

The effects of curvature on line of sight can be expressed as:

$$H_f = 0.093M^2 = 0.0033F^2$$

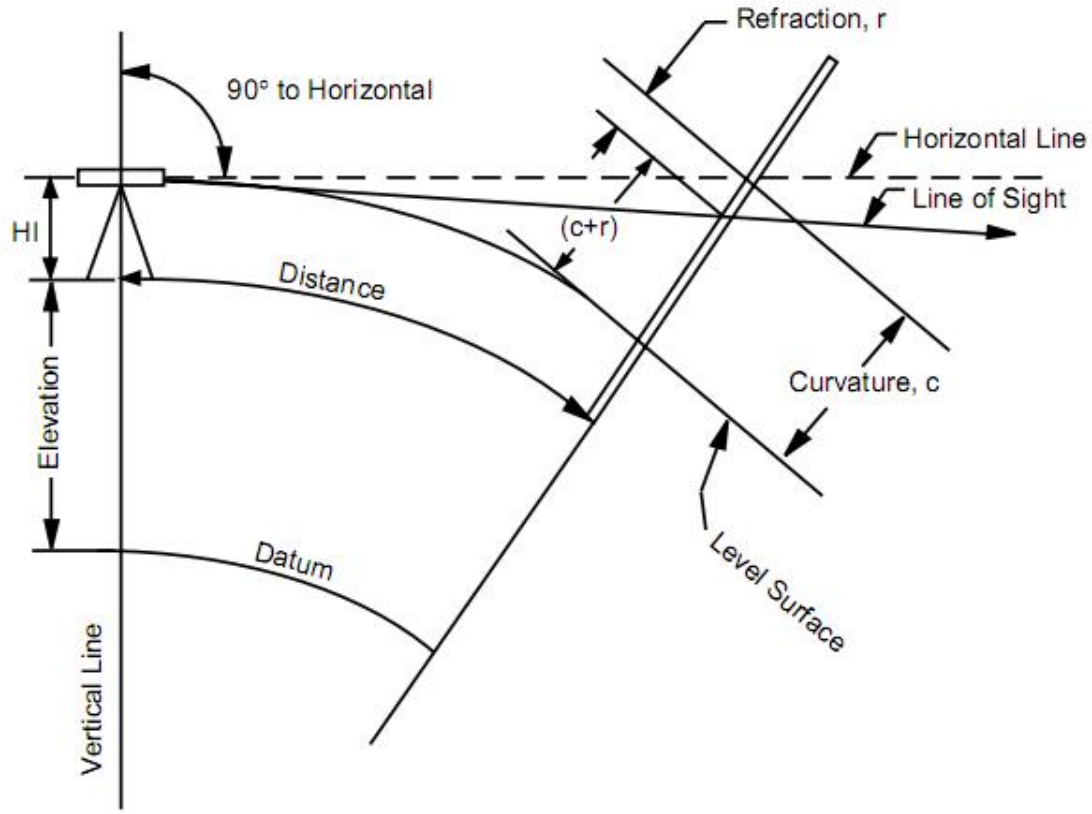
The two formulas for curvature and refraction corrections can be combined as:

$$H_f = 0.574M^2 = 0.0206F^2$$

Example: In a level rod shot of 300’ (beyond the scope of our level guns), the effects of refraction and curvature only amount to 0.0019’

$$H_f = 0.0206(\frac{300'}{1000'})^2 = 0.001854'$$

Curvature and Refraction



Types of Leveling

- Profile leveling
- Differential leveling
- 3-wire leveling
- Trigonometric leveling
- Barometric leveling
- GPS

Profile Leveling

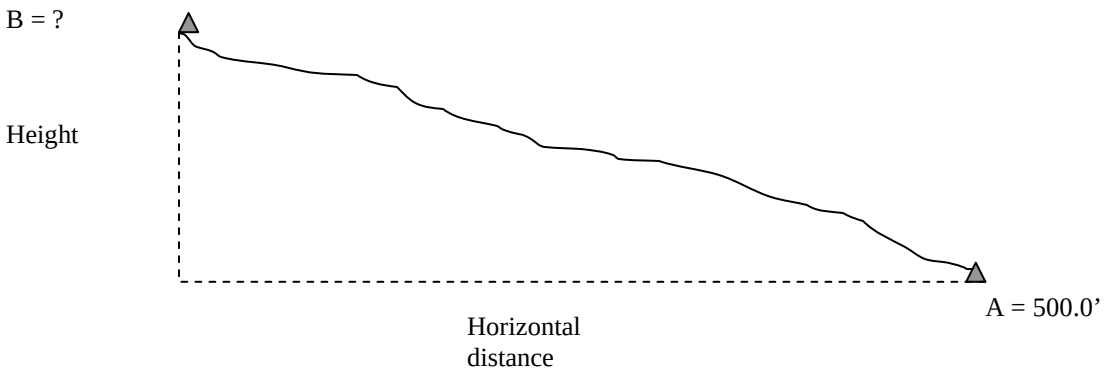
Profile leveling is the simplest form of leveling and is use to determine ground profiles for forest operations and planning

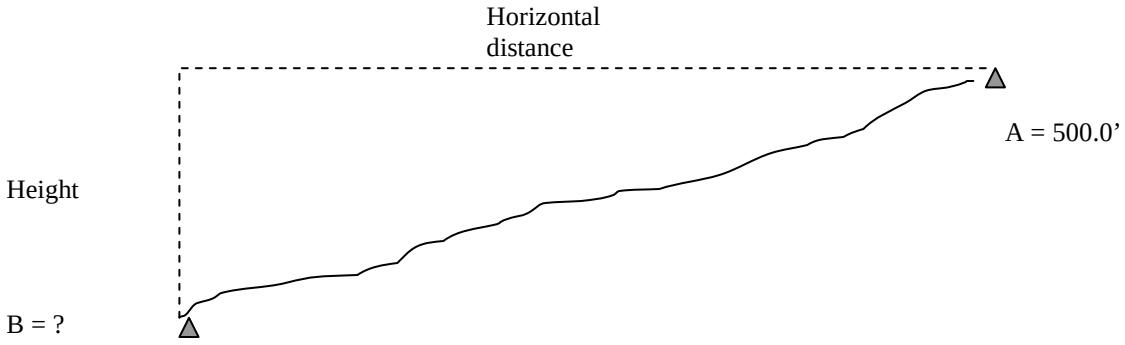
- Road maintenance for grade changes
- Skylines for deflection clearance
- Preliminary route design for major breaks
- General landform

Equipment used

- Clinometer or Abney
- Hand level and grade rod
- Tape or other distance measurement device

Elevation can be thought of as the difference in height between a known point and an unknown point.

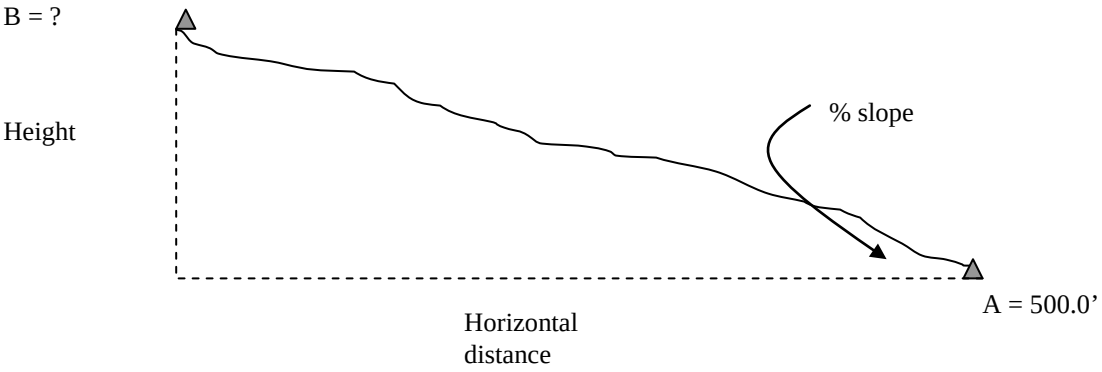




Methods for Profile Leveling

Clinometer or Abney

The clinometer or Abney may be used to determine the % angle between two points of interest



% slope = Rise / Run

Rise = % slope x Run

Height = % slope x Horizontal distance

Example 1

The slope angle at A to B = +27%, the horizontal distance is 125’, the elevation at A = 500.0’

The height difference between A and B = +0.27 x 125’ = +33.8’

Therefore, the elevation at B = 500.0 + 33.8’ = 533.8’

Example 2

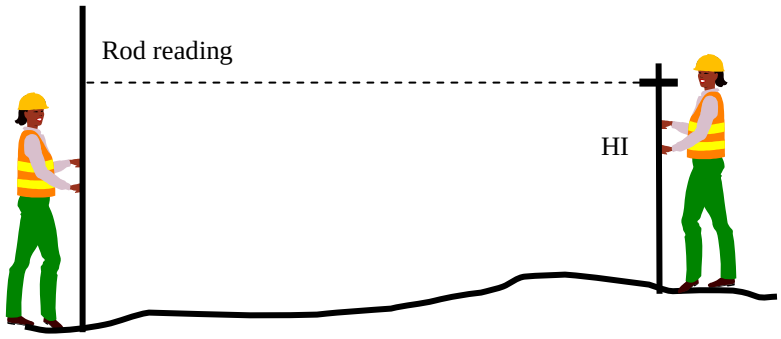
The slope angle at A to B = -27%, the horizontal distance is 125', the elevation at A = 500.0'

The height difference between A and B = -0.27 x 125' = -33.8'

Therefore, the elevation at B = 500.0 + -33.8' = 466.2'

Hand Level

The hand level and grade rod may be used to determine the height difference between two points of interest directly. The hand level uses the concept of a height of instrument reading subtracted from a grade rod reading.



Height difference = HI – rod reading

Elevation = Previous elevation + height difference

Note: a rod reading larger than the HI indicates a lower elevation

Example 1

The HI is at 5.2'. The rod reading from A to B is 3.1'. The elevation at A = 500.0'

The height difference between A and B = 5.2' – 3.1' = +2.1'

Therefore, the elevation at B = 500.0 + 2.1' = 502.1'

Example 2

The HI is at 5.2'. The rod reading from A to B is 7.3'. The elevation at A = 500.0'

The height difference between A and B = 5.2' – 7.3' = -2.1'

Therefore, the elevation at B = 500.0 + -2.1' = 497.9'

Notes for profile leveling with a clinometer

STA	SD	%	HD	VD	ELEV
1+94.3					500.1
	56.5	-26	54.7	-14.2	
1+39.6					514.3
	41.0	-8	40.9	-3.3	
0+98.7					517.6
	53.0	+23	52.0	12.0	
0+46.7					505.6
	47.0	+12	46.7	5.6	
0+00					500.0

Notes for profile leveling with a hand level

STA	HD	HI	Rod	VD	ELEV
1+94.3					500.4
	54.7	5.2	9.1	-3.9	
1+39.6					504.3
	40.9	5.2	7.3	-2.1	
0+98.7					506.4
	52.0	5.2	2.7	2.5	
0+46.7					503.9
	46.7	5.2	1.3	3.9	
0+00					500.0