Carpentry

Level-II

Learning Guide-32

Unit of Competence: apply basic leveling procedure

Module Title: Applying basic leveling procedure

LG Code: EIS CAP2 M08 LO2-LG-32

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LO 2: Set up and use leveling device

Instruction Sheet	Learning Guide # 32

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 for leveling procedures
- Setting up and testing Leveling devices
- Applying Leveling staffs accurately
- Shooting levels and transferring heights to required location and marking to job requirement
- 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 from project plans or instructions for leveling procedures**.**
- Set up and test Leveling devices in accordance with manufacturer instructions, including leveling device tolerance checks**.**
- Apply Leveling staffs accurately
- Shoot Levels and transfer heights to required location and mark and/or record to job requirements.
- Document results of leveling procedure to organizational requirements.

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”.
4. Accomplish the “Self-check 1, Self-check t 2, Self-check 3, Self-check 4 and Self-check 5” respectively.
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1 and Operation Sheet 2 Operation Sheet 3”
6. Do the “LAP test” (if you are ready).

Information Sheet-1	Identifying Heights or levels to be transferred/ established for leveling procedures

2.1 Heights or levels

- chalk or nail marks on vertical surface

The process of leveling involves the transferring of elevations from a point of known elevation to points of unknown elevation by means of establishing a visual reference plane. This is done by setting up the level at any convenient point and “leveling” the instrument. The person then sights back to a level rod on a point of known elevation, usually referred to as a “bench mark” (BM).The rod reading, also known as a “back sight” (BS) or “plus sight”, is added to the known elevation of the bench mark to establish the “height of instrument” (HI).(This value is essentially the elevation of the center of the eyepiece of the level).operation required in the determination of heights of points on the surface of the Earth. It is the process of measuring heights. It is possiblewhenlevellingtomeasureheightswithanaccuracyofmillimetres Heights can also be measured using total stations, hand held lasers and GPS devices.

However,levellingoffersaninexpensive,simpleandaccuratemethodformeasuringheights,anditiswidelyusedin

constructionsites.Anymethodofmeasuringtheheightsofpointsaboveorbelowthegroundusing an agreed datum.

Thesedatum'sorreferencepointsarepresentinallconstructionsitesandhasan arbitraryheightassignedtothepoint.Mostconstructionsiteswillhaveseveralofthese benchmarks,andiftheyhaveheightsbasedonanarbitrarydatum,theyareknownas 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-linedefines the verticalatpointP.AhorizontalorlevellineisanylineatrightanglestothisForesight work, any horizontal line can be chosen as a datum for heights and for levelling. The height of a point is measured along the vertical above or below the chosen datum. 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 orsurfacepassingthroughthis,withitsheight,becomesthelevellingdatum. The height of the datum can be arbitrary, a value often used for this is 100.000m.Thisischosen toavoidanynegativeheightsoccurring.Anyreferencepointonsitewhichhashadaheightassignedtoitisknownasabenchmark.Formostsurveysandconstructionwork,severalbenchmarkswouldnormally be established by leveling from the datum. If heights are based on an arbitrary datum these are known as Temporary Bench Marks or TBM

1.1. Leveling Procedures

- **Setting up**
  - ✓ Back sight and fore sight 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;

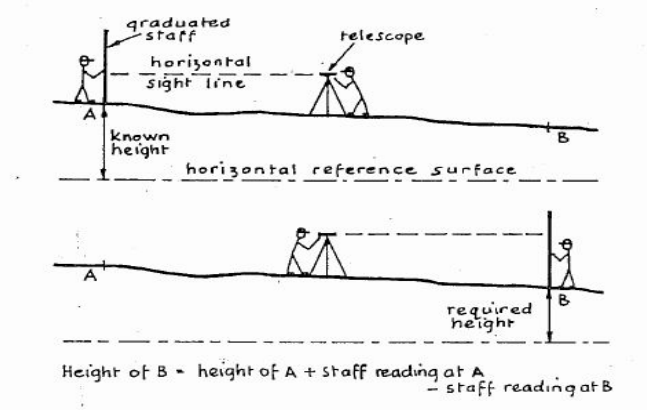


Figure1.Adjusting leveling

Instrument to the required level

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
   - 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

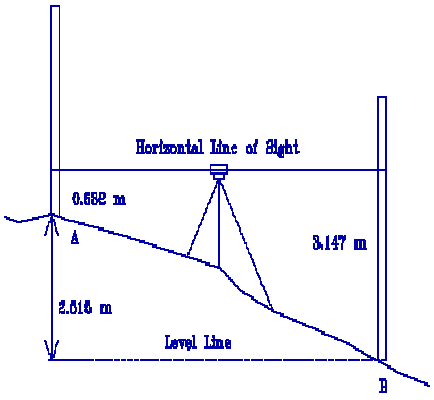


Figure2. Setting up instrument at the middle of two pegs

   - 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, especially if INVAR
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**
  - ✓ Parallaxistheapparentmovementoftheimageproducedbymovementoftheobserver'seyeatth e eyepiece.
  - ✓ Itiseliminatedbyfocusingthetelescopeoninfinityandthenadjustingtheeyepieceuntilthe cross-hairsappearinsharpfocus.Thesettingwillremainconstantforaparticularobserver'seye.

- **Booking**
  - ✓ Level books or loose –leaf leveling sheets shall be numbered and indexed in a register.
  - ✓ Details of the site, work, date, observer, chain man, 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 set up. 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 set up on the out ward 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.
- **Nail mark**

To ensure that your line is totally straight, the chalk line itself needs to be pulled tight. To ensure it stays tight you will need something to either hold the hook end on your mark, use the claw on the hook itself to pull against or hook the actual hook over something.

In this instance we have knocked in a nail at either end so that we can hang the hook at one end and then at the other, lever against it to pull the line tight.

If you needed to free both hands up, using this method you can wrap the line around the end to keep it tight.

Before you secure the chalk line and get it tight, slip one end over your nail or screw or hold it on your mark and pull it out of the chalk box at an angle away from the surface you're marking and give it a slight "twang".
This will get rid of any excess chalk and give you a much sharper line on the surface you're working with.

- ✓ **Snap Your Line**

With your marks made and fixing points ready, slip the hook over your first nail and pull some line out of the box, pull towards your second nail, keeping the line as tight as possible.
As you move towards your second nail, pull the line slightly diagonally to keep it away from the area you're marking to avoid getting any excess chalk on the surface.
Secure the line at your second fixing, ensuring it's as tight as possible. Push the line down to the base of each nail or screw so that it's as close to the surface as possible.
With everything ready, using your thumb and finger, pull the line out around 100mm (4 inches or so) roughly around the centre point between you're two marks.
This will ensure an even amount of down force with the snap and ultimately a crisper, cleaner line.
If you want to get your line as defined and bold as possible, give it two or three snaps.

If you are creating a line over a long distance, this can be challenging as the longer the run, the tighter the string needs to be.
A handy trick here is to get the line as tight as possible (but not too tight as it may snap) and then find the rough centre point.
Once you have found this, put your finger over it and push down, holding the centre point tight to the surface.
You can then individually snap the left and right sides that should then give a sharper line with much less risk of the line straying away from level.

- Datum peg

Elevations shall be based on the National Geodetic Benchmarks (N.G.B.M.).

Where no N.G.B.M. can be located within a 5km radius of the survey then specific written instructions must be obtained from the Client. Unless otherwise instructed by the Client, all heights shall be based on heights above Mean Sea Level (MSL).

A Datum Point or Benchmark must be verified from at least one or preferably two other such points before its height may be adopted.

- **Levelling Terminology**

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

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

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

MeanSeaLevel(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 appoint 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.

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 readings 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.

Self-Check -1	Written Test

Directions:

Match leveling terminology under column "A" to its correct definition under column "B".

write your answer on the provided answer sheet

A

1. Datum
2. Bench mark (BM)
3. Back sight (BS)
4. Reduced level (RL)
5. Changed point (CP)
6. Intermediate sight (IS)
7. Staff station
8. Level
9. Fore sight (FS)
10. Elevation

B

A. The place where the leveling is held vertically
B. Sight taken after the level has been set up
C. Last sight taken before moving the level
D. The staff position at which a Fh and then a Bs reading are taken
E. Level surface to which elevations are referred
F. Height of points stated with reference to the selected datum
G. An instrument used to take readings on staff
H. Vertical distance from a level
I. Other staff readings taken between BS and FS
J. Permanent object having a marked point whose elevations above or below an adopted datum is k

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Matching

1. ___
2. ___
3. ___
4. ___
5. ___
6. ___
7. ___
8. ___
9. ___
10. ___

Operation Sheet 1	Identifying heights or levels to be transferred/established

The following procedures of Identifying heights or levels to be transferred/established

should be taken into acount:

Step 1. Wear PPE.

Step 2. Read and understand the given drawing

Step 3. Select working site

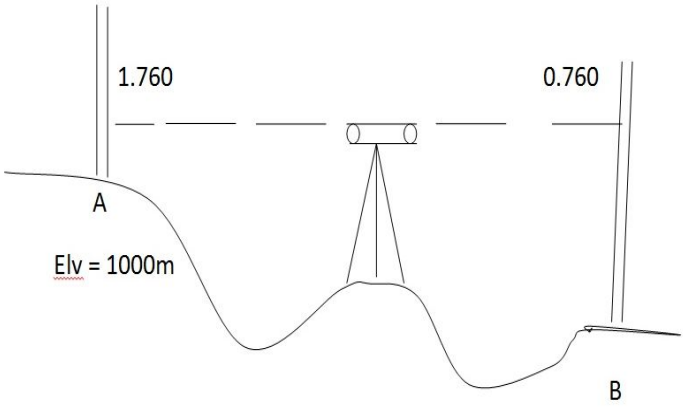
Step 4. Select materials,toolsand instruments

Step 5. Use appropriate methods of leveling

Step 6. Setup instruments

Step 7. Eliminateparallax

Step 8. Document your results



2.1.Concepts of setting-up and testing leveling devices

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 -Dilmpy 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.

c

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

4.Horizontal circl
5.Baseplate
8.Collimator(sight)
9.Objectlens

Figure3. Parts of optical level and automatic level

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.

Laserlevelscontainarotatinglaserwhichdefinesavisiblehorizontalplanefromwhichdistancetothegroundcanbemadeandthentheheightcanbedetermined

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..

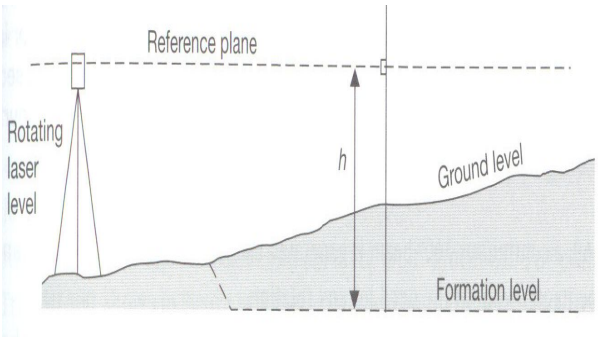


Figure4. Leveling by Rotary laser level

- ✓ **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. Setting up procedures the leveling instruments.

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, latly targeting & Focusing. I.e

Spread the tripod Center the inst 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.

2.3.2. Checking the level's accuracy

Levels can move out of adjustments of t hat 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 fore sight 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 centre 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 centre peg and read the staff on each of the out side 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 4m to the far side of one of the outside pegs. Read the staff on the peg 4m away and the non the one 64m 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 5mm.

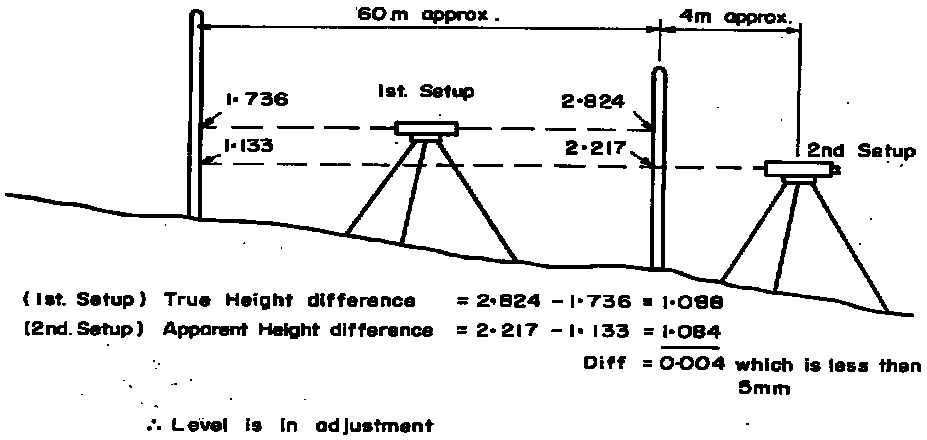


Figure5. *A method for checking the level accuracy*

If the instrument's collimation appears to be out, recheck by repeating the process. Then, whilst set up 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 around 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.

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.

Figure6. 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

Figure7. 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

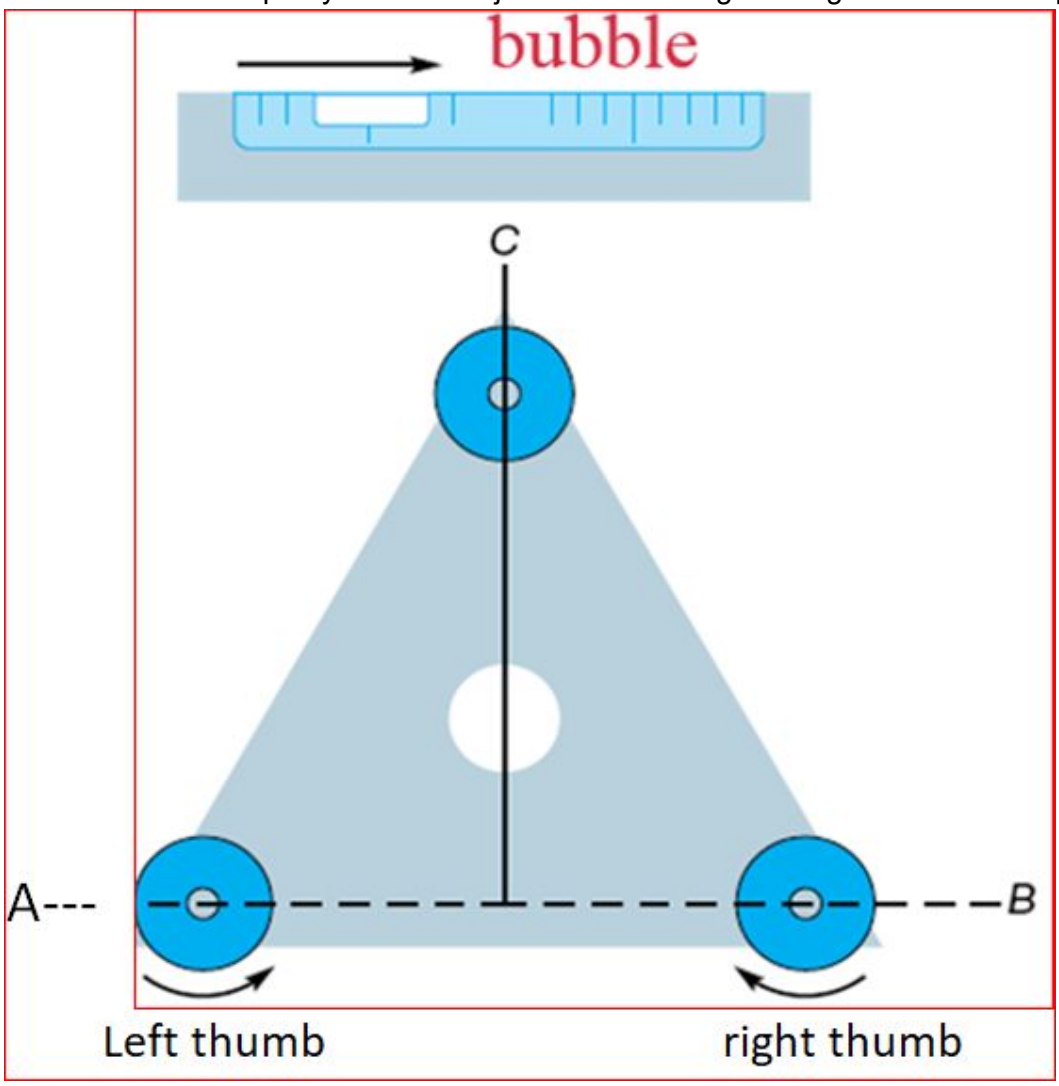


Figure8. The sign of fully adjusted equipment

A bubble follows the left thumb when turning the screws

Self-Check -2	Written Test

Directions: 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 at a 90 degree

A. Electronic level
C. Optical level
B. Automatic level
D. Laser level

2. A staff carried by the operator is equipped with _____

A. Sprit level
C. Movable sensor
B. Plumb bob
D. No answer

3. _____ is used to make sure that the rod is held vertical when making a reading

A. Laser level
C. Electronic level
B. Rod level
D. Optical level

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

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Choice

1. _____
2. _____
3. _____

Operation Sheet -2	setting-up and testing leveling devices

The following Techniques of **setting-up and testing leveling devices should be taken into acount:**

Step1Identify the device's to be set up

Step 2 Set up the device

Step 3 Ensure the top is level

Step 4 Push legs firmly into the ground

Step 5 Attach level

Step 6 Use foot screws to centralize the circular bubble

Step 7 Test by using Two peg test to see if the compensator is working

Step 8 Remove parallax

Information Sheet-3	Applying Leveling staffs accurately

2.3 Applying Leveling staffs

There are several types of graduated staffs available (telescopic, folding). Readings are always in the metric system to the nearest millimeter. Always study the leveling staff you will be working with before you use it in the field.

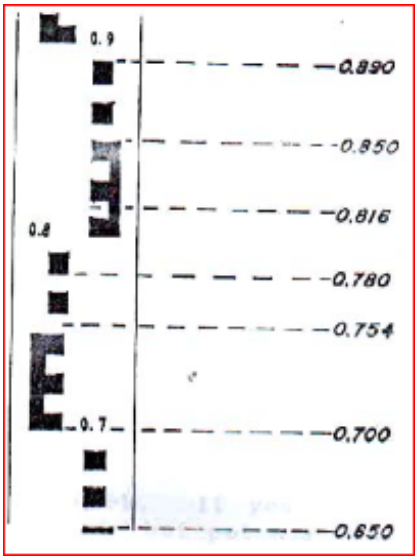


Figure9. Detail of leveling staff

Levelling involves measuring vertical distances with reference to a horizontal plane or surface. To do this, a levelling staff is needed to measure vertical distances and an instrument known as a level is required to define the horizontal plane.

Many types of staff are used with varying lengths and different markings.

The E-type face is commonly used in the UK, Ireland 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 some times fitted to help this.

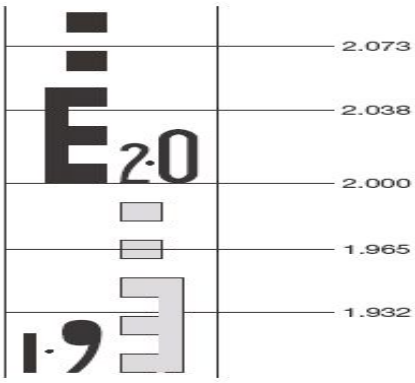


Figure10. Reading a staff

3.1. 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.

3.2. Examples of leveling staff procedures

1. The level is setup at Points where BM may be observed
2. The 1st reading (BS) made with the staff on a point of known RL

- ✓ The staff is now held at points A, Band C (ISs) in turn, and record the readings
- ✓ A change point (CP) is chosen at D, owing to the nature of the ground and take the reading (FS)

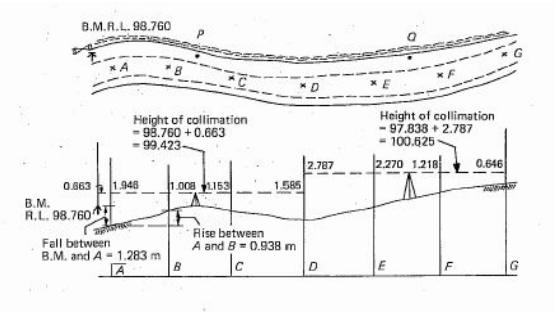


Figure11. Leveling and recording result

2. The staff remains at point D. The level is moved to Q, set up and levelled
   - ✓ Taking the reading on the staff at the change point D (BS)
   - ✓ Followed by IS with the staff on E, F and G until a further change becomes necessary
3. This procedure is repeated until all the required levels have been obtained
4. The final staff position is at a point of known RL

Self-Check -3	Written Test

Directions: Answer all the questions listed below.

Fill the blank space by the appropriate answer on the provided answer sheet (5 point)

1. One of the following is correct about leveling

A. It involves measuring horizontal distance with reference to vertical surface

B. It involves measuring vertical distance with reference to vertical surface

C. It involves measuring sloppy distance with reference to bench mark

D. No answer

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

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

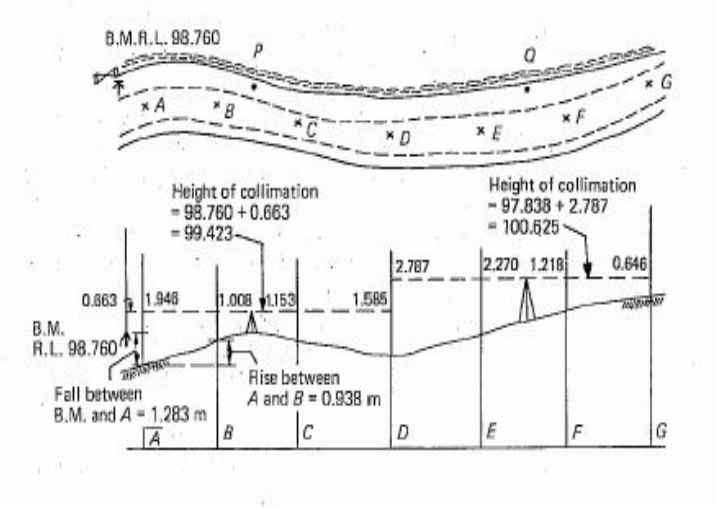
Short Answer Questions

1. _____
___

Operation Sheet -3	Applying leveling staffs

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

step1 The level is setup 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)

step 2 Remain staff at point D.

step 3 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

step 4 Repeat this procedure until all the required levels have been obtained

step 5 position the final staff at a point of known RL

Information Sheet-4	Shooting levels and transferring heights to required location

2.4. Concepts of Shooting level and transferring heights

Figure12. Taking a shot of marked point

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 cannot be overstated. It affects a project from the ground up. As important as it is, shooting grade is simple.

2.4.1. 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.

2.4.2. 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.

2.4.3. 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.

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

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

Self-Check -4	Written Test

Directions: **Answer all the questions listed below.**

Essay part: Write appropriate answer for the following question on the provided answer sheet (5 point)

1.what are the necessary steps for shooting leveling?

True / false: Write true if the statement is correct and false if the statement is false on the provided answer sheet (3 points)

1. A survey elevation shot determines the elevation of a known point by referencing an unknown point.

Note: **Satisfactory rating -4 points** **Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Essay part

1. _____
   _____
   _____
   _____
   _____

True false

1. _____

Operation Sheet -4	Shooting levels and transferring heights

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

Step1. Setup the tripod

Step2. Ensure the top is level

Step3. Push legs firmly into the ground

Step4. Attach level

Step5. Use foot screws to centralize the circular bubble

Step6. Test to see if the compensator is working

Step7. Remove parallax

Step8. Read from marks BS and FS

Information Sheet-5	Marking and recording to job requirement

2.5 Survey Records

- ✓ Any plan that is required to be made as a result of a survey must –

a) Be prepared in a manner and form determined by the relevant registering authority; and

b) Be lodged with that registering authority; and

c) Where required by the Surveyor General or registering authority, be accompanied by survey notes.

- ✓ Any survey notes accompanying or forming part of a plan under sub-section 5.1.1 must

a) Contain the information and measurements collected by the surveyor in the course of a survey; and

b) Be prepared in a manner and form set out in these Directions; and

- ✓ A plan and survey notes lodged with a registering authority under this section and accepted by the registering authority shall, upon that acceptance –

a) Constitute the public record of the survey to which the plan and survey notes relate; and

b) Become the property of the Crown.

- ✓ All lengths or distances shown on any plan or survey notes must be horizontal lengths or distances, measured or calculated at the terrain mid-height of the location of the measurement.

- After leveling the instrument:
  - ✓ Balance BS and FS
  - ✓ Make sure rod will be visible when instrument leveled at new position

1. Rod person
   - ✓ Hold rod vertical (plumb)
   - ✓ Move rod back and forth (minimum reading noted)
   - ✓ Select tp's that are stable

Self check 5	Written test

Directions: Answer all the questions listed below. (10 points)

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

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Rating: _____

Short Answer Questions

1. _____
   _____
   _____
   _____
   _____
2. _____
   _____
   _____
   _____
   _____

Information Sheet-6	documenting Results of leveling procedure

2.6. Introduction

c) Level books or loose-leaf levelling sheets shall be numbered and indexed in a register.

d) Details of the site, work, date, observer, chainman, booker, weather, wind, instrument and any other relevant items shall be entered.

e) Enter the first observation (which is on a known point) in the Backsight 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.

f) 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.

g) Change the instrument to the next setup. Enter the following backsight on the same line as the previous foresight but in the Backsight column.

h) 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.

2.6.1. 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.

2.6.2. Forms of Field Notes

STA	BS	HI	FS	ELEV

- Sum BS – Sum FS = Difference of Elevation

2.6.3. 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.

2.6.4. Importance's 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

2.6.5. Methods of Levelling 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.

2.6.6. 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.

2.6.7. 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.

∑ B.S. - ∑ 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			

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

- 0.952 = - 0.952

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 #6	Written test

Directions: Answer all the questions listed below.

Write correct answer for the following questions on the provided answer sheet (4 points)

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

True / False

Write true if the statement is correct and false if the statement is wrong on the provided answer sheet (6 points)

1. When we use height of collimation method the distance from datum to the line of sight is calculated as BS-elevation of BM
2. In rise and fall method each reading is entered on a different line in the applicable column , even when fore sight and back sight occupy the same line
3. Results of leveling procedure documenting are the record of work done in the field

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____

Score = _____

Short Answer Questions

1. _____
   _____
   _____
   _____
   _____
2. _____
   _____
   _____
   _____
   _____

True / false

1. _____
2. _____
3. _____

Operation Sheet -6	Documenting results of leveling procedure

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

Step1 Follow proper note keeping procedures

Step 2 Start at a BM with an elevation of 100 feet.

Step 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.

Step 4You must take a total of 15 readings, INCLUDING moving the tripod 4 times.

Step 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.

Step 6 take survey notes and make accurate calculations.

LAP Test	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 heights or levels to be transferred / established

Task 2 setting up and test leveling devices

Task 3 Apply leveling staff accurately

Task 4 shooting levels and transferring heights to required location

Task 5 documenting results of the leveling procedure

List of Reference Materials

1. http://www.engr.mun.ca/~sitotaw/Site/Fall2007_files/Lab2_Lecture2_leveling.pdf
2. https://www.diydoctor.org.uk/projects/Usingachalkline.htm