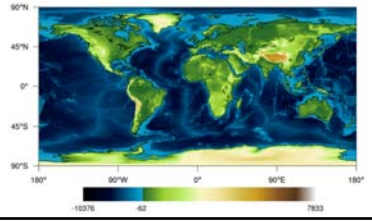
Measuring Elevation

- Elevation refers to the height above or below a fixed geographic reference point.
- In most cases, we the Earth's sea level as our reference point, but in some cases the ground level is used as the reference point.



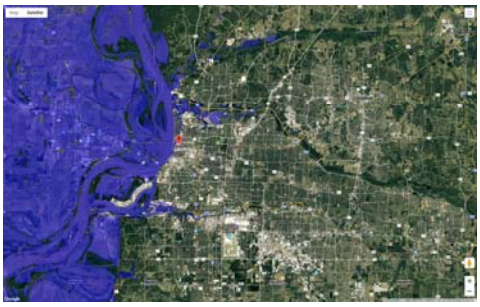
Measuring Elevation

- Elevation plays a crucial part in everyday life.
- In engineering, elevation is used to determine the center of gravity and the type of materials to be used.
- The elevation of a particular place can also help predict and prevent disasters such as flooding.

Measuring Elevation

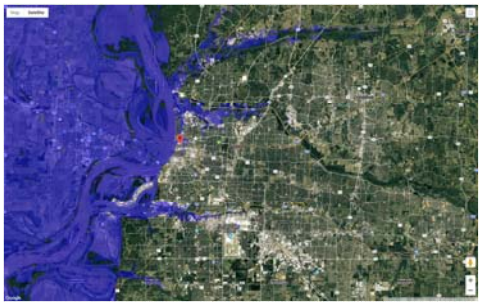
Mississippi River at flood stage ~ 217 ft. above sea level

Measuring Elevation



Mississippi River at flood stage ~ 227 ft. above sea level

Measuring Elevation



Mississippi River at flood stage ~ 237 ft. above sea level

Measuring Elevation

- Humans adapt to their environment, as some are adapted to higher elevations while others are adapted to low elevations.
- A majority of the world's population lives in coastal regions with elevations of 500 feet or less.
- The people of Tibet in Central Asia are adapted to living at 17,500 ft. where crops cannot grow and the oxygen is extremely thin.

Measuring Elevation

- Elevation refers to the height above or below a fixed geographic reference point.
- In most cases, we the Earth's sea level as our reference point, but in some cases the ground level is used as the reference point.
- One method for measuring elevation is to use differential leveling.

Differential Leveling

Importance of Vertical Positions

- A **vertical position** is the height of a point relative to some reference surface, such as mean sea level, a geoid, or an ellipsoid.
- The roughly 600,000 vertical control points in the U.S. National Spatial Reference System (NSRS) are referenced to the North American Vertical Datum of 1988 (NAVD 88).

Differential Leveling

Importance of Vertical Positions

- Surveyors created the National Geodetic Vertical Datum of 1929 (NGVD 29, the predecessor to NAVD 88), by calculating the average height of the sea at all stages of the tide at 26 tidal stations over 19 years
- Surveyors extended the control network inland using a surveying technique called **leveling**.

Differential Leveling

Importance of Leveling

- The determination of elevations is called ***leveling***
- Measuring relative elevations changes is a comparatively simply process
- Precise and accurate control of relative elevations are critical to most construction projects

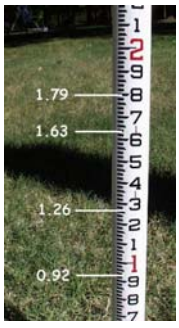
Differential Leveling

The Level

- A ***level*** consist of a high-powered telescope
- The level is attached to a spirit or bubble level that keeps the line of sight of the telescope horizontal

Differential Leveling

Level Instrument

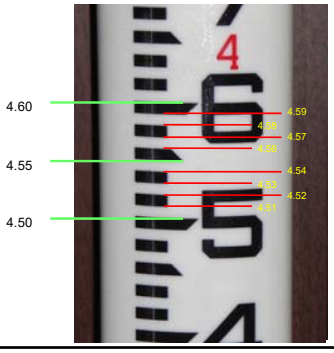


Differential Leveling

Level Instrument

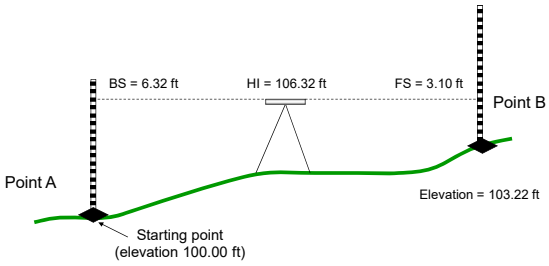
Differential Leveling

Level Instrument



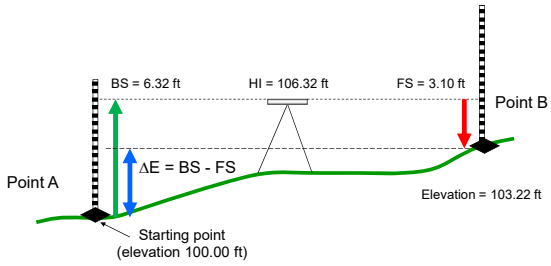
Differential Leveling

Definitions



Differential Leveling

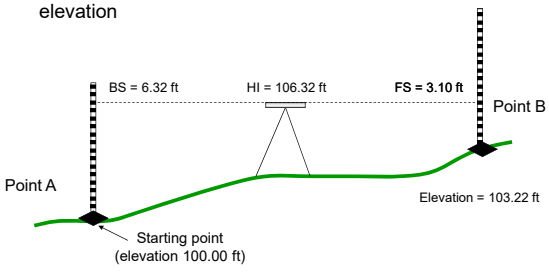
Definitions



Differential Leveling

Definitions

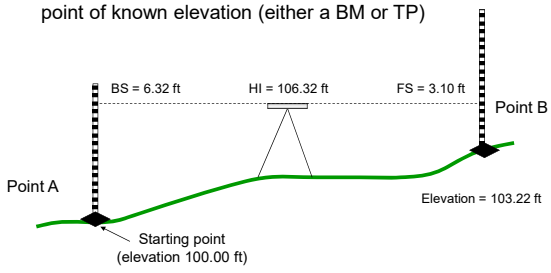
Bench mark (BM) - relatively permanent point of known elevation



Differential Leveling

Definitions

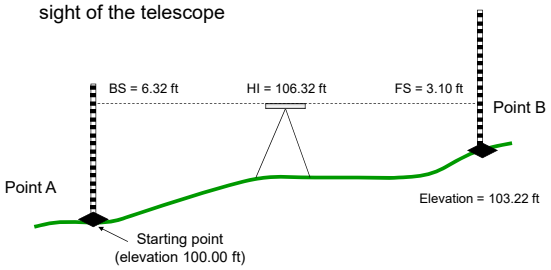
Backsight (BS) - a sight taken to the level rod held at a point of known elevation (either a BM or TP)



Differential Leveling

Definitions

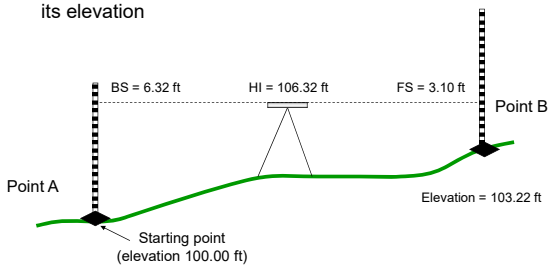
Height of instrument (HI) - the elevation of the line of sight of the telescope



Differential Leveling

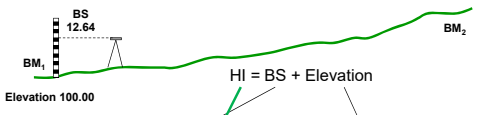
Definitions

Foresight (FS) - a sight taken on any point to determine its elevation



Differential Leveling

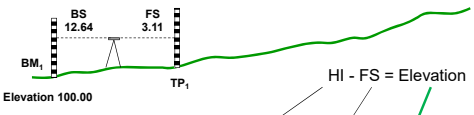
Computation of Elevations – Find Elevation of BM_2



Point	BS	HI	FS	Elevation
BM_1	12.64	112.64		100.00

Differential Leveling

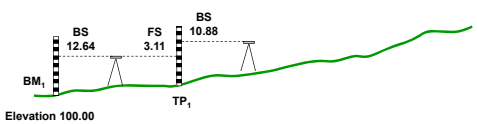
Computation of Elevations – Find Elevation of BM_2



Point	BS	HI	FS	Elevation
BM_1	12.64	112.64		100.00
TP_1			3.11	109.53

Differential Leveling

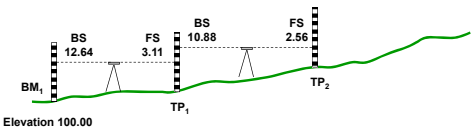
Computation of Elevations – Find Elevation of BM_2



Point	BS	HI	FS	Elevation
BM_1	12.64	112.64		100.00
TP_1	10.88	120.41	3.11	109.53

Differential Leveling

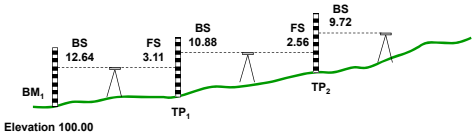
Computation of Elevations – Find Elevation of BM_2



Point	BS	HI	FS	Elevation
BM_1	12.64	112.64		100.00
TP_1	10.88	120.41	3.11	109.53
TP_2			2.56	117.85

Differential Leveling

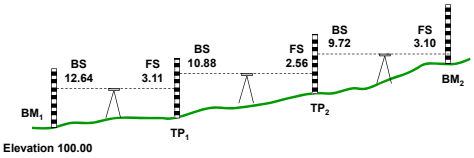
Computation of Elevations – Find Elevation of BM_2



Point	BS	HI	FS	Elevation
BM_1	12.64	112.64		100.00
TP_1	10.88	120.41	3.11	109.53
TP_2	9.72	127.57	2.56	117.85

Differential Leveling

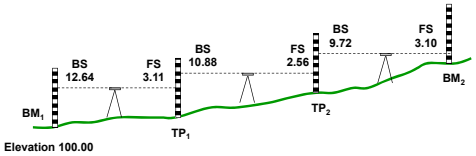
Computation of Elevations – Find Elevation of BM_2



Point	BS	HI	FS	Elevation
BM_1	12.64	112.64		100.00
TP_1	10.88	120.41	3.11	109.53
TP_2	9.72	127.57	2.56	117.85
BM_2			3.10	124.47

Differential Leveling

Computation of Elevations – Find Elevation of BM_2



Point	BS	HI	FS	Elevation
BM_1	12.64	112.64		100.00
TP_1	10.88	120.41	3.11	109.53
TP_2	9.72	127.57	2.56	117.85
BM_2			3.10	124.47

Differential Leveling

Computation of Elevations – Find Elevation of BM_2

Check the summation of the backsight and the foresight with the change in elevation

Point	BS	HI	FS	Elevation
BM_1	12.64	112.64		100.00
TP_1	10.88	120.41	3.11	109.53
TP_2	9.72	127.57	2.56	117.85
BM_2			3.10	124.47
	+33.24		**-8.77**	

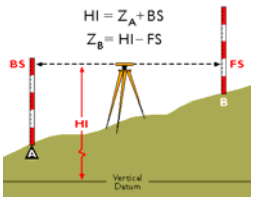
Change in elevation = **33.24 - 8.77 =24.47**

Differential Leveling

- The initial ***backsight (BS)*** is taken to a point of known elevation
- The backsight reading is added to the elevation of the known point to compute the ***height of the instrument (HI)***
- The level may be moved to a temporary point called a ***turning point (TP)***
- The elevation of a point is the ***height of the instrument (HI)*** minus the ***foresight (FS)***

Differential Leveling

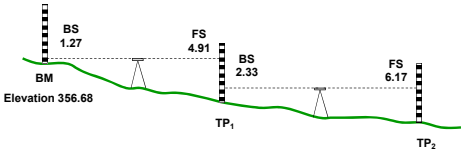
TopHat Problems



Differential Leveling

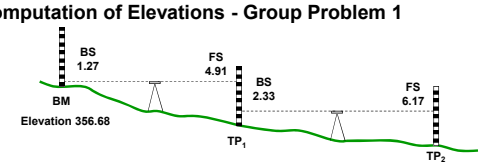
Computation of Elevations - Group Problem 1

Prepare a set of level notes for the survey illustrated below. What are the elevations of points TP_1 and TP_2?



Differential Leveling

Computation of Elevations - Group Problem 1

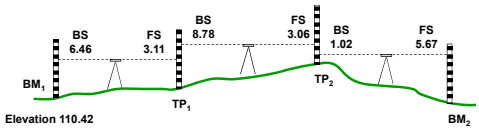


Point	BS	HI	FS	Elevation

Differential Leveling

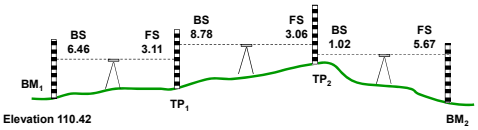
Computation of Elevations - Group Problem 2

Prepare a set of level notes for the survey illustrated below. What are the elevations of points TP_1 and TP_2?



Differential Leveling

Computation of Elevations - Group Problem 2



Point	BS	HI	FS	Elevation

Differential Leveling

Common Mistakes

- Misreading the rod - *reading 3.54 instead of 3.45*
- Moving the turning point - *use a well-defined TP*
- Field note mistakes - *work within your group to check you records*
- Mistakes with extended rod - *make sure the leveling rod is fully extended*

Differential Leveling

Common Mistakes

- Level rod not vertical
- Settling of leveling rod
- Leveling rod not fully extended or incorrect length
- Level instrument not level
- Instrument out of adjustment
- Environment - wind and heat

Differential Leveling

Suggestions for Good Leveling

- Anchor tripod legs firmly
- Check the bubble level before and after each reading
- Take as little time as possible between BS and FS
- Try to keep the distance to the BS and the FS equal
- Provide the rodperson with a level for the rod

Differential Leveling

Any Questions?