BAR BENDING AND CONCRETING

Level-II

Learning Guide-20

Unit of Competence: Apply basic leveling Procedures

Module Title: Applying basic leveling Procedures

LG Code: EIS BBC2 M06 LO2-LG-20

TTLM Code: EIS BBC2 TTLM 1019v1

LO-2: Set up and use leveling Device

Instruction Sheet	Learning Guide #20

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Identifying heights or levels to be transferred/established
  - ✓ levelling procedures
- setting-up and testing leveling devices
- Applying leveling staffs
- shooting levels and transferring heights
- Documenting results of leveling procedure.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Identify heights or levels to be transferred/established
- leveling procedures
- set-up and testing leveling devices
- Apply leveling staffs
- shoot levels and transfer heights
- Document results of leveling procedure.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3, Sheet 4 and Sheet 5" in **page -3, 14, 32,40 and 44** respectively.
4. Accomplish the "Self-check 1, Self-check t 2, Self-check 3, Self-check 4 and Self-check 5" in **page - 13, 31, 37, 43 and 49** respectively.

5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3, Operation Sheet 4 and Operation Sheet 5 ” in **page - 50,51,51,52 and 53** respectively.
6. Do the “LAP test 1” in **page – 54** (if you are ready).

Information sheet-1	Identifying heights or levels to be transferred/established

1.1 Introduction to heights or leveling

Leveling is the process of identifying the heights of points on a surface by taking and comparing measurements. It’s possible to discover the height of a mountain with the correct leveling technique.

Identifying elevations (heights) is essential in the construction industry to create or profile the surfaces required when building stable, safe and economical structures of all types including roads, bridges, mines, dams and commercial, community and residential buildings. In this section we’ll look at:

- What levels are
- How leveling is used in building and construction
- leveling methods
- leveling tools.

Earth. It is the process of measuring heights. It is possible when leveling to measure heights with an accuracy of millimeters Heights can also be measured using total stations, handheld lasers and GPS devices.

However, leveling offers an inexpensive, simple and accurate method for measuring heights, and it is widely used in construction sites. Any method of measuring the heights of points above or below the ground using an agreed datum.

level is a measurement of the elevation (height) of a point above or below another point, e.g. the height of the floor of a building above ground or the depth of a sewerage drain below ground.

This datum's or reference points are present in all construction sites and has an arbitrary height assigned to the point. Most construction sites will have several of these benchmarks, and if they have heights based on an arbitrary datum, they are known as Temporary Bench Marks.

- **Heights** are defined using horizontal and vertical lines. The figure below shows a plumb- bob suspended at point P, the direction of gravity along the plumb-line defines the vertical at point P. A horizontal or level line is any line at right angles to this For site work, any horizontal line can be chosen as a datum for heights and for leveling. The height of a point is measured along the vertical above or below the chosen datum.

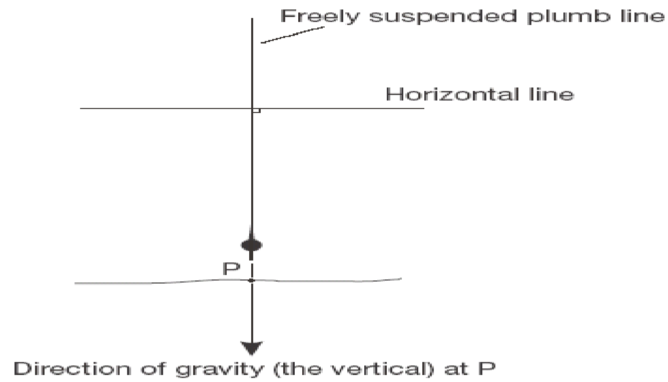


Fig 1.2 plumb- bob suspended to check Verticality

The height of a point relative to a datum is known as its reduced level (RL).On most construction sites there is a permanent datum. The horizontal line or surface passing through this, with its height, becomes the leveling datum. The height of the datum can be arbitrary; a value often used for this is 100.000m. This is chosen to avoid any negative heights occurring. Any reference point on site which has had a height assigned to it is known as a bench mark. For most surveys and construction work, several bench marks would normally be established by leveling from the datum. If heights are based on an arbitrary datum these are known as Temporary Bench Marks or TBM

1.2. Leveling Terminology

Geoid; is a surface coinciding with mean sea level in the oceans, and lying under the land.

Level surface; is a curved surface that at every point is perpendicular to the plumb line.

Level line; is a line in a level surface, therefore a curved line.

Mean Sea Level (MSL): is the average height of the sea's surface for all stages of the tide over a 19 year period.

Datum: is a level surface to which elevations are referred (for instance mean sea level).

Elevation is the vertical distance from a datum (usually mean sea level) to a point or object.

Bench Mark (BM) is a relatively permanent object, natural or artificial, having a marked point whose elevations above or below an Adopted datum is known or assumed (metal disks set in concrete, large rocks, non-movable parts of fire hydrants, and curbs.

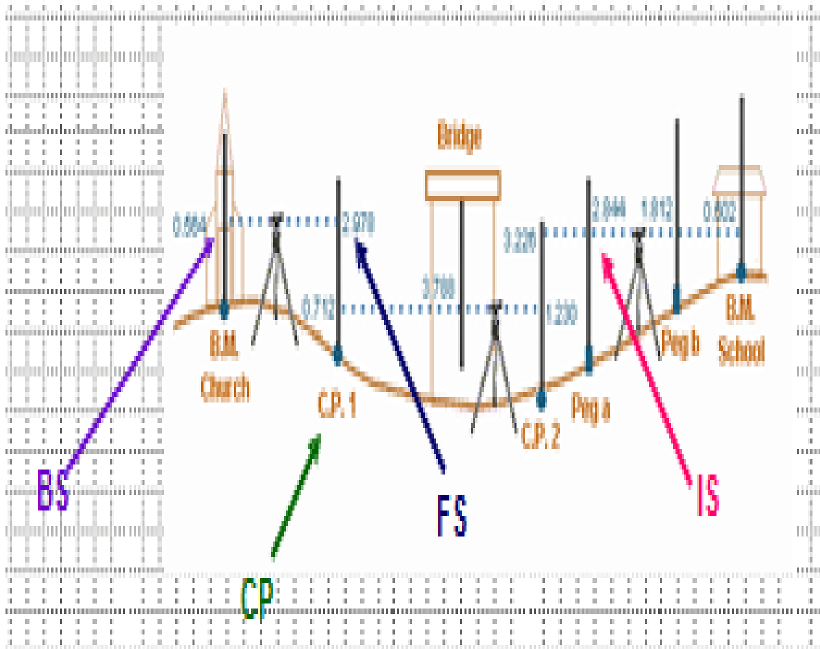


Fig.1.3 sample terms figure

Back sight (BS) – 1st sight taken after the level has been set up. It is also a sight taken to a point whose height above HKPD is known

Foresight (FS) – last sight taken before moving the level. It is also a sight taken to a point whose height is required to carry on the line of levels

Intermediate Sight (IS) – other staff readings taken between BS and FS

Change Point (CP) – the staff position at which a FS and then a BS reading are taken

Reduced level (R.L):- it is the height of points stated with reference to the selected datum for the work in hand.

Instrument station: - is the place where the instrument is set up for observation.

Staff station: - is the place where the leveling is held vertically.

Height of collimation: - is defined as the vertical distance from the datum to the line of sight.

Turning point (T.P):- is the station where a back sight and Foresight readings are taken. It indicates the shifting of Instrument.

Level- is an instrument used to take readings on a staff.

Leveling- is the process of determining the elevations of Points.

1.3. Uses of Leveling

In the context of measurements, leveling is used for the following purposes:

- **Referencing of Points:** To determine and check the vertical stability of the points with respect to reference points (benchmarks) in its immediate vicinity.
- **Connection to GPS Reference Points:** To determine its regional stability and to separate sea level rise from vertical crustal motion, the point should be connected via GPS to reference stations fixed in a global co-ordinate system.
- **Connection to National Leveling Network:** Mean sea level is used to define vertical datum's for national surveying and mapping , hence the point must be connected to the national leveling network. Connection to the network will also allow all points to be connected to each other, providing information on spatial variations in mean sea level.

1.4. Leveling purpose

To provide heights or contours on a plan, to provide data for road cross-sections or volumes of earthworks, or to provide a level or inclined surface in the setting out of construction works and that are;

- Knowing the topography of an area,
- In the design of highways, railways, cannels, sewers, etc.
- Locating the gradient lines for drainage characteristics of an area,
- Laying out construction projects, and Calculating volume of earth work, reservoir etc.

Example

► Elv of B = elv of A ± (HA-HB)

= 1235.53 – 0.59

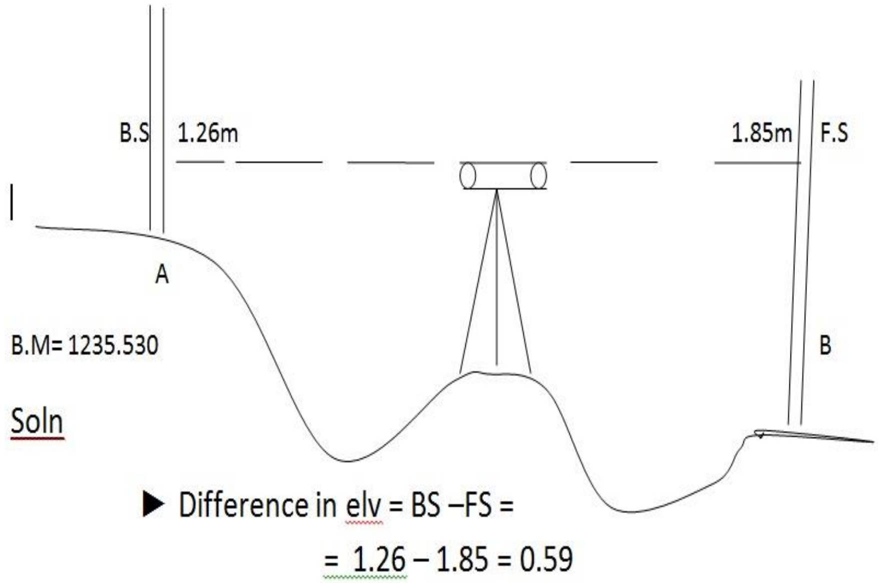
= **1234.940m**

► Check

☞ BS – FS = Last Rl –first Rl

☞ 1.26 – 1.85 =1234.94 -1235.53

☞ **0.59** = **0.59**



1.5. Types of Leveling

There are different types leveling. But in our context we use;

1.5.1. **Geometric Leveling** : In geometric leveling the difference of height between two points is determined by differences of readings to the leveling rod placed on those points. The readings are made with a leveling instrument.

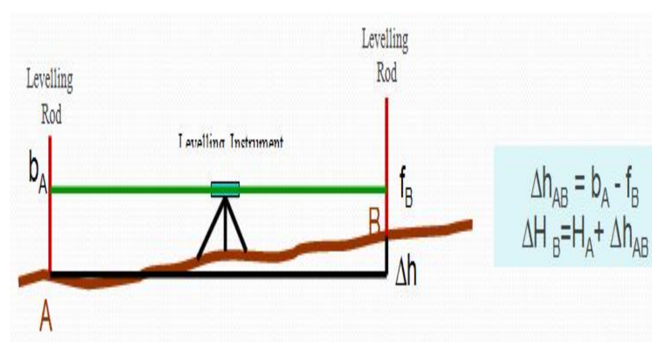
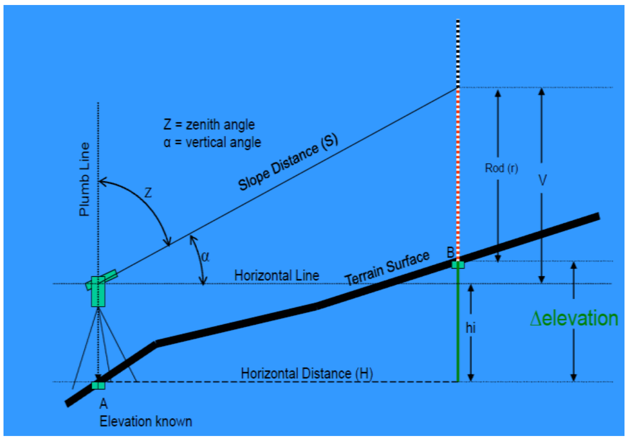


Fig. 1.7 geometric leveling

1.5.2 Trigonometric Leveling : The difference in elevation between two points is determined by measuring distance (slope or horizontal) and vertical angle.



$$V = S \times \sin \alpha \quad \text{or} \quad V = H \times \cot z$$

$$\Delta elevation + r = hi + V$$

$$\Delta elevation = hi + V - r$$

$$H_B = H_A + hi + V - r$$

Fig. 1.7.1 Trigonometric leveling

1.5.3 **Precise Leveling:** is a particularly accurate method of geometric leveling which uses highly accurate levels and with a more rigorous observing procedure than general engineering leveling.

In precise leveling we aim to achieve high orders of accuracy such as 1 mm per 1 km traverse.

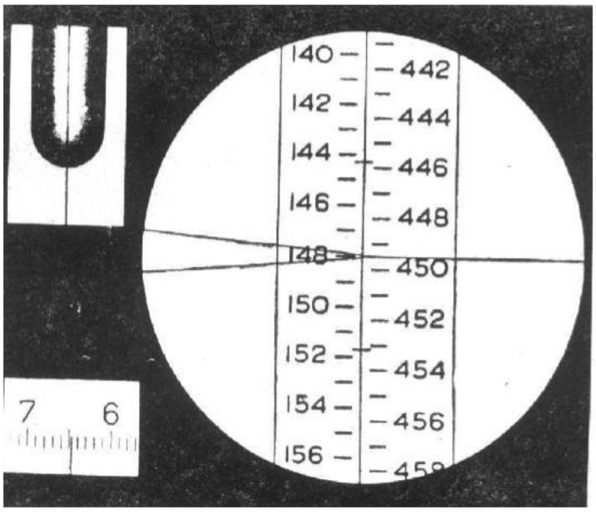


Fig. 1.7.3 Invar rod reading (1.48647)

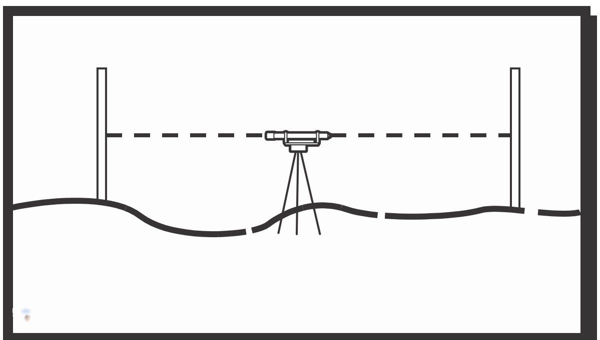
1.6. Methods of leveling

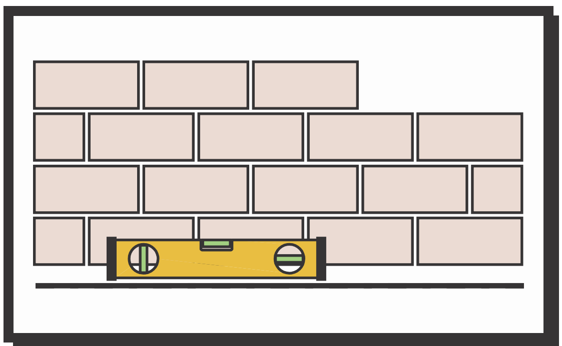
A variety of leveling methods are used for different purposes. They include:

Profile leveling, which involves taking a series of levels along a line, eg when constructing a road Reciprocal leveling, used to determine the levels of two points across an obstruction like a river or chasm by taking measurements from both sides
Trigonometric leveling or calculating angles and distance to determine levels when, for example, one point is inaccessible. On a building site, levels are identified by comparing them to other levels or to a datum.

Simple leveling simple leveling is taking or comparing the levels of two or more points from a single location. It is usually done over relatively short distances.

Simple leveling would be used to, for example, set pegs at a uniform height for a concrete pour (so that a foundation or floor slab will be level) or to ensure that a brick wall remains straight and plumb as it's being built.





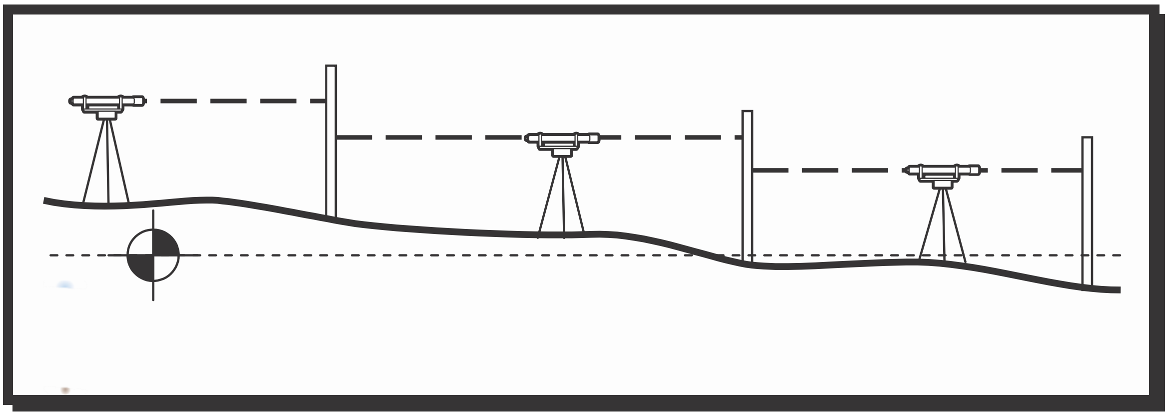
Differential leveling

Sometimes it's not possible to take all the required level measurements from a single point. This can happen when:

- the points are too far apart
- the difference in height between the two points is too great
- there are obstacles obstructing the view between the two points.

Differential levelling is taking levels from different locations and calculating the relationships between the measurements and a datum.

Differential levelling may be used, for example, to take levels around the boundary of a building block, or to transfer a datum or benchmark from one side of the site to the other where there is a significant slope, a structure or natural feature in the way.

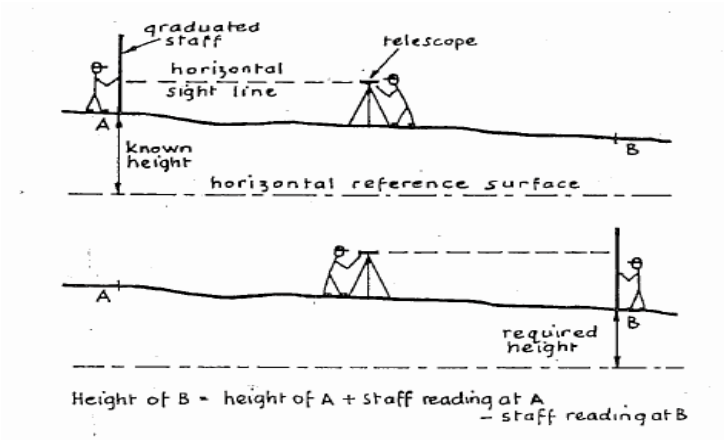


1.7. Basic Rules for Leveling

- Always start and finish a leveling run on a Benchmark (BM or TGBM) and close the loops
- Keep fore sight and back sight distances as equal as possible
- Keep lines of sight short (normally < 50m)
- Never read below 0.5m on a staff (refraction)
- Use stable, well defined change points
- Beware of shadowing effects and crossing waters

1.8. Leveling Procedures

- **Setting up**



✓ Back sight and foresight distances should be approximately equal to avoid any errors due to collimation, refraction or earth curvature.

✓ Distances must not be so great as to not be able to read the graduations accurately.

✓ The points to be observed must be below the level of the instrument, but not lower than the height of the staff. And;

1. The instrument must be check before use!
2. The instrument and level must be stable settled-up
3. The bubble tube must be leveled before the reading

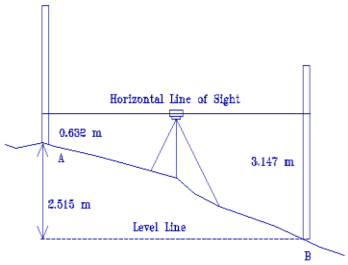


Fig.1.2 setting up leveling

   - Beware of sun exposure (will wander)
   - Ensure the instruments pendulum is in-limit
4. The instrument must be set up in the middle between two staffs
   - Prevents curvature effects
   - If impossible, use the same distances, but opposite for the next readings
5. You must not use the parallax screw between the back sight and foresight readings
6. Readings must be taken 30-50 cm above the ground
   - Surface refractions
   - Beware also of temperature gradients (inside/outside buildings)
7. Staff should be set up vertically
8. A change plate should be used
9. Leveling must be done in two opposite directions but the same line (beware of gravity gradients)
10. Staff should be calibrated
11. Be careful when crossing rivers (large water surfaces)
    - Use “same-time” (mutual) observations
    - Repeat it during different times of the day

- **Elimination of parallax**

✓ Parallax is the apparent movement of the image produced by movement of the observer's eye at the eyepiece.

✓ It is eliminated by focusing the telescope on infinity and then adjusting the eyepiece until the cross-hairs appear in sharp focus. The setting will remain constant for a particular observer's eye.

- **Booking**

- ✓ Level books or loose-leaf leveling sheets shall be numbered and indexed in a register.
- ✓ Details of the site, work, date, observer, chainman, booker, weather, wind, instrument and any other relevant items shall be entered.
- ✓ Enter the first observation (which is on a known point) in the back sight column, and sufficient detail in the remarks column to identify it. Enter the point's r.l. zero from the site register or plate on the bm, etc.
- ✓ Enter all other points on subsequent lines as intermediates except the point chosen as the foresight. Identify them in the remarks column as above. Enter the foresight on a further line in the foresight column.
- ✓ Change the instrument to the next setup. Enter the following back sight on the same line as the previous foresight but in the back sight column.
- ✓ Repeat the above procedure at each setup on the outward run then reverse it to work back to the starting point on the return run. The furthest point out is treated as for all other change points.

Self-Check -1	Written Test

Directions I: **Say True or False** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Reduced levels are relative permanent and fixed reference point of known elevation and after elevation are determined from it.
2. Elevation is the vertical distance from a datum to a point.
3. Bench mark is relative permanent and fixed reference point of known elevation and after elevation is determined from it.
4. Turning point is the station or point where both foresight and back sight readings are taken it denotes the shifting of the instrument.
5. What are leveling procedures?(5points)

Note: **Satisfactory rating - 10 points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _____________________________ Date: _________________

Short Answer Questions

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____

Information sheet-2	Setting-up and testing Leveling devices including checking leveling device tolerance.

2.1. Concepts of setting-up and testing leveling devices

All but the most basic leveling tasks will require the use of an optical or laser level to take precise level measurements of locations on the building site.

In this section you'll find information about:

- The process of setting up an optical or laser level
- taking a reading using a staff
- The types of errors that may affect the accuracy of leveling operations.

The first step in setting up the level is to attach the level itself to the tripod or legs. The level is placed in a location which is fairly open so that a clear rod reading may be obtained on the benchmark. The proper setting of the tripod is very important. The legs of the tripod are required to be spread so that the base plate of the level is approximately horizontal and a stable base is provided. If the ground has a steep slope, two of the legs should be set about the same elevation and lower on the slope than the third leg. The legs are set firmly into the ground and the three wing nuts of the legs just under the head tightened. The tripod is not set on a hard slick surface, such as a hot mix asphalt pavement, concrete pavement, or sidewalk, unless absolutely necessary.

2.2. Types of leveling devices

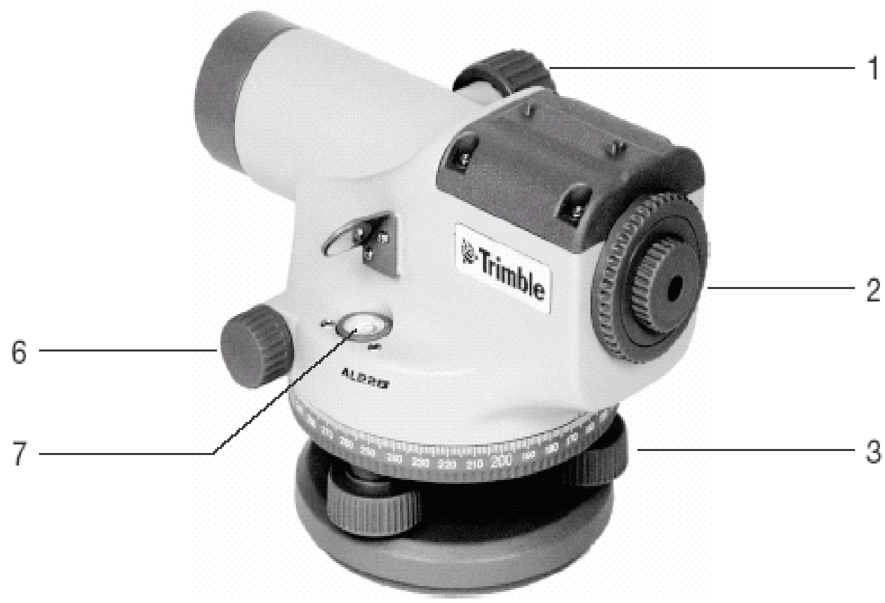
Most common leveling instrument today is the Automatic or Self-leveling level – has an internal compensator that automatically provides a horizontal line of sight and maintains this through gravity (prism hanging on pendulum)Instruments for Leveling: Basically there are different types of levels; namely -Dimply level- Tilting level- Automatic level & - Digital level. Generally there are Four basic level types are available: optical, automatic, electronic, and laser.

2.2.1 Optical level: An optical level is used to project a line of sight that is at a 90 degree angle to the direction of gravity. Both types, dumpy and tilting, use a precision leveling vial to . Orient to gravity. The dumpy type was used primarily in the United States, while the tilting type was of European origin and used in the remainder of the world. The dumpy level has the leveling vial fixed to the telescope, which is fixed at 90 degrees to a Rota table vertical spindle. Leveling screws, attached to the spindle, are used to center the leveling vial.

2.2.2 Automatic level: Automatic levels use a pendulum device, in place of the precision vial, for relating to gravity. The pendulum mechanism is called a compensator. The pendulum has a prism or mirror, as part of the telescope, which is precisely positioned by gravity. The pendulum is attached to the telescope by using precision bearings or wires (metallic or nonmetallic). Leveling screws are used to roughly center a circular vial, and the optics on the pendulum then correct the line of sight through the telescope. Finally, Roughly leveled using a circular spirit level, then internal mechanisms take over to make sure the level remains level and maintains a horizontal sight. They are very popular, quick to set up and easy to use.

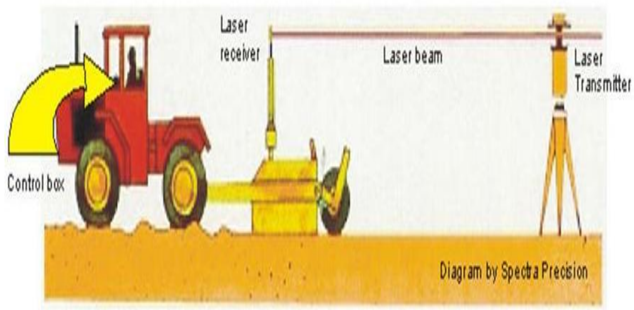
1. Focusing screw
2. Eyepiece
3. Foot screw
6. Tangent screw
7. Circular bubble

Fig.2.2 Automatic level with parts name



4. Horizontal circle
5. Base plate
8. Collimator (sight)
9. Object lens

2.2.3 Electronic level: This type of instrument has a compensator similar to that on an automatic level, but the graduated leveling stall is not observed and read by the operator. The operator has only to point the instrument at a bar-code-type staff, which then can be read by the level itself. The electronic level eliminates human reading error and increases the speed at which leveling work can be performed. The only significant disadvantage is the high cost as compared to the optical automatic level.



2.2.4 Laser level: Although this type of instrument is categorized as laser, these levels actually employ three different types of light sources: tube laser, infrared diode, and laser diode. The instrument uses a rotating head to project the laser beam in a level 360 degree plane. The advantages are twofold: no operator is required once the instrument is set up; and different people in various locations can work by using a single light source. The disadvantages are that accuracy is less than that provided by other types of levels and that the cost is significantly higher.

✓ **Operating Laser levels**

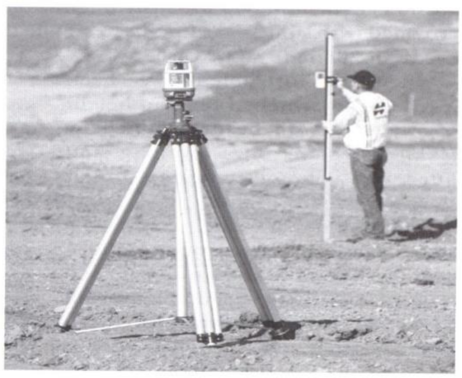
Land Leveling through Laser Leveler is one such proven technology that is highly useful in conservation of irrigation water.

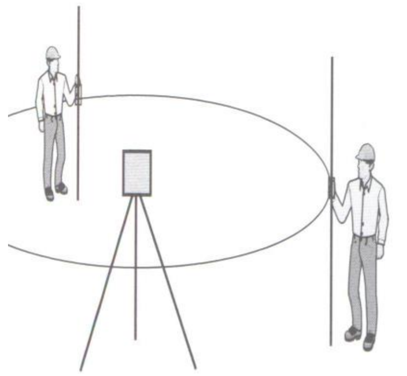
✓ Laser Guided Land Leveling

As per studies, a significant (20-25%) amount of irrigation water is lost during its application at the farm due to poor farm designing and unevenness of the fields. This problem is more pronounced in the case of rice fields. Fields that are not level, have uneven crop stands, increased weed burden and uneven maturing of crops. All these factors lead to reduced yield & poor grain quality.

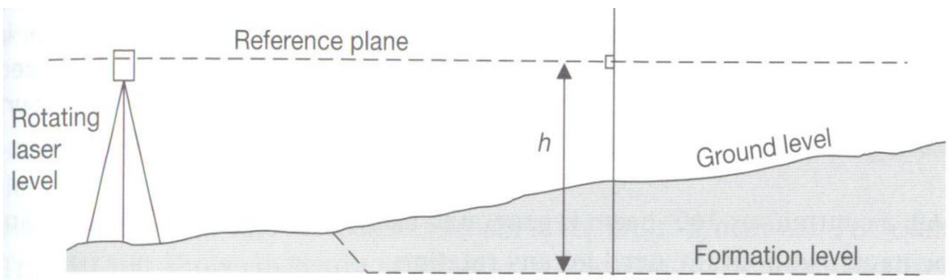
Laser land leveling is leveling the field within certain degree of desired slope using a guided laser beam throughout the field. Unevenness of the soil surface has a significant impact on the germination, stand and yield of crops. Farmers also recognize this and therefore devote considerable time resources in leveling their fields properly. However, traditional methods of leveling land are cumbersome, time consuming as well as expensive

✓ Rotary laser level





A rotary laser level is a more advanced laser level in that it spins the beam of light fast enough to give the effect of a complete 360 degree horizontal or vertical plane, thus illuminating not just a fixed line, but a horizontal plane. Laser levels contain a rotating laser which defines a visible horizontal plane from which distance to the ground can be made and then the height can be determined



The laser beam projector employs a rotating head with a mirror for sweeping the laser beam about a vertical axis. If the mirror is not self-leveling, it is provided with visually readable level vials and manually adjustable screws for orienting the projector. A staff carried by the operator is equipped with a movable sensor, which can detect the laser beam and gives a signal when the sensor is in line with the beam (usually an audible beep). The position of the sensor on the graduated staff, also known as a grade rod, or story pole, allows comparison of elevations between different points on the terrain. Most laser levels are used in the construction industry..

- ✓ **Tower-mounted laser level** A tower-mounted laser level is used in combination with a sensor on a wheel tractor-scraper in the process of land laser leveling to bring land (for example, an agricultural field) to near-flatness with a slight grade for drainage.
- ✓ **Benefits**

- For better distribution of water
- For water savings (reduces the amount of water required for irrigation)
- For Improvement in nutrient use efficiencies
- Option for Precision Farming
- Higher crop productivity
- Reduces weed problems
- Energy saving

2.2.5 Leveling Rods: Can be made of wood, metal, or fiberglass Graduated in meters. Rod levels are used to make sure that the rod is held vertical when making a reading.

2.3 Care of equipment

- Ensure that tripod screws and hinges are kept tight.
- Always transport the level in a padded box.
- When removing from the box lift it by the centre and not by the eyepiece or objective end of the telescope.
- Screw it firmly onto the tripod, whilst holding it in one hand (make certain that it is not cross-threaded and that threads are compatible).
- When carrying the level tripod assembly in the field, support it over the shoulder or, in bush, crooked over an arm with the telescope unclamped (i.e. free to rotate).
- Automatic levels should not be carried in a vertical or near-vertical position, as the compensator will swing about and be prone to damage.
- Staves are too much of a precision item of equipment to be used in place of a slasher, vaulting pole, etc.
- Staves shall be transported in their protective cases to protect the face from damage.
- Wooden staves which become wet should be dismantled and dried out before storing away.
- Any moisture which is evident in an instrument must be allowed to disperse by storing the level out of its case in a warm room. Should it persist after several days the instrument may require specialist servicing?

2.3.1 Setting up procedures the leveling instruments.

A tripod is used as a stable platform to hold the leveling device. To correctly set up and stabilize a tripod, consider the following tips.

- Do not position the tripod legs too far apart or too close together.
- On sloping ground, set the tripod so that one leg is uphill and the other two are downhill on the slope.
- Set up on firm, dry ground that doesn't shift as you walk around.
- Push the tripod's pins into the ground as far as they will go.
- Extend the legs on the tripod so that the tripod is just above chest height (the leveling instrument should be at eye height) as bending down or standing on tiptoe can be tiring.
- Set the top of the tripod as level as possible with the leg adjustment. This will minimize the adjusting that needs to be done with the base plate, adjusting screws or compensating devices and the amount that an automatic or laser level will need to correct itself. And The first step in leveling is to spread the tripod leg, used to support the head part, so that the tripod head is approximately horizontal, the legs should be far enough and they should be pushed to the ground to make the level sable. The next step is to center the bubble by the help of foot screws, latterly targeting & Focusing. I.e.

Spread the tripod → Center the instrument → Targeting → Focusing.

Once the level is set up its important that the line of sight is horizontal. When the foot screws have been used to centralize the circular bubble, it is assumed that the compensator has set the line of sight to be horizontal.

However, most levels are not in perfect adjustment and when leveled their line of sight is never exactly horizontal.

If the line of sight is not horizontal when the instrument has been leveled, the level has a collimation error.

Think about where you're setting up. You may need to leave the instrument there for several hours or even all day. Will it be in the way of vehicles, other workers or members of the public?

Example;

Using an optical level

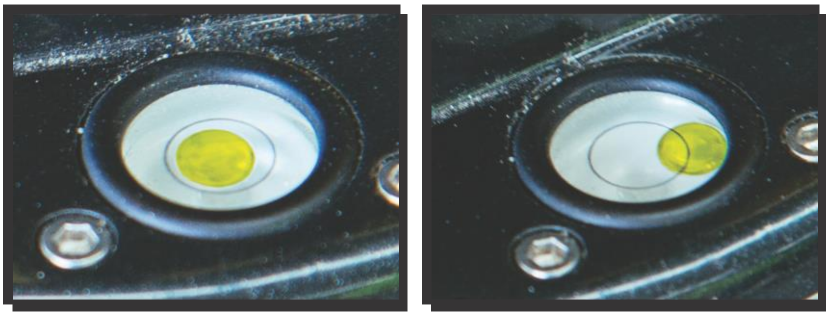
As an optical level is a very simple instrument, there is little difference in the way the various types are used to take a measurement. However, there are variations in the process of setting up and adjusting the instrument for accuracy.

The following information relates to the simple, automatic levels commonly used in building and construction.

Setting up

1. Mount the leveling instrument on the tripod and, if necessary, make manual adjustments to ensure that it's level.

a) Use the base plate adjustment screws to bring the bubble in the attached spirit level into the center.



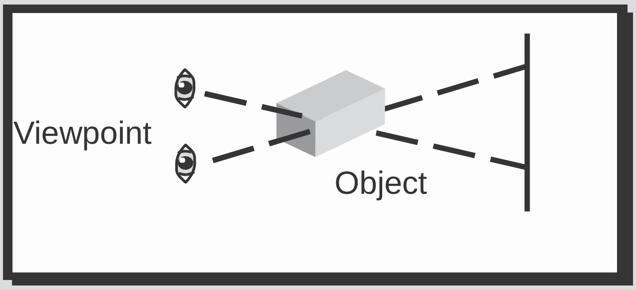
b) Swing the optical level around 180° and center the bubble again.

c) Return the optical level to the starting position and recheck the bubble. Adjust as necessary until the optical level is accurate in all directions. As long as the bubble in the circular level is central, the automatic compensators will make the necessary fine adjustments.

2. Look through the eyepiece of the optical level towards the leveling staff. Turn the focusing knob (clockwise or anticlockwise) until the details of the staff are clean.

3. Adjust the eyepiece (by turning clockwise or anticlockwise) to eliminate parallax error.

Parallax error



Background

Parallax is the difference in the perceived position of an object viewed along different lines of sight; that is, as you can see above, the background behind the object will seem to be in a different position.

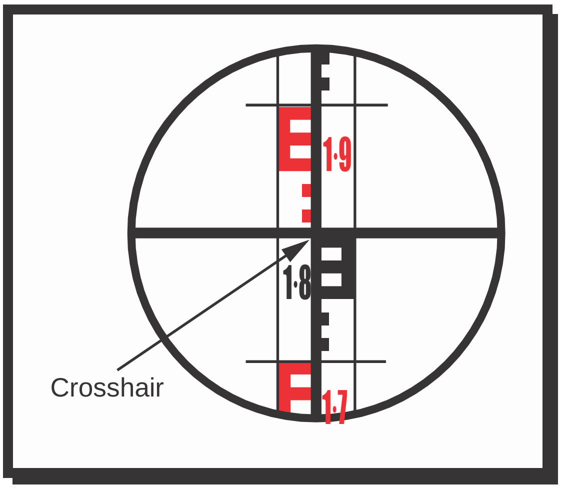
Hold an object in front of your face at eye level. Look at it with one eye closed then the other eye closed. What do you notice?

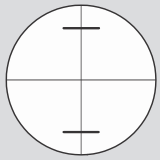
When you look through an optical leveling instrument, parallax error will distort your view of the markings on the staff.

You can check for this error in an optical level by moving your eye up and down in front of the eyepiece. If the crosshairs (the marks on the telescope glass) appear to move in relation to the view in the telescope, parallax error is present

Taking a reading

When you look through an optical level, you'll see a horizontal line and a vertical line creating a crosshair. When you look at the staff, the level reading is the measurement at the exact centre of the cross, as pictured here.





There are two short, parallel lines at the top and bottom of the view. These are called **stadia lines**. These lines are used to measure distance.

You will look at that process in Section 6.

Using a laser level

Laser levels vary from make to make and model to model. Before you use a laser level, read the manufacturer’s instructions to familiarize yourself with that particular instrument.

The following information is a basic guide to setting up and taking level readings with a rotating laser level as these are the most commonly used on Australian building sites.

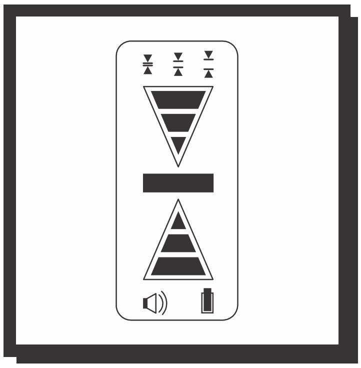
Setting up

1. Securely mount the laser level on a tripod or suitable surface.
2. Press the power button on the instrument, allowing enough time (approximately 60 seconds) for the laser to self-level. The laser head may begin to rotate before the self-leveling is complete.
3. Select the required rotation speed.

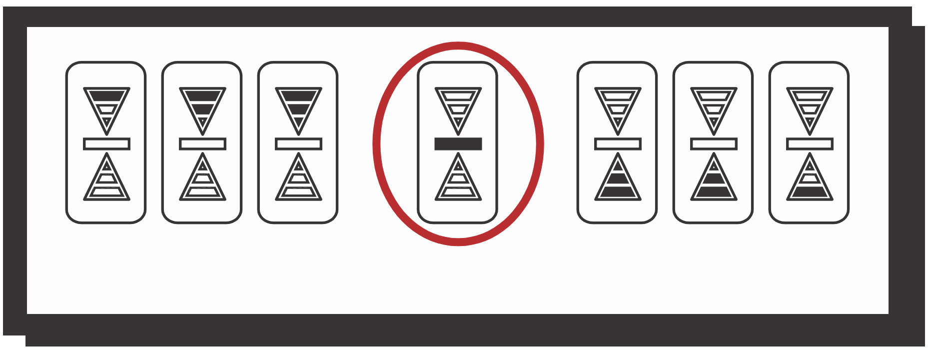
Taking a reading

1.Mount the laser receiver on the staff at the measurement position, turn it to face the laser beam then press the receiver’s power button.

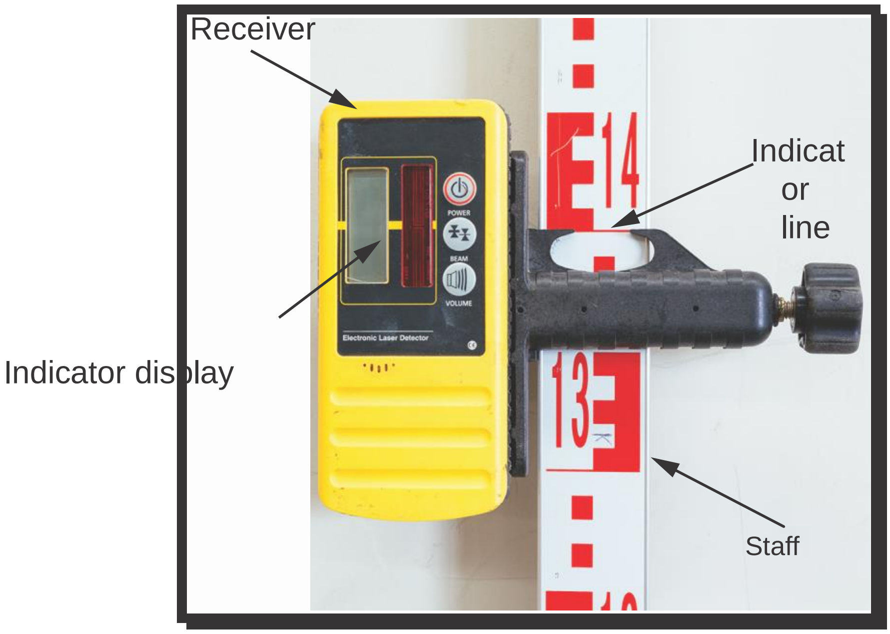
2.Slowly move the receiver in an upwards and downwards direction until the laser beam indicator arrows appear and you hear an audible signal.



3.Using the indicator as a guide, move the receiver up or down until the centre line lights up and you hear a continuous sound. This shows you that the laser beam is Move receiver **down the staff precisely level with the receiver.**
Move receiver **up** the staff



4. Lock the receiver into place on the staff and read the measurement at the indicator


Receiver
Indicat
or
line
Indicator display
Staff
POWER
BEAM
VOLUME
Electronic Laser Detector
14
13

2.3.2. Checking the level's accuracy

Levels can move out of adjustment so that their line of sight (line of collimation) is not truly horizontal. This will cause errors in readings which become greater as the viewing distance increases. However if a back sight and a foresight are exactly equi-distant from the instrument, the error in each sighting will cancel each other out. This feature can be used to check the accuracy of a level by the following simple method which is depicted in figure below.

- install three pegs or marks firmly in the ground at distances of 30 m apart in a straight line; the center peg is only to mark the distance, but the outside two shall be firm enough for reliable change points
- set up the level over the center peg and read the staff on each of the outside pegs in turn. Book these values and calculate the height difference. This will be a true height difference, as the distances are equal and any errors will be self-compensating
- set up the level about 4 m to the far side of one of the outside pegs. Read the staff on the peg 4 m away and then on the one 64 m away. Book these values and calculate the apparent height difference
- compare the two height differences; if the instrument is in adjustment (i.e. its collimation is true) they will be within 5 mm.

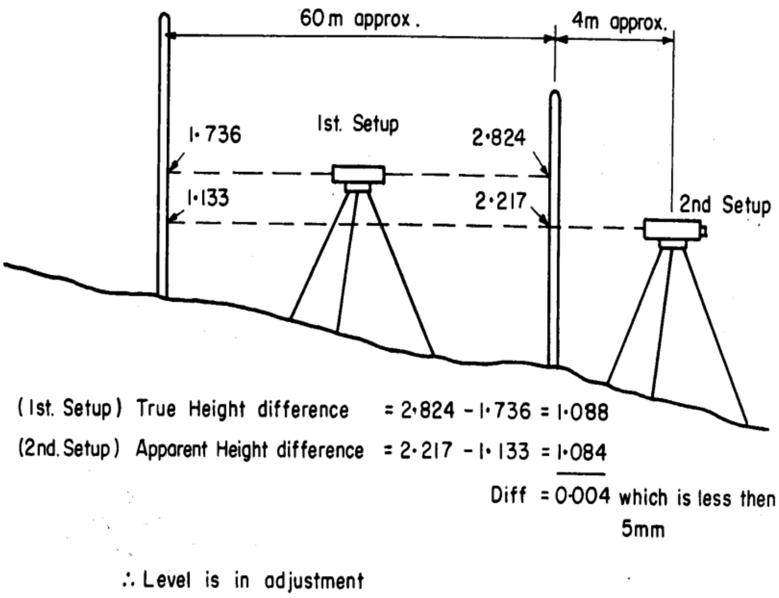


Figure *A method for checking the level accuracy*

If the instrument's collimation appears to be out, recheck by repeating the process. Then, whilst setup at one of the outside locations, adjust the instrument (according to the manufacturer's instructions) so that it reads the correct value on the far staff, checking it against the near one. Two staves are useful for this.

This type of level check shall be carried out at least once per year, preferably just prior to carrying out a round of station inspections. The details and results of the checks shall be recorded in a numbered level book and be readily retrievable as a quality record, and the date of this calibration check shall also be recorded in the instrument inventory.

Example-2

Setting up Leveling devices

• Start by placing the tripod over the point with the legs spread and extended about halfway.

• You want to have the plate as level as possible.

Figure4. Placing tripod

• Mount the instrument in the center of the plate with the shape of the instrument bottom plate and the tripod plate shape aligned

• Coarsely level the instrument by adjusting the leg length of the tripod. When looking at the level bubble, the bubble being to that side indicates the high side

Figure5. Adjusting the instrument

• Adjust the instrument by adjusting the leveling screws.

• The bubble is approximately centered by using the thumb and first finger of each hand to simultaneously adjust the opposite screws.

• Rotate the telescope by 900 and adjust the remaining leveling screw until it is precisely c

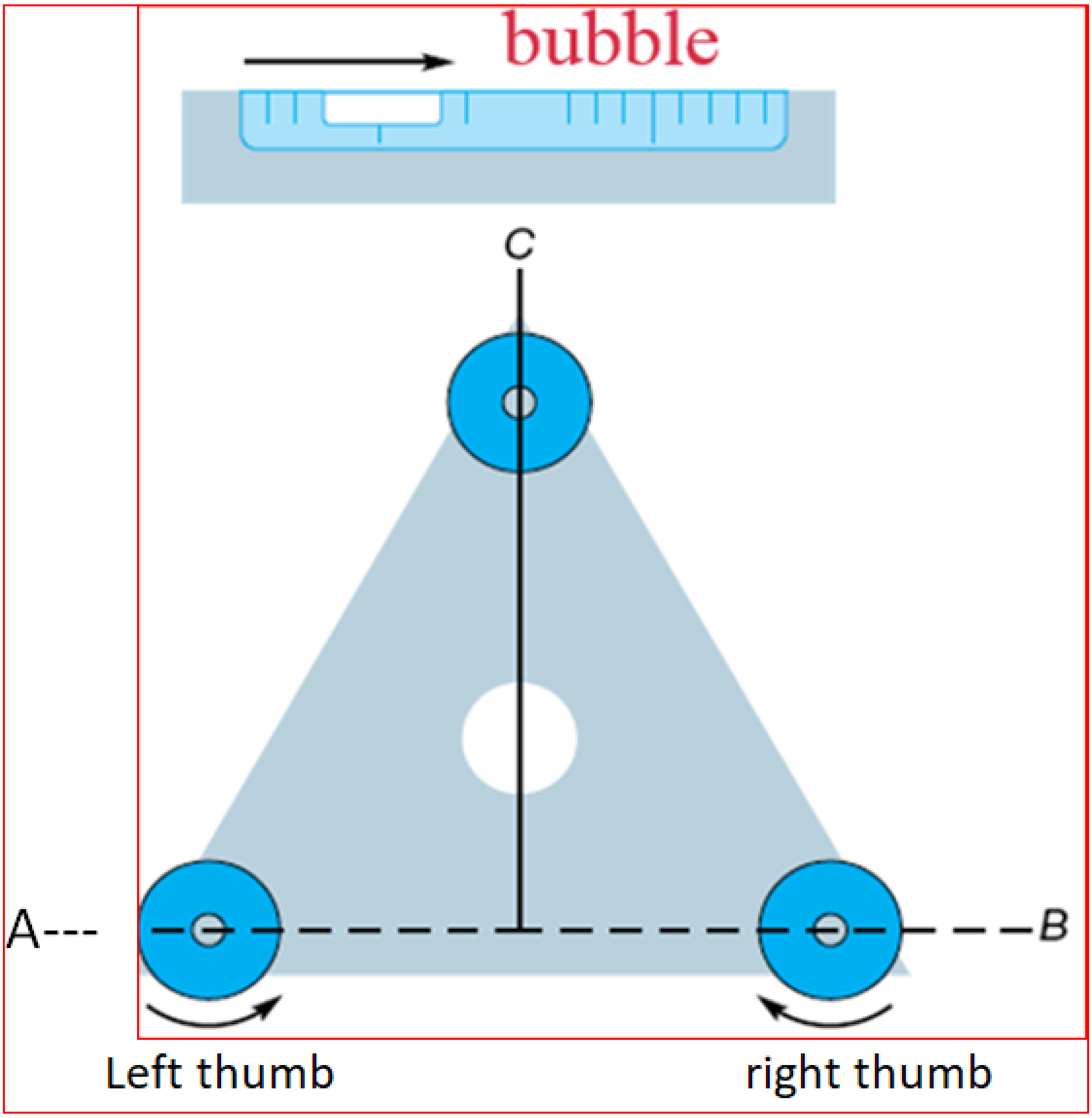


Figure6.the sign of fully adjusted equipment

A bubble follows the left thumb when turning the screws

2.4 Levelling device tolerance checks

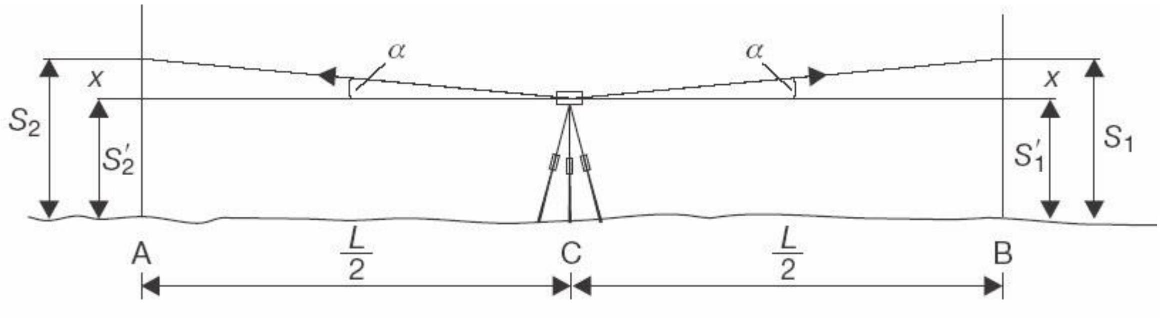
As most levels will have some level of collimation error, a method is required to check. if the error is within acceptable limits. This is known as a **two-peg test**. This needs to be conducted when using a new or different level for the first time and at regular intervals thereafter.

Two peg test

Stage 1

On fairly level ground, two points A and B are marked a distance of Lm apart. In soft ground, two pegs are used, on hard surfaces nails or paint may be used.

The level is set up midway between the points at C and carefully leveled. A leveling staff is placed at A and B and staff readings S1 (at B) and S2 (at A) are taken.



The two readings are:

S1 = (S_1' + x) and S2 = (S_2' + x)

S_1' and S_2' are the staff readings that would have been obtained if the line of collimation was horizontal, x is the error in each reading due to the collimation error, the effect of which is to tilt the line of sight by angle α.

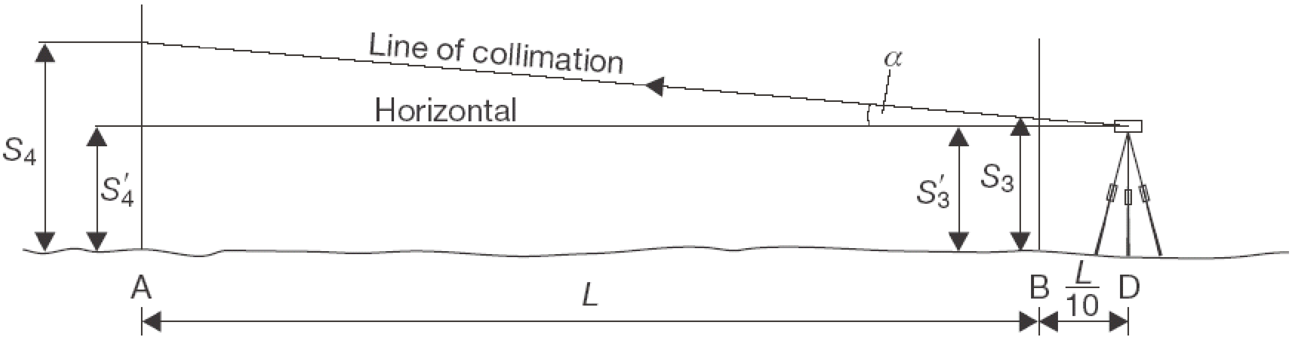
Since AC = CB, the error x in the readings S_1 and S_2 will be the same. The difference between readings S_1 and S_2 gives:

$S_1 - S_2 = (S_1' + x) – (S_2' + x) = S_1' - S_2'$

This gives the true difference in height between A and B. This demonstrates that if a collimation error is present in a level, the effect of this cancels out when height differences are computed provided readings are taken over equal sighting distances.

Stage 2

The level is then moved so that it is L/10m from point B at D and readings S_3 and S_4 are taken.



The difference between readings S_3 and S_4 gives the apparent difference in height between A and B. If the level is in perfect adjustment then: $S_1 - S_2 = S_3 - S_4$

However this is not always the case and that an error term (e) needs to be estimates

e = (S1 – S2) – (S3 – S4) per Lm

If the results of these tests show that the collimation error is less than 1mm per 20m (or some specified value). If the collimation error is greater than this specified value then the level has to be adjusted. This is normally done by the manufacturer or a trained technician.

Example

Readings obtained from a two peg test carried out on an automatic level with a staff placed on two pegs A and B 50m apart are:

Staff reading at A = 1.283m Staff reading at B = 0.860m

With the level position 5m from peg B (L/10):

Staff reading at A = 1.612m Staff reading at B =1.219m

Calculate the collimation error of the level per 50m of sighting distance

Solution

S_1= 0.860M S_2 = 1.283M S_3 = 1.219M S_4 = 1.612M

e = (0.860 – 1.283) – (1.219 – 1.612) per 50M

= (-0.423 – (-0.393)) = -0.030M per 50M

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What are the concepts of leveling devices? (3 points)
2. What is leveling setting up? (3 points)
3. Write the safety of leveling. (3 points)
4. Discuss the methods of two-peg checking? (3 points)

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

1. ---

2. ---

3. --

4. --

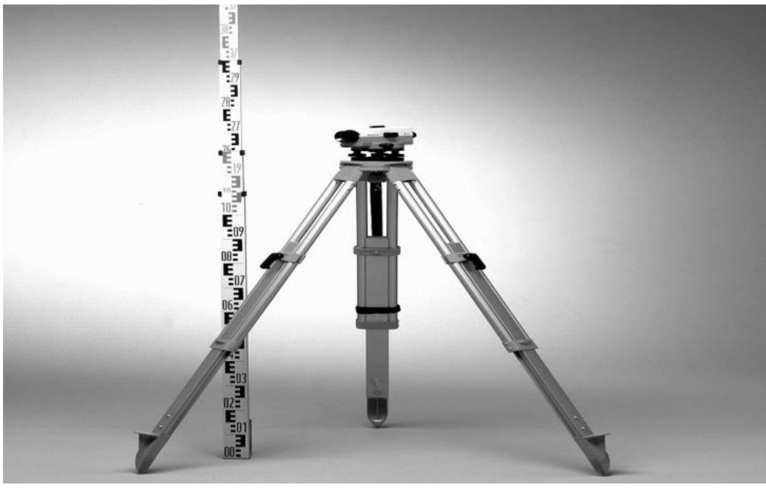
Directions II: Answer all the questions listed below.

Choose item: chose the correct alternative and write letter of the correct answer on the provided answer sheet (6 points)

1. ----------------- is used to project a line of sight that is a 90 degree.
   A. Electronic level
   B. Automatic level
   C. Optical level
   D. Laser level
2. A staff carried by the operator is equipped with-----------------
   A. Sprit level
   B. Plumb bob
   C. Movable sensor
   D. No answer
3. ---------------- is used to make sure that the rod vertical when making a reading.
   A. Laser level
   B. Rod level
   C. Electronic level
   D. Optical level

Information sheet-3	Applying Leveling staffs accurately

3.1 concepts of leveling staffs

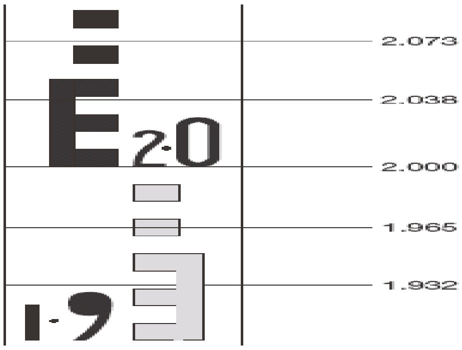


To take a precise level reading, you use a staff to measure elevation in meters to three decimal places, eg 1.255; that is, the meters and tenths, and hundredths and thousandths of a meter. While there is a variety of staffs available, the E-staff is the most commonly used on construction sites.

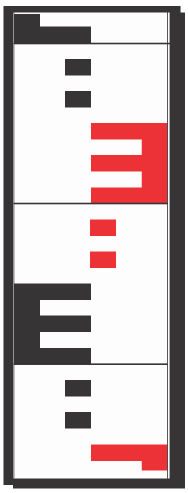
3.2 Leveling staff and accessories

Leveling rods are manufactured of metal, wood, or fiberglass. They are graduated in feet or meters and can be read directly to the nearest tenth of a foot or centimeter. For less precise work, an extendable or folding rod may be used. The sole of the rods are made of a metal base, machined for accuracy. Precise rods have a built-in circular bubble level to maintain the plumb of the rod. Placing the rod on a stable, consistent surface and maintaining plumb are keys to completing accurate, differential-leveling measurements.

- **Reading an E-staff**



An E-staff has a series of ‘E’ shapes printed at set intervals along its length, with two small squares between each. These shapes are used like the lines on a ruler or tape measure but are easier to see at a distance.



Many types of staff are used with varying lengths and different markings. The E-type face is commonly used in the UK,I re land and over the worlds. This can be read directly to 0.01m and by estimation to the nearest mm.

The staff must be held vertically – a circular bubble is sometimes Fitted to help this.

Note: The design and color of the staff can vary; however,

most staffs use a combination of black and red with an alternating pattern of E-shapes

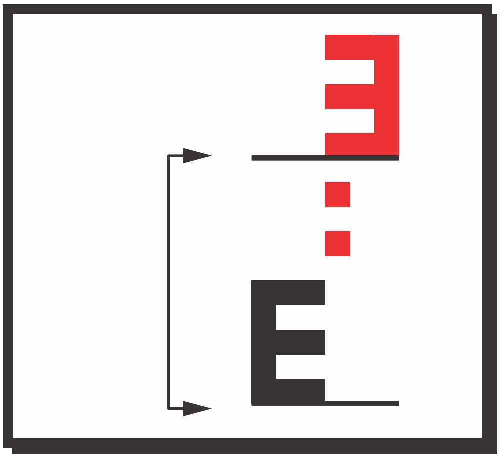
The staff is initially divided into **meters** and **tenths of meters** (100 mm).

These are labeled with a number with a decimal point.

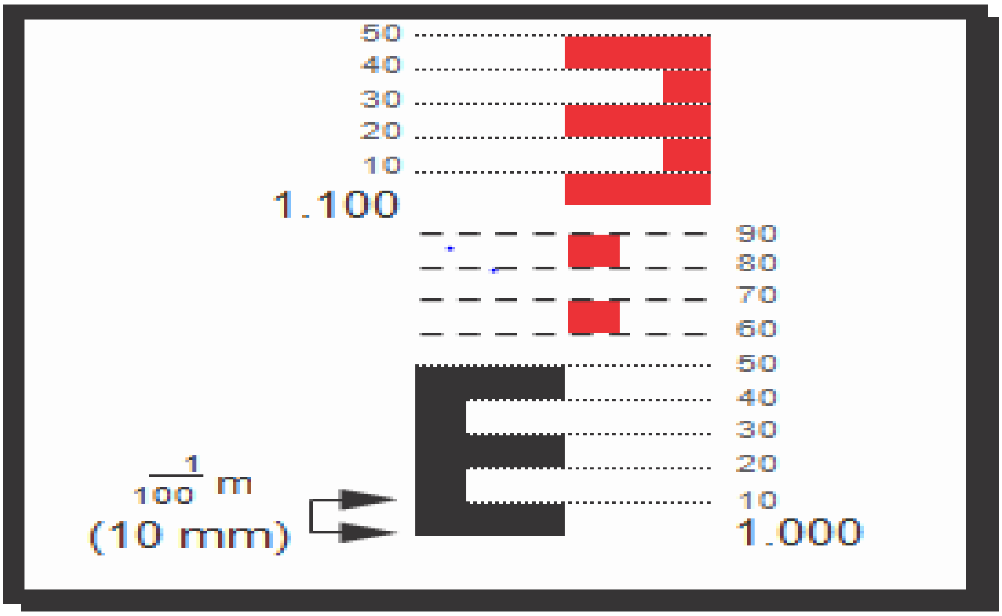
The measurement line always lines up with either

the bottom or top of each E-shape.

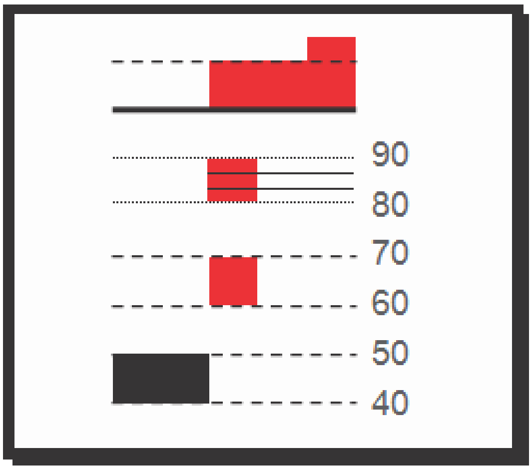
Each vertical block of color (and space between) in the shapes is **one hundredth of a meter** (10 mm) high. There are 10 separate blocks of color (and space) between each numerical label (10 × 10 mm = 100 mm).



Note: You will notice that each E-shape is 50 mm (5 × 10 mm).

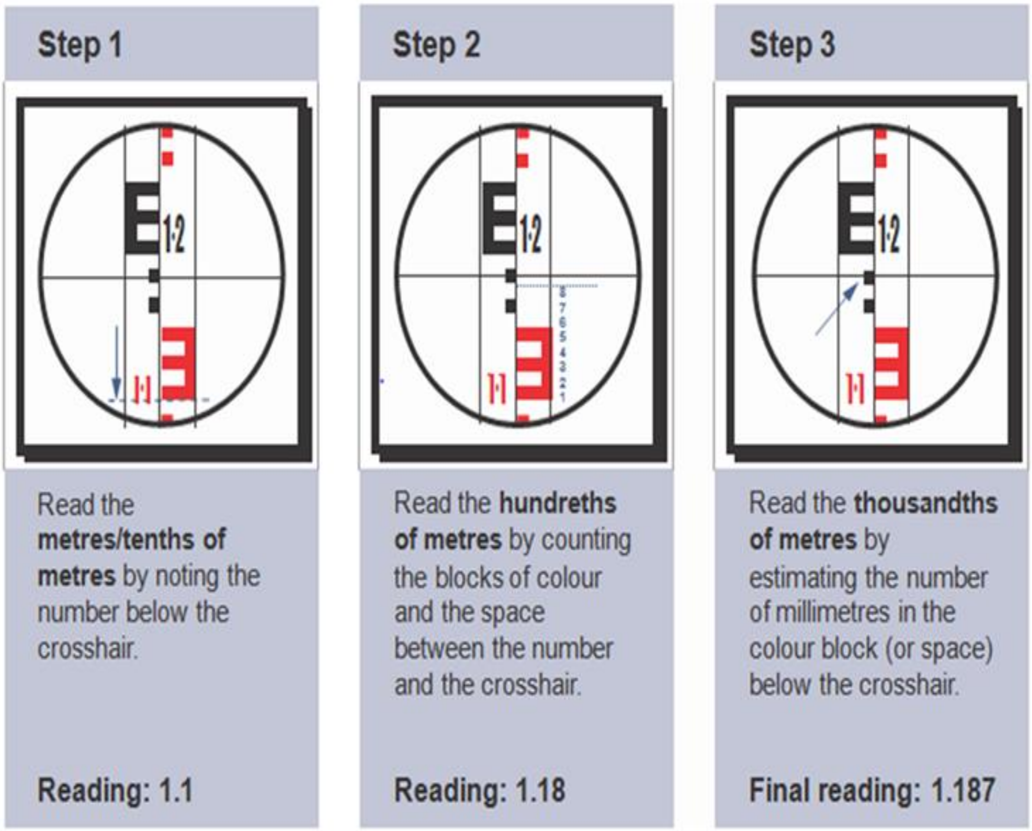


As each block is 10 mm high, the **thousandths of metres** (1 mm) can be estimated by dividing each colour block (or space) into 10.

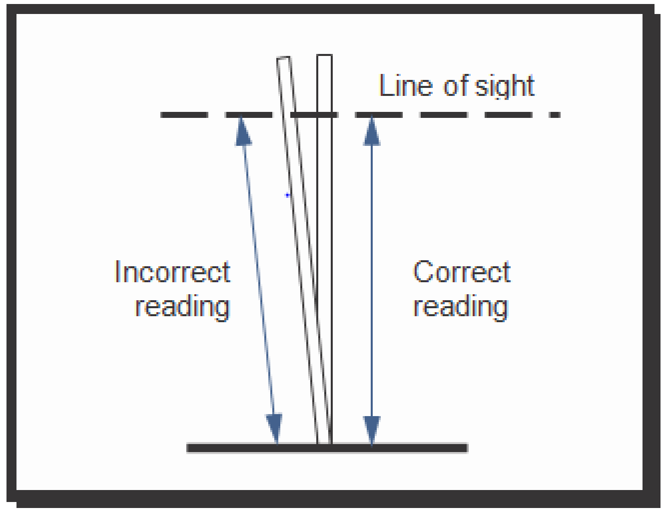


The process for taking a level reading on an E-staff is completed in three steps.

The process for taking a level reading on an E-staff is completed in three steps.



3.3. Holding a staff



Taking a level with an optical leveling instrument usually requires an operator to look through the telescope and take the reading, and an assistant to hold the staff at the measurement point.

A land surveyor's assistant is also known as a chain person because surveyor's measure distances with a special type of chain rather than a tape.

The most important aspect of holding a staff is making sure it's plumb (vertical). If it's leaning in any direction, the crosshairs will appear to be further up the staff and the reading will be incorrect.

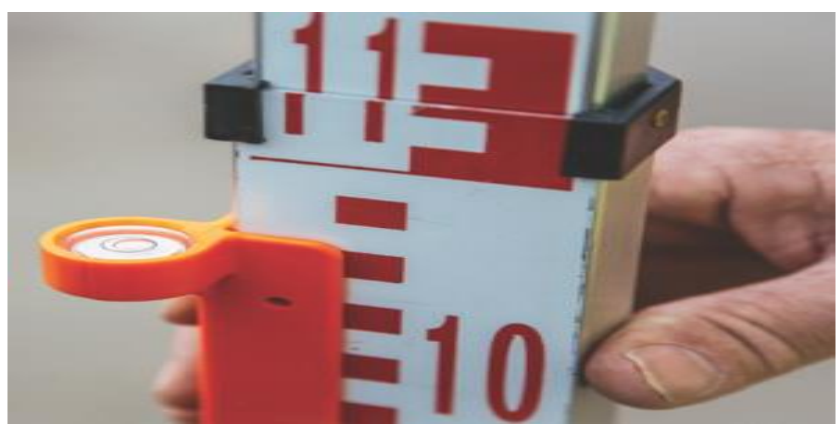
If the assistant stands behind the staff, neither the assistant nor the instrument operator can tell whether the staff is vertical from the side.

Note: The movements of the staff in this direction are generally referred to as 'fore and aft'.

If the assistant stands to the side of the staff, they can tell if it's vertical 'fore and aft', while the instrument operator can see if it's vertical the other way.

- **Staff level**

You can buy a small circular level that's made especially
for keeping the staff vertical. It's held against the staff and
the assistant holds the staf



- **Communication**

Good communication is essential in all construction tasks because, in most situations, you'll be working with a partner or a team.

The challenge of communicating while completing a leveling task is that you will usually be working some distance from your partner on a noisy worksite. Leveling instrument operators and their assistants traditionally use hand signals to pass messages to each other.

While some hand signals are simple and common to most worksites, there is no standard set used across the construction industry in Australia. So you must always make sure that you and your partner or team agree on the signals to be used when you're carrying out leveling tasks.

Self-check 3	communication

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. **Look at the signals used in these photographs. What do you think they mean?**

2.

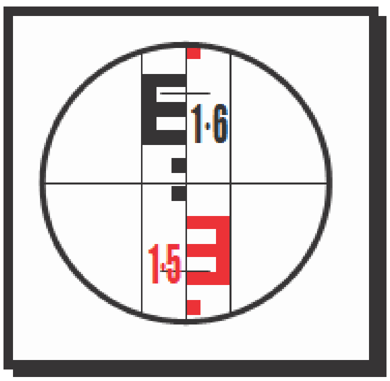
self Taking level readings

Your lecturer will identify positions in your classroom or workshop for you to take level measurement readings. Record each reading in this table.

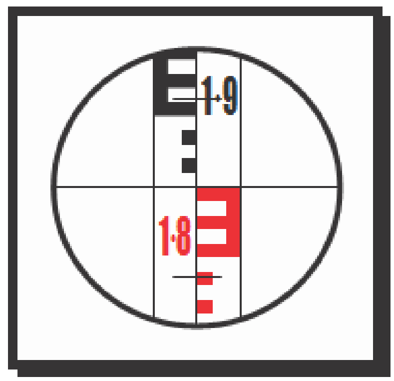
Location name/number	Staff reading

3. Level readings

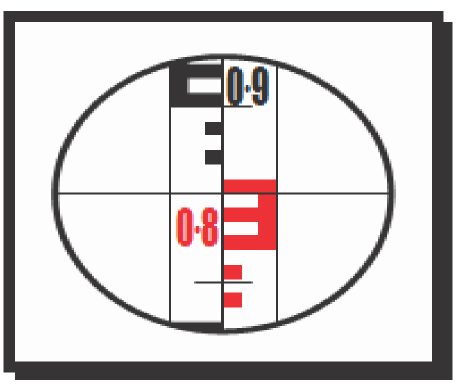
Read the metres and tenths, and hundredths and thousandths of metres on these staff sights.
Write the level measurement reading below each image.



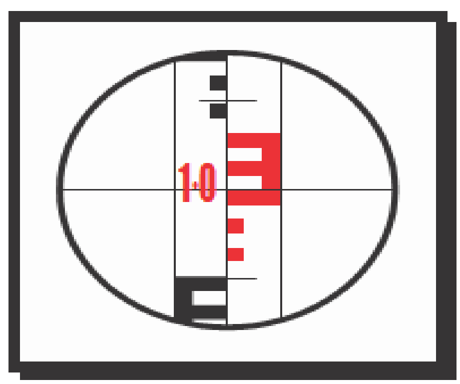
Reading: ______________________________



Reading: ______________________________



Reading: ______________________________



Reading: ______________________________

Note: **Satisfactory rating – above 6 points** **Unsatisfactory - below 6 points**

Answer Sheet

Score = ___________
Rating: ____________

Name: ___________________________ Date: _________________

Short Answer Questions

1____

Information sheet-4	Shooting level and transferring heights

4.1 Concepts of Shooting level and transferring heights

Shooting mark is the process of testing the elevation of a construction project in order to level or slope it. Shooting mark properly is critical to every surface of construction including excavation, pipe laying and forming footers and foundations. The importance of shooting grade and leveling or sloping the ground in accordance to the plans can not be overstated. It affects a project from the ground up. As important as it is, shooting grade is simple.

4.2. Importance of shooting

A survey elevation shot, an important tool in both engineering and construction, determines the elevation of an unknown point by referencing a known point, called a benchmark, or BM. A survey elevation shot achieves this by measuring vertical distances between different points by reading a leveling rod through the cross-hairs of an engineer's level. Surveyors use this process in topographic surveys and road, house and sewer construction. This task requires a partner to hold the leveling rod.

4.3. Necessary steps

Step 1

Find a point of known elevation -- a benchmark, or BM -- to which you will reference your survey elevation shots. You can use any object or point as a reference provided you know its exact elevation.

Step 2

Label five columns in your field book with the headings Back-Sight (BS), Height of Instrument (HI), Fore-Sight (FS), Elevation (ELEV) and Description (DESC).

Step 3

Fasten the engineer's level to the tripod with the fastening screw and level it using the fine leveling screws. Set the level up in a location where you can see both the BM and the area in which you wish to determine an elevation.

Step 4

Instruct your partner to hold the leveling rod vertically on the BM. Sight the rod with the engineer's level and record the reading in the field book. This is your BS. To determine the HI, add this reading to the BM elevation and record this number in the field book in the ELEV column.

Step 5

Instruct your partner to move the leveling rod to the other points where you wish to determine elevations. Record the readings of the leveling rod under FS in the field book. Include a description in the column labeled DESC for each point that will allow you to recall which FS corresponds with each location.

Step 6

Subtract the recorded FS from the recorded HI. Record the values in the ELEV column of your field book. You now have elevations of each point on which you have taken a shot.

4

4.4. Examples shooting for buildings

Step 1

Set up the tripod of the laser level or transit; spread the three legs, each an equal distance from the other two. Put the laser level or transit on top of the tripod. Level the base of the tripod using the three bubble levels as indicators. Adjust the knobs on the base, in conjunction with one another, until all three bubbles are within the marks indicating level.

Step 2

Position you partner within the building site or in the pipe trench. Direct her to raise or lower the receiver on the grade rod. When the receiver is at elevation with the laser level's eye, it delivers a constant beep. If the receiver is too high or low on the grade rod, the beep is broken with intervals of silence. For a transit, simply read the elevation on the rod through the transit and record the value.

Step 3

Set the grade rod at different locations on the site. Record whether the ground, concrete forms or trench are above or below the original reading. Inconsistencies in grade require further excavation. Consistency is typically within 1/24 of a foot, or half an inch. Trenches for gravity fed lines have a constant fall, at least 1/8 inch per foot. Use the grade rod to test the fall.

Self-Check -4	Written Test

The following steps are taken when using a level to measure heights from shooting;

1. Set up the tripod
2. Ensure the top is level
3. Push legs firmly into the ground
4. Attach level
5. Use foot screws to centralise the circular bubble
6. Test to see if the compensator is working
7. Remove parallax
8. Read from marks BS and FS

To understand more, please Click Here for my how to level ground with a laser level guide

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. what are the necessary steps for shooting leveling?

Note: **Satisfactory rating - 10 points** **Unsatisfactory - below 10 points**

Answer Sheet

Name: _________________________ Date: _______________

Score = ___________
Rating: ____________

Short Answer Questions

1____

Information sheet-5	Documenting results of leveling procedure

5.1 Documenting results of leveling procedure

Results of leveling procedure Documenting are the record of work done in the field. They contain the complete graphic, written (or combination thereof) survey records which depict each step of the activities. Results of leveling procedure notes should be recorded on suitable forms, special notebooks or in digital format. They should enable knowledgeable persons to interpret and use the survey and its results, and to retrace the footsteps of the surveyor. Field notes are not an accessory to the survey; they are an integral part of the survey. A survey is never completed until field notes are submitted, checked, and filed.

5.2. Forms of Field Notes

STA	BS	HI	FS	ELEV

Sum BS – Sum FS = Difference of Elevation

5.3. Responsibility of recorder

The recorder is responsible for all documentation during the survey; completes all note forms properly; ensures that all requirements are satisfied; ensures that calculations and checks are performed without errors and expeditiously and that all technical specifications have been satisfied; and prepares the description of BMs and any supplemental vertical-control points.

5.4. Important of Field notes

Field notes perpetuate a survey even when dangers have rotted and monuments are eliminated. Good field notes make it possible to re-establish lost monuments or other measured data. Conversely, incomplete, illegible or incorrect field notes cause the time and money invested in the survey to have been wasted.

Field notes of boundary or right-of-way surveys, together with diaries and survey crew reports, are important documentation in court cases arising between the department and landowners or contractors.

Field notes are the means of communication between field and office personnel. The office personnel should be able to understand and process the data without needing additional explanations. In view of the importance of the field notes, the duties of notekeeping should always be assigned to a knowledgeable member of the crew. The notekeeper should have a thorough understanding of the purpose of the survey and the operations

5.5 Methods of Leveling Field books

There are two methods of booking and reducing the elevation of points from the observed staff readings.

1. Rise & Fall method
2. Height of collimation method.

5.5.1 Rise and Fall Method

Each reading is entered on a different line in the applicable column, except at change points where a fore-sight and a back-sight occupy the same line. This is to connect the line of sight of one setup of the instrument with the line of sight of the second setup of the instrument. From the above figure it can be seen that they are not at the same level. R.L. of change point *D* is obtained from the first line of sight by comparing intermediate sight 1.645 with foresight 1.515, i.e. a rise of 0.130m. For the R.L. of next point *E*, back sight 1.815 is compared with intermediate sight 1.715, i.e. a rise of 0.100m. At the end of the table arithmetic checks are shown. If a positive result is obtained there is a rise on the ground b/n the points, similarly of a negative result id obtained a fall on the ground can be conclude.

The checks are:

∑ Backsights - ∑ Foresights = ∑ (Rises) - ∑ (Falls) = Last R.L. – First R.L.

Cheking levels (Arithmetic check)- The difference b/n the sum of the B.S & sum of rise & the sum of fall & should also be equal to the difference b/n the R.L of Last & first point. Thus

∑B.S - ∑ F.S = ∑ Rise- ∑Fall = Last R.L – First R.L

It is advisable that on each page, the rise & fall calculations shall be completed & checked by comparing with the difference of the back & fore sight column summations, before the R.L calculations are commenced.

Start	B.S	I.S	F.S	Rise	Fall	R.L	Remark
BMA	2.462					165.265	B.M
1	2.660		2.048	0.414		165.679	T.P
2		2.381		0.279		165.958	
3		2.042		0.339		166.297	
4		1.984		0.058		166.355	
5	2.990		2.656		0.672	169.683	T.P
6		3.220			0.230	165.453	
7		3.123		0.097		165.550	
8			2.885	0.238		165.788	
∑ 8.112		7.589	1.425	0.902			

∑ B.S- ∑F.s = ∑Fall =∑Rise= Last R.L – First R.L

8.112 – 7.589 = 1.425- 0.902= 165.788-165.265

0.523= 0.523 0.523

The Reduced level of the points is calculated by adding the rise to the previous reduced level or by subtracting the Fall to the previous Reduced level of a point.

5.5.2 Height of Collimation Method

In this methods, the height of collimation i.e, the distance from datum to the line of sight, is calculated for each setting of the instrument by adding back sight to the elevation of the B.M. The reduced level of the turning point is then calculated by subtracting from H.C of the Foresight. For the next setting of the instrument, the H.C is obtained by adding the B.S. taken on T.P to its R.L (reduced level). The process continues until the R.L of the last point (Fore sight) is obtained by subtracting the staff reading from height of collimation of the last setting of the instrument.

Arithmetic level (checking of Level) – The difference b/n the sum of B.S & the sum of F.S should be equal to the difference b/n the last R.L & the first R.L.

$\sum$ B.S. - $\sum$ F.S. = Last R.L. – First R.L.

Examples- The following staff readings were observed successively with a level, the instrument having been moved after third, sixth and eighth readings:

2.228; 1.606; 0.988;2.090;2.864;1.262;0.602; 1.982;1.044;2.684 meters.

Soln- Since the instrument was shifted after third, sixth & eigth readings, these readings will be entered in the F.S column & there fore, the Forth, seventh and ninth readings will be entered in the B.S column & the last reading in the F.S. Column. All other readings will be entered in the I.S. column.

Stan	B.S	I.S	F.S	H.C	R.L	Remark
1	2.228			1010.693	1008.465	B.M
2		1.606		1010.693	1009.087	
3	2.090		0.988	1011.795	1009.705	T.P
4		2.864		1011.135	1018.931	
5	0.602		1.262	1011.135	1010.533	TP
6	1.044		1.982	1010.197	1009.153	TP
7			2.684		1007.513	
Check	5.964		6.916			

$\sum$ B.s- $\sum$ F.s = Last R.L – First R.L.   5. 964-6.916 = 1007.513 – 1008.465

<u>- 0.952</u>   = - <u>0.952</u>

Stand	B.S	I.S	F.S	Rise	Fall	R.L	Remark
1	2.228					1008.465	B.M
2		1.606		0.622		1009.087	
3	2.090		0.988	0.618		1009.705	T.P

4		2.864			0.774	1008.931	
5	0.602		1.262	1.602		1010.533	TP
6	1.044		1.982		1.380	1009.153	TP
7			2.684		1.640	1007.513	
∑	5.964		6.916	2.842	3.794		

∑ B.S- ∑ F.S = ∑ Rise - ∑ Fall = Last R.L – First R.L

s.964-6.916 = 2.842-3.794 = 1007.513-1008.465

- 0.952 = - 0.952 = -0.952

Self-Check -5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What are documenting information?
2. What are methods note booking

Note: **Satisfactory rating - 10 points** **Unsatisfactory - below 10 points**

Answer Sheet

Name: ___________________________ Date: ________________

Score = ___________

Rating: ____________

Short Answer Questions

1____

Operation sheet -1	Identifying heights or levels to be transferred/established

Techniques of Identifying heights or levels to be transferred/established

Procedures:

Step 1. Wear PPE.

Step 2. Read and understand the given drawing

Step 3. Select working site

Step 4. Select materials, tools and instruments

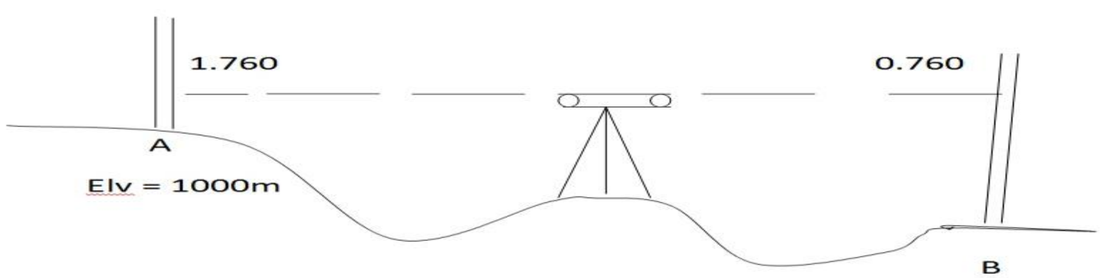
Step 5. Use appropriate methods of leveling

Step 6. Set up instruments

Step 7. Eliminate parallax

Step 8. Document your results

By using the above procedure and diagrams do the LAP test below.



Operation Sheet -2	setting-up and testing leveling devices

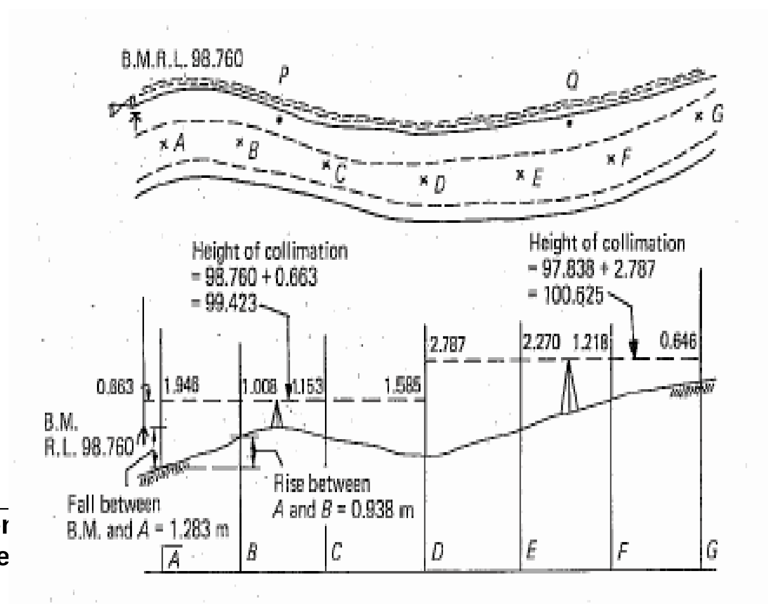
By using optical levels for your class. With a partner or in a small group, complete the following set-up steps.

1. Identify the device's to be setted up
2. Set up the device
3. Ensure the top is level
4. Push legs firmly
5. Use foot screws to centralize the circular bubble into the ground
6. Attach level
7. Turn the receiver on and test for visual and audible signals.
8. Move the receiver up and down in front of the laser to check the level indicator
9. Test by using Two peg test to see if the compensator is working
10. Remove parallax

Operation Sheet -3	Applying Leveling staffs accurately.

The following Techniques of Applying leveling staffs should be taken into acount:

1. The level is set up at P where BM may be observed and readings taken at points A, B, C and D
   - ✓ 1st read (BS) made with the staff on a point of known RL
   - ✓ Hold The staff at points A, B and C (ISs) in turn, and record the readings
   - ✓ Choose A change point (CP) at D, owing to the nature of



the ground and take the reading (FS)

1. Remain staff at point D.
2. Move the level to Q, set up and level
   - ✓ Take the reading on the staff at the change point D (BS)
   - ✓ Follow IS with the staff on E, F and G until a further change becomes necessary
3. Repeat this procedure until all the required levels have been obtained
4. position the final staff at a point of known RL

operation Sheet -4	Shooting and transferring Levels heights to required location and marking/or recording

The using a level to measure heights from shooting apply the following steps;

Step1. Set up the tripod

Step 2. Ensure the top is level

Step 3. Push legs firmly into the ground

Step 4. Attach level

Step 5. Use foot screws to centralize the circular bubble

Step 6. Test to see if the compensator is working

Step 7. Remove parallax

Step 8. Read from marks BS and FS

Operation Sheet -5	Documenting Results of leveling procedure as to organizational

	Requirements

The following are Documenting results of leveling procedure when using a level to measure heights;

1. Follow proper note keeping procedures
2. Start at a BM with an elevation of 100 feet.
3. Make up only the Back sight and Foresight rod readings, place them in the correct locations on your note sheet, and perform accurate calculations.
4. You must take a total of 15 readings, INCLUDING moving the tripod 4 times.
5. Your LAST reading will be back at the BM (with an original elevation of 100.00 feet). Adjust your rod readings to end up with a final BM rod reading of 100.05.
6. take survey notes and make accurate calculations.

LAP Test -1	Practical Demonstration

Name: _______________________________ Date: _________________

Time started: _________________________ Time finished: _________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within a given hours.

Task 1. Identify height or level to be transferred ***/*** established

Task 2. Set up and test leveling devices

Task 3. Apply leveling staffs accurately

Task 4. Shoot levels and transfer heights to required location

Task 5 documented results of the leveling procedure

References

- CPCCCA3023A Carry out leveling operations Toyota 2L-T, 3L engine repair manual.
- http://www.engr.mun.ca/~sitotaw/Site/Fall2007_files/Lab2_Lecture2_leveling.pdf
- https://www.diydoctor.org.uk/projects/Usingachalkline.htm
- Leveling set up process1,leveling vedio,

Staff reading

Name trainers who prepared the material

N0	Name	Qualification	Region	E.mail
1	Tesfaye Assegidew	MSC in CoTM	SNNPR	tesfayeassegidew@gmail.com
2	Habtamu wendmagegn	Bsc in Civil Eng	Dire Dawa	Joniyitna9@gmail.com
3	Yazachew Geneti	Msc in CoTM	BGRS	0917858176
4	Gebresilasie Jemal	Bsc	Addis Abeba	Gebrajemal@gmail.com
5	Getachew Mohammed	MSC in CoTM	Amhara	Gerimom07@gmail.com
6	Kibryisfaw Tulema	Bsc in	Somalie	kibrutulema@gmail.com