Levelling

- Levelling is one the basic surveying measurements
- Other ones are height, angles, distances and together can give 3-D positioning
- Levelling is the process of measuring or setting out a difference in height between two or more points
- When levelling we measure from the geoid height (AHD)
- There are many forms of levelling such as hydrostatic and spirit levelling (the most accurate)

- The height datum Australia uses is called the AHD (Levelling datum)
- It is measured from tide several tide gauges around Australia

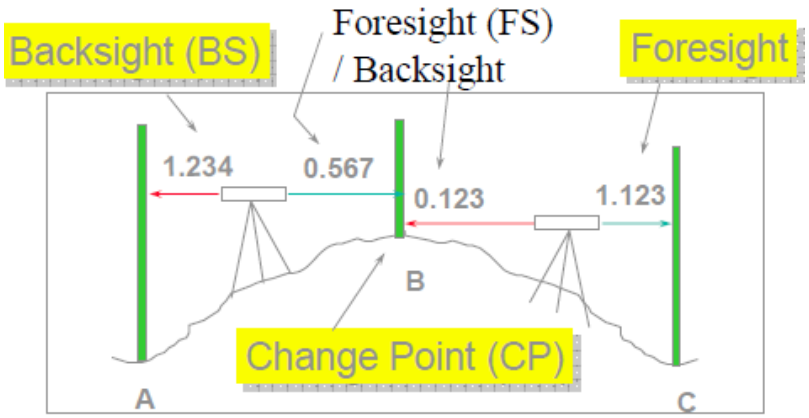
- Geoid is an equipotential surface (mean surface of the Earth)
- Direction of gravity define the vertical line or "plumbline"
- Direction of gravity changes 1" for a horizontal distance of every 30m due to earth curvature
- Plumblines are bend due to the curve of the Earth
- For most engineering projects, this can be ignored as it only covers small portion of the Earth
- Plumbline changes all over the earth due to the Earth's non-sphericity and local mass anomalies (gravity change due to uneven mass

- The principles of spirit levelling are using optical instrument to define a horizontal line
- Graduated staff (ruler)
- "Absolute height" benchmark
- Operational procedure to determine height difference between two points

- There are 3 types of levelling instruments ; tilting (old), automatic, digital (modern)
- Tilting level is essential a telescope with a pivot
- It has a precise spirit bubble to make sure the instrument is level
- It has lower accuracy than the other 3 methods
- Automatic level has no pivot and precise spirit bubble. But a compensator
- The compensator make sure the instrument is levelled and correct any errors, but needs to approximately levelled by the means of the circular bubble
- Digital level is an automatic level which allows measurements to be made electronically by using a barcode staff (possible to use manual measurements)

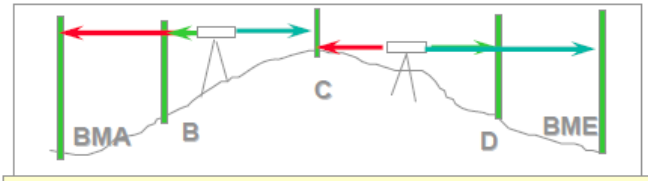
- The telescope often have parallax
- Parallax is the apparent displacement of an object due to being viewed at different line of sights
- To remove parallax, put an object in front of the telescope (30cm – 50cm) and focus
- Keep focussing the cross hairs (aimer or + in the lens view) until BOTH are clear and define at the same time
- If parallax is present, one of the cross hairs will clear before the other

- There are two methods to do spirit levelling ; “Rise and Fall”, “Height of Collimation”
- Spirit levelling is relative so errors are cancelled out
- Back Sight (BS) is the first staff reading observed after setting the level
- Foresight (FS) is the staff reading observed before shifting of the level
- Intermediate Sights (IS) are staff reading observed after BS before FS (between BS and FS)
- Reduce Level (RL) is a point measured from the tide gauges (AHD71) (usually the height)
- Bench Marks (BM) are points with known Reduce Level (RL)

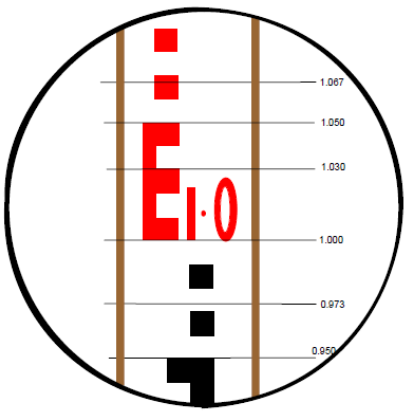


- To use the “Rise and Fall”, we must have an absolute known point, Bench Mark (BM)
- This is recorded on the first RL
- Our first measurement is the Back Sight (BS) and record it
- Then we measure the Intermediate Sight (IS) (or Fore Sight (FS))
- We record on the Remark column where we measured
- We then do the calculations: <u>BS – FS or IS</u> and determine whether rise or fall (Negative or positive value)
- We then add or minus on to the RL and determine the final value
- If we record a measurement that is upside down we record it as a negative value

- There is a check method where we add the BS and separately add the FS
- We then use calculations of BS – FS and value is shown
- Another calculation is done where we get the last and first RL and minus them and obtain another value (<u>Final RL – First RL</u>)
- These two values should equal and it is a check that your arithmetic is correct (Not measuring errors)

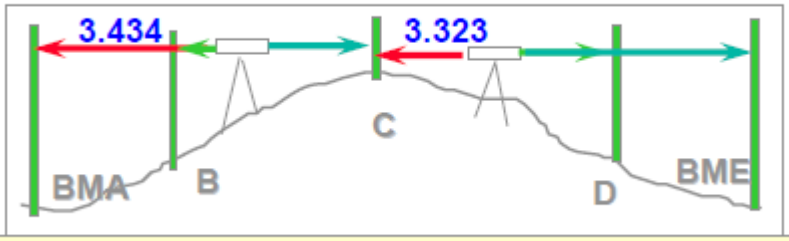


BS	IS	FS	Rise	Fall	RL	Remark
2.191					1.243	BMA
	1.564		0.627		1.870	B
0.342		0.453	1.111*		2.981	C (CP)
	1.845			1.503	1.478	D
		2.134		0.289*	1.189	BME
2.533		2.587	1.738	1.792	1.189	Arithmetic Checks!
2.587			1.792		1.243	
-0.054			-0.054		-0.054	



- To use the “Height of Collimation”, we use the same method as “Rise and Fall”, but we have a column called “Height of Collimation”
- In this column we add the current RL with e Back Sight (BS)
  Ht. of Col. = RL + BS

Height of Collimation Method (U & P pp47)



BS	IS	FS	Ht of Collimation	RL	Remark
2.191			3.434	1.243	BMA
	1.564			1.870	B
0.342		0.453	3.323	2.981	C (CP)
	1.845			1.478	D
		2.134		1.189	BME
2.533		2.587		1.189	
2.587				1.243	
-0.054				-0.054	

- Errors can occur such as misreading staff, instrument out of adjustment, not taking account invert levels and instrument not levelled properly (uncommon with automatic level)
- If the final RL does not match up with the absolute value (Bench Mark), u can have an adjusted RL, where the misclose is evenly distributed and added or minus to the RL
- However, this misclose cannot be too large and must be within the accuracy specification

$$E = \pm C\sqrt{K}$$

where E = allowable misclose in mm
C = constant in mm (3rd order = 12mm)
K = total length of the level circuit in kms

- If there is instrument out of adjustment, a test called “2 peg” is used to fix it
- A instrument is put directly in the middle of two pegs, the error is cancelled when measured
- The instrument is then put behind the two pegs and used to measure the two ruler
- The measurement of the further peg, should a much more recognisable