Agricultural TVET College

Small Scale Irrigation Development

Level III

MODEL TTLM

Learning Guide #12

Unit of Competence: Carry out Surveying and Leveling

Module Title: Carrying out Surveying and Leveling

LG Code: AGR SSI3 M12 LO1-LO5

TTLM Code: AGR SSI3 TTLM12 1218V$_1$

Nominal Duration: 75 Hours

Instruction Sheet	Learning Guide #12

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

- Plan and prepare work
- Perform survey techniques
- Establish offsets for civil works
- Set up and use leveling device
- Clean up

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 –

- ✓ Measure distance and angles
- ✓ Apply surveying techniques
- ✓ Locate, interpret and apply of relevant information, standards and specifications
- ✓ Comply with site safety plan, OH&S regulations and legislation applicable to workplace operations
- ✓ Comply with organizational procedures including quality requirements
- ✓ Conduct of a minimum of three different leveling tasks, at least one utilizing an automatic level. One of the tasks must include closed traverse utilizing either the height of instrument or rise and fall method of reduction
- ✓ Conduct of a two peg test with an automatic level, to confirm instrument meets manufacturers' tolerances
- ✓ Record of the results of each leveling procedure to organizational requirements
- ✓ Communicate and working effectively and safely with others

Learning Activities

1. **Read the specific objectives of this Learning Guide.**
2. **Read the information written in the "Information Sheet"**
3. **Accomplish the "Self-check".**
4. **If you earned a satisfactory evaluation proceed to the next "Information Sheet". However, if your rating is unsatisfactory, see your facilitator for further instructions or go back to Learning Activity.**
5. **Submit your accomplished Self-check. This will form part of your training portfolio.**

6. **Read and Practice "Operation Sheets".**
7. **If you think you are ready proceed to "Job Sheet".**
8. **Request you facilitator to observe your demonstration of the exercises and give you feedback.**

INFORMATION SHEET#1	Plan and prepare work

Introduction to leveling & surveying

1 General

The primary reference at water-level recording stations is a set of stable bench-marks, installed in locations where their level should not change. Upon initial set-up of a station, the levels of the relevant parts of the installation are established and recorded by means of accurate leveling. At least every two years, the levels of the staff gauges, sensor level, internal gauge, tower structure and benchmarks should be measured relative to each other as a check that records are not in error due to bank subsidence or other movement. Accurate leveling is thus a particularly important part of site establishment, installation and quality assurance. All staff shall be thoroughly familiar with its theory and practice. Leveling and surveying methods are also used for measurements of river channel and lake configurations. Often, less accurate methods can be used for this work than for water-level recording stations, although the techniques are common.

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.

2. Definitions

Differential leveling is the term applied to any method of measuring directly with a graduated staff the difference in elevation between two or more points.

Precise leveling is a particularly accurate method of differential leveling which uses highly accurate levels and with a more rigorous observing procedure than general engineering leveling. It aims to achieve high orders of accuracy such as 1 mm per 1 km traverse.

A level surface is a surface which is everywhere perpendicular to the direction of the force of gravity. An example is the surface of a completely still lake. For ordinary leveling, level surfaces at different elevations can be considered to be parallel.

A level datum is an arbitrary level surface to which elevations are referred. The most common surveying datum is mean sea-level (MSL), but as hydrological work is usually just concerned with levels in a local area, we often use:

An assumed datum, which is established by giving a benchmark an assumed value (e.g. 100.000 m) to which all levels in the local area will be reduced. It is not good practice to assume a level which is close to the actual MSL value, as it creates potential for confusion.

A reduced level is the vertical distance between a survey point and the adopted level datum.

A bench mark (BM) is the term given to a definite, permanent accessible point of known height above a datum to which the height of other points can be referred.

It is usually a stainless steel pin embedded in a substantial concrete block cast into the ground. At hydrological stations rock bolts driven into bedrock or concrete structures can be used, but structures should be used warily as they themselves are subject to settlement. The locations of benchmarks shall be marked with BM marker posts and/or paint, and recorded on the Station History Form.

A set-up refers the position of a level or other instrument at the time in which a number of observations are made without mooring the instrument. The first observation is made to the known point and is termed a back sight; the last observation is to the final point or the next to be measured on the run, and all other points are intermediates.

A run is the leveling between two or more points measured in one direction only. The outward run is from known to unknown points and the return run is the check leveling in the opposite direction.

A close is the difference between the starting level of the initial point for the outward run and that determined at the end of the return run. If the levels have been reduced correctly this value should be the same as the difference between the sum of the rises and falls and also the difference between the sum of the back sights and foresights.

Height of Collimation is the elevation of the optical axis of the telescope at the time of the setup. The line of collimation is the imaginary line at the elevation.

Orders of leveling refer to the quality of the leveling, usually being defined by the expected maximum closing error.

Change points are points of measurement which are used to carry the measurements forward in a run. Each one will be read first as a foresight, the instrument position is changed, and then it will be read as a back sight.

1.1. Obtaining, confirming and applying work instructions

Establishing the task

Before you start a leveling task, you'll need to make sure that you've got all the information required. This information usually comes from the project plans, drawings and specifications.

Interpreting these documents accurately is particularly important, because leveling must be very precise.

Other sources of information may include (Compliance documentation at your workplace) may include::

- Legislation, Regulations, Ethiopian Standards® and building codes
- Company policies and procedures
- National survey data
- The building or site supervisor, and/or your supervisor.
- organization and site requirements and procedures
- manufacture's guidelines and specifications (this will be important when you use leveling equipment)

Work instructions

Whenever you're given instructions for a task or project, you'll need to make sure that you clearly understand what you have to do. Instructions may be provided in written or verbal form, or sometimes a mix of the two. Here are a few tips to help you out if you're given instructions that are unclear or incomplete or if you have trouble understanding them.

- Take notes. It's hard to remember everything by keeping it in your head.
- Ask questions.
- Be aware of language.
- Confirm the instructions before you start the task.
- Sequence the instructions. Putting instructions and/or steps into the order you'll be completing them makes them much easier to follow.

1.2. Confirming and applying safety requirements

Most of the risks and hazards encountered while surveying are associated with the local terrain, weather and climate, the means of transportation used to access the survey area, and the degree of remoteness where the survey takes place.

Depending on the type of survey, individuals may need to be physically capable of carrying heavy loads, as some geophysical survey equipment is very heavy, as is the cumulative weight of geochemical samples collected during a day's work. Slips, trip, falls and back strains are common injuries and may be associated with specific terrain. The most serious injuries are usually caused by transportation related accidents so it is important to follow the safety guidelines in the relevant transportation chapters. Also, heavy loads should be lifted and carried in a safe manner to avoid back injuries.

A. Essential Safety Guidelines for Surveys

Employees who conduct surveys should be trained to perform their work safely. New or inexperienced employees should be teamed with experienced employees who are familiar with the terrain, climate and equipment. Before experienced personnel begin work in unfamiliar terrain or a new region, they should receive training to become familiar with risks and hazards of the terrain, climate and location. Contractors should provide trained survey crews with written safe operating procedures (SOPs) that address the specific hazards of survey work. Some practices should be carried out each day before a crew starts work. SOPs (Safe Operating Procedures) should cover, but not be limited to, the following topics:

1. **Training**: Survey employees should be trained for the work they carry out and be familiar with the manufacturer's safe operating procedures (SOPs) and guidelines in the instruction manuals that accompany the survey equipment and tools they use.
2. **Tracking system**: Develop a tracking system to record where employees are working each day. Record the planned survey routes or work sites on a centrally located map or white board at the camp or base. Location updates including changes in plans should be called in and recorded.

3. **Communications**: Develop a communication call-in system to maintain contact with employees. Employees should carry functioning communications equipment appropriate for the area.

4. **Emergency response plans** (ERPs): Survey crews should develop ERPs that address site specific risks and hazards and potential injuries associated with specific surveys, terrain and the degree of remoteness. When a contractor's employees are based at a project site, the ERP for survey crews should be integrated with the exploration project ERPs.

5. **Tool and equipment check**: Before departing for work, each survey crew should check their equipment. They should have: (a) all tools, fully charged communication and navigation equipment with spare batteries; (b) required personal protective equipment (PPE) including bear spray, as appropriate; (c) suitable clothing for the weather and potential changes; and (d) appropriate survival kits and first aid kits. If conditions are dry, carry fire suppressant materials when using tools or survey equipment that could start a fire (e.g., chainsaw, small generator or electrical equipment).

6. **Transportation**: Crews should perform an inspection check of their mode of transportation to make sure it is in good working order and all equipment is present.

7. **Supervision**: Workers should receive appropriate supervision in the field while performing surveys.

8. **Working alone**: Follow the regulations of the authorities having jurisdiction (AHJs) to protect the health and safety of workers. Develop and implement the required SOPs if it is necessary for employees to work alone.

B. General Safety Tips

Weather related risks: Be fully prepared for the local weather and climate. Carry a suitable survival kit, extra water and food, etc. Wear appropriate clothing and carry rain gear and extra clothing in case you become stranded and must spend a night away from camp. Lightning can be a serious risk depending on the location and especially when carrying out electrical surveys.

Personal protective equipment (PPE): Required PPE will vary depending on the risks and hazards of each type of survey and the terrain. Safety glasses should be required for most surveys. It is usually advisable to wear high visibility vests. Hearing protection may be required (e.g., when using a chainsaw). Wear gloves to protect hands from cuts and infections.

- **Footwear**: Wear leather boots that provide good ankle support and traction appropriate for the terrain. It is advisable to wear waterproof boots when working in extremely wet areas and heavy, insulating boots during very cold weather. As stable footing is very important, appropriate high quality boots may be considered PPE by some companies.
- **Footing and balance**: Carrying heavy equipment or samples hinders good balance. Be vigilant when traversing cut lines and/or climbing over logs or debris. Because some surveys are carried out along straight lines, it may not be possible to avoid difficult and sometimes dangerous terrain (e.g., cliffs, swamps). While trees and brush are usually cut down to ground level, stubs or "pungies" may remain if the ground was snow-covered when the lines were cut. It is easy to trip over them and get cut or impaled, especially when carrying a heavy pack or surveying equipment.
- **Snow and ice**: Follow all appropriate precautions when working on snow and ice. Be critically aware of fire risks. Carry appropriate fire extinguishing equipment, including: a fire extinguisher, extinguishing powder, water and/or a small shovel when using gasoline powered machinery (e.g., chainsaws, generators, brush cutters, power augers). Keep the exhaust area clear of vegetation and place hot machinery on bare rock so it will not start a fire. Always observe fire bans.
- **Wildlife and insects**: Where bears are a hazard, be trained in bear safety procedures and carry appropriate deterrents including bear pepper spray. Be aware of potential fauna at ground level. Watch out for signs of bees or wasps which often build nests in the ground. Do not place your hands where they might be bitten by a venomous snake or stung by scorpions or insects. When working in insect infested areas and using insect repellent, avoid applying it to your eyes and mouth. Do not overuse repellent as it is absorbed

through the skin. Be vigilant when wearing head nets as they restrict your range of vision. Follow medical advice regarding the use of anti-malarial medications and avoid mosquito bites when working where malaria and other serious insect-borne diseases are present.

- **Audio entertainment equipment**: In general, it is not good practice to allow employees to wear personal electronic music devices with headphones or earplugs (including iPods) when working. Headphones or earplugs interfere with the ability to clearly hear directions via radio communication, noise due to machine malfunctions and dangerous wildlife, etc.
- **Survey completion**: When a survey is completed remove all equipment, including wires. Fill in holes if they present a future tripping hazard to workers or to animals.

1.3. Identifying, obtaining and observing signage requirements

The following equipment and requirements will be used by all survey crews when working within the limits of the traveled way (TW) upon any highway and is intended to be considered minimum requirements by the enterprise:

- 2 Roll-up signs “SURVEY CREW AHEAD" with stands for use on secondary roads.
- 10 Florescent orange cones
- 4 Flags with staff for signs and traffic control

Orange Fluorescent vests (one for every crew member): In addition, there will be one green fluorescent vest per crew to be used by the flagger when performing flagging operations. Note: The information stated above is minimum protection, if your survey task requires more equipment see your area supervisor or the survey office for additional equipment.

Location and use of signs

The signs warning the oncoming traffic shall be a minimum distance of 1500 ft (460 m) from any person working in the highway with a posted speed of 100 km/hr, and decreasing proportionately according to design speed and safety requirements, and a maximum distance of 1370 m apart: Under no condition shall any member of the crew attempt to do any work within the traveled portion of the road until the signs are in place.

If actual speeds are higher, adjust sign package to better protect yourselves and the public.

- 55 mph (90 kmh) speed limit = 500 ft (150 m) between signs and 500' from last sign to first cone.
- 35 mph (55 kmh) speed limit = 350 ft (100 m) between signs and 350' from last sign to first cone.
- Cone spacing should be 80 ft (25 m) apart. (Every other white line)

Signs shall be moved as the work progresses so as to keep within suggested distances. The maximum distance for a work zone will be 3 mi (5 km). When workers leave the highway, such as lunch break, etc., all signs shall be removed and placed so that the traveling public cannot see or read them.

General safety information

If in the opinion of the crew chief, the signs are not adequate for the conditions, or the traveling public does not heed to caution, it may be necessary to employ flag-persons or even solicit State Police or Local Police for the necessary protection. The crew chief will be responsible w/ coordinating this need with the Survey Supervisor.

It should be kept in mind at all times that when the motorist is blinded by direct sunlight; it is not safe to be working on the highway. Usually the progress of the work can be planned to avoid this situation.

Survey crews will not work on the highway during severe road conditions or low visibility. The Crew Chief will make this determination. Crews should report to their designated inclement weather assigned locations.

In order to further insure the safety of our personnel, and the traveling public, flashing warning lights on vehicles will be used as follows:

1. Whenever any of the survey crew is working within the right of way limits of the highway. The vehicle shall be parked within the signed area.

2. Flashing warning lights need not be used whenever the vehicle is parked off the traveled way or shoulders and the crew is working entirely outside of the highway right of way limits.

1.4. Selecting and Checking tools and equipment to carry out tasks

It is important to use the right levelling equipment for the job. Not all levelling equipment will provide accurate information for the same tasks. So you need to select the equipment for the task it was intended.

When using a tool for a task it is not designed for, you may damage the tool or hurt yourself or others. Choosing the right piece of equipment will help you work with greater safety and efficiency. Only use equipment for what it was originally designed to do.

You should also prepare for tasks by putting on suitable personal protective equipment. Appropriate protective equipment must always be provided by employers and it is your duty of care to use it.

Examples of personal protective equipment include:

- goggles or safety spectacles
- safety boots with steel toe caps
- overalls or other well-fitted clothing
- safety vests appropriate for the category of site (e.g. rail or highways)

Before using tools check that they work properly and are not damaged. Pre-start checks are carried out equipment is started. What is involved with the pre-start check will vary with individual contractor, but should be according to a written check list which may be part of the daily report.

There will also be 'tolerance' checks that you will need to perform on equipment to check it is accurate, and this will be discussed later in the learner guide.

Any defects should be reported to your supervisor.

You should also check the working condition of non-mechanical equipment. For example, if you are using a hammer, giving it a quick look over to check its condition could prevent a situation such as the end of the hammer flying off and hurting someone.

Your workplace should have a system in place where all equipment is scheduled for regular maintenance. If equipment is due for a maintenance check then you must follow workplace procedures, including notifying the appropriate person, for this to be done.

If a service is needed, take it to someone who is qualified. Never try to service equipment yourself unless you are authorized to do so.

Selecting correct tool for the job

spirit levels	These are tools with a straight edge and a levelling bubble that moves to show when the vertical or horizontal measure is level.
laser levels	These are becoming more popular and they give a non-stop level mark through a laser transmitter and receiver.
string lines	A string line is what it says – a line from a length of string, the string needs to be pulled tight and not caught up on any obstructions. Other tools are used to get the string to the right height.
tape measures	A tape measure is used for measuring tasks
automatic levels	Some automatic levels use laser to show the height or depth. Some include a GPS based on the machine set up
survey pegs	These pegs are hammered into the ground to show levels, offsets, slopes and information from plans. They can be made of wood or metal.
levelling staffs or survey rods	There are many types of levelling staffs or rods. Some may be in one piece or they may be able to adjust their length by telescoping sections inside each other. Markings may be on one side or both sides. The levelling staff is used with the 'dumpy' level – the surveying tool you will see many surveyors using to look through to the levelling staff.
plumb bobs	This is a heavy weight that hangs from a particular point to show vertical alignment.
optical square	This is used to check angles
clinometers	This is used to check the slope of an area by being placed at the base of the slope
batter pegs/boards	This is a peg driven into the ground or a board used to show the limits of an earth slope
wooded/steel pegs	Wooden pegs are used for temporary markers and steel pegs are used more for long term marking
straight edges/T-square	Used to check an angle in a mark-up
hammers	Used to put pegs etc. in place as markers
chalk line	This is a string line that has had chalk run over it so that when it is 'snapped' the string hits the object such as a wall and marks a straight line on it
theodolite	Is like a rotating telescope used to measure horizontal and vertical angles.

1.5. Checking leveling equipment for serviceability

Checking equipment for serviceability

When using levelling equipment it is important that it is accurate so that it can give readings are that correct. Otherwise buildings will be built at the wrong height or trenches won't be dug to the correct depth. Equipment may not be accurate because it has been knocked as it is packed or unpacked or as it was being carried or transported. Care should always be taken with levelling equipment and following manufacturer's instructions for how to move these so that they continue to give accurate levels.

Faults that are not discovered through checking will lead you to incorrect readings and construction that is not according to plan specifications.

Leveling equipment and devices need to be maintained according to manufacturer's instructions. This will make sure their high level of accuracy is maintained.

Some leveling equipment will need to be checked by qualified specialists are recalibrated so they give accurate levels.

Leveling equipment can be checked using:

- two peg test
- reverse reading for spirit level

Two peg test

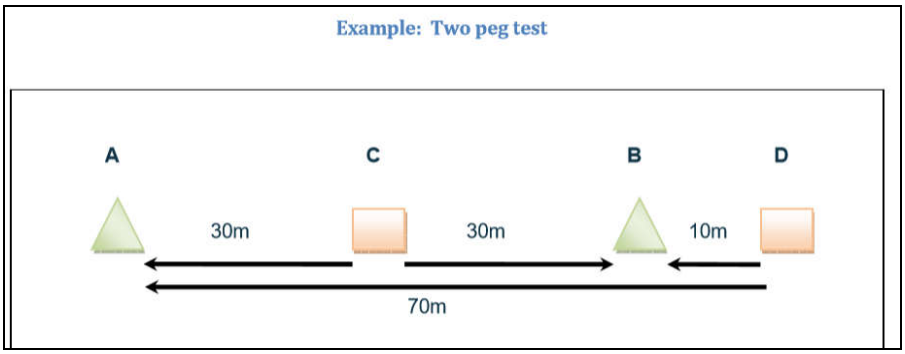
This test is commonly used for leveling tools such as automatic levels. At the most basic level the test is conducted as follows:

Steps 1 – Chose a flat area and measure out two pegs and place the automatic level in the exact centre. For example, place the two pegs 60 meters apart and place the level tool at 30 meters in the centre of the two pegs.

Step 2 – Take the automatic level at point from C to A and from C to B. Write down the heights.

Step 3 – Move the level from point C to point D and take the heights of point A and B again.

Step 4 – Compare the heights to see if the automatic level is accurate or needs adjusting.



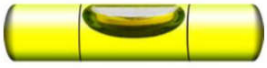
Reverse readings

This test is used for leveling tools that use a bubble to show level, such as spirit levels.

The test performed to check the accuracy of this type of level is called 'reverse readings'. It is a test to check whether the level indicates a truly horizontal surface is, in fact, level

To do this, the level is placed on surface that can be adjusted until the bubble in the level is centered. The spirit level is then rotated 180°. If the spirit level is accurate, the bubble will again be centered.

If the bubble is not centered an adjustment of the spirit level is needed or the tool may need to be cleaned or replaced, (for example, look for a build-up on the level bottom flat edge of the spirit level).



1.6. Identifying environmental protection requirements

Environmental issues

All construction projects have the potential to affect the environment negatively. Although leveling tasks are generally considered to have very little environmental impact as they don't use resources heavily, create a lot of waste or require much clean-up, environmental issues still need to be considered. Most construction companies or worksites will have an environmental management plan (EMP) or policies and procedures for ensuring that projects have as little impact as possible. It's everyone's responsibility to work in a way that has as low an impact on the environment as possible. As part of your planning and preparation, make sure you:

- check if there's an existing EMP for the company, worksite and project
- Comply with waste management and clean-up procedures as required.

You will need to take precautions in the planning process to prevent any adverse environmental effects occurring during the work stage and protect the surrounding environment of the worksite. Otherwise heavy penalties could apply. You must follow all environmental regulations when planning and carrying out work. These are identified in the project environmental management plan.

The environmental protection plan should provide detail on how to deal with waste. There are different types of waste including:

- general waste
- recycling waste – glass, aluminum, soil
- infectious waste – blood, needles, bandages, human waste
- hazardous waste – chemicals and harmful substances

In most cases waste is treated in the following way:

- general waste is put in a rubbish bin
- recycling waste is put in a specially marked area or container
- infectious and hazardous waste should only be handled using personal protective equipment such as gloves, masks and goggles (specialized help may be needed to do this task, so you should always consult your supervisor)

Check the environmental management plan for your work site for specific instructions.

There are several things to be aware of in relation to environmental issues when undertaking leveling activities at a worksite:

- ✓ waste management
- ✓ water quality protection
- ✓ noise
- ✓ vibration
- ✓ dust and clean-up management

Self-check-1	**Written test**

Name: _____ Date: _____

1. Explain in your own words the meaning of bench mark and level datum. (**4pts**)
2. What is work place signage? (**3pts**)
3. Explain what 'level' work means? (**1pts**)
4. What leveling equipment do you use in your workplace and what is each used for? (**10pts**)
5. What is the use of work instructions? (**2pts**)

Note: Satisfactory rating – 20 points and above Unsatisfactory - below 20points

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

INFORMATION SHEET#2	Perform survey technique

2.1 Identifying different methods of Leveling in Surveying

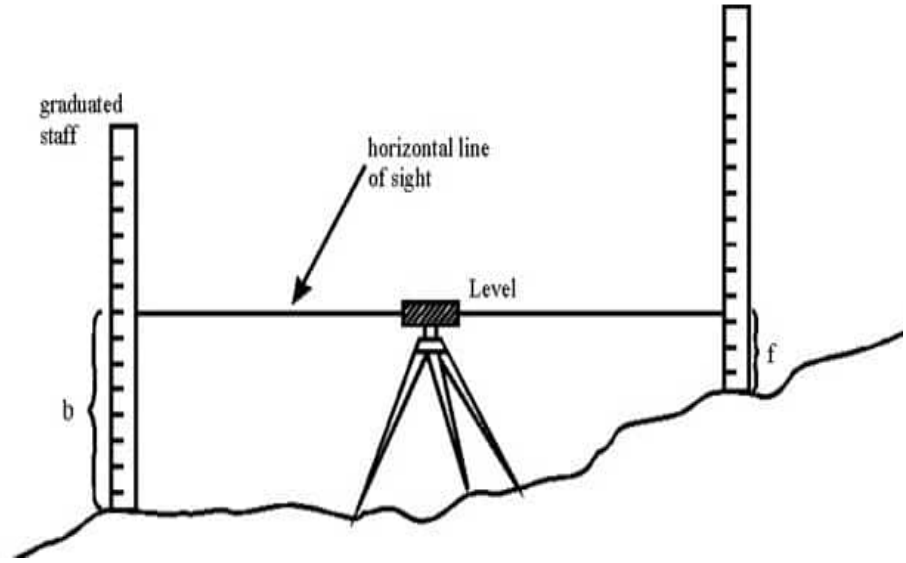
Leveling is a branch of surveying in engineering to measure levels of different points with respect to a fixed point such as elevation of a point, height of one point from a reference points etc. there are four methods of leveling in surveying these are direct leveling, trigonometric leveling, barometric leveling and stadia leveling.

2.1.1: Direct Leveling

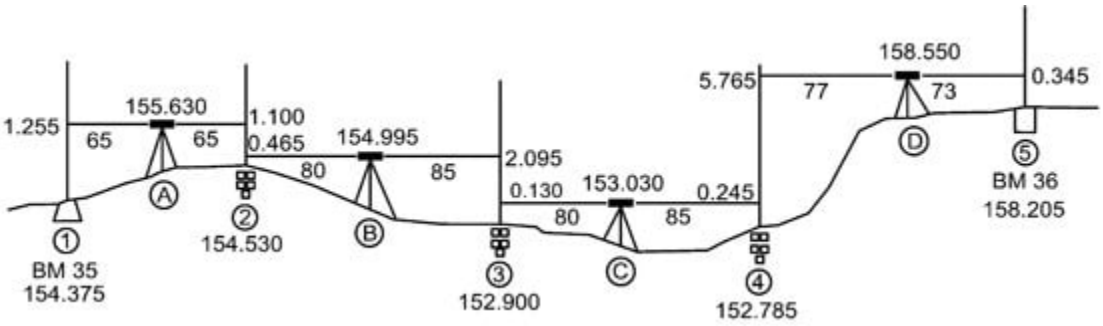
It is the most commonly used method of leveling. In this method, measurements are observed directly from leveling instrument.

Based on the observation points and instrument positions direct leveling is divided into different types as follows:

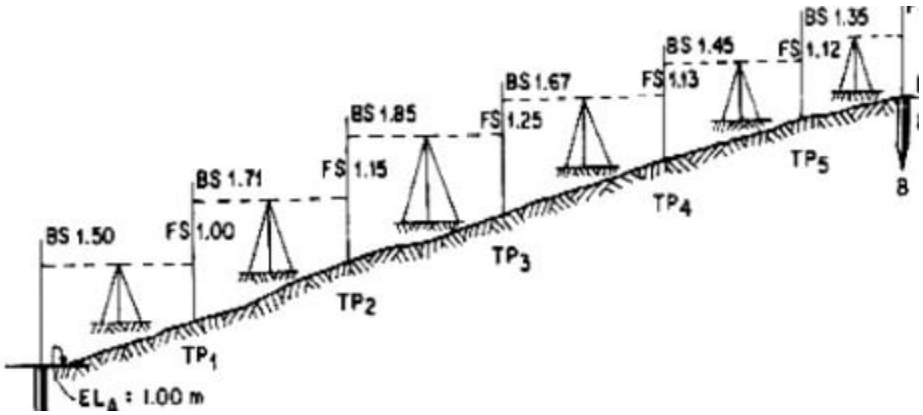
- **Simple leveling:** It is a simple and basic form of leveling in which the leveling instrument is placed between the points which elevation is to be finding. Leveling rods are placed at that points and sighted them through leveling instrument. It is performed only when the points are nearer to each other without any obstacles.



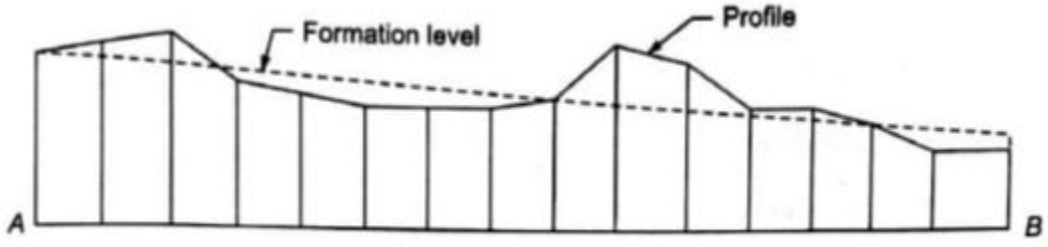
- **Differential leveling:** Differential leveling is performed when the distance between two points is more. In this process, number of inter stations are located and instrument is shifted to each station and observed the elevation of inter station points. Finally difference between original two points is determined.



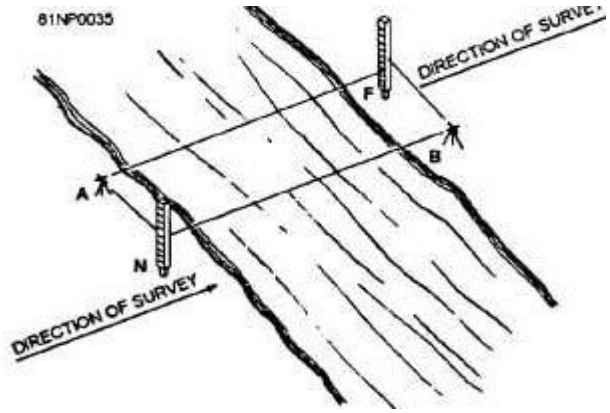
- **Fly leveling:** Fly leveling is conducted when the benchmark is very far from the work station. In such case, a temporary bench mark is located at the work station which is located based on the original benchmark. Even it is not highly precise it is used for determining approximate level.



- **Profile leveling:** Profile leveling is generally adopted to find elevation of points along a line such as for road, rails or rivers etc. In this case, readings of intermediate stations are taken and reduced level of each station is found. From this cross section of the alignment is drawn.

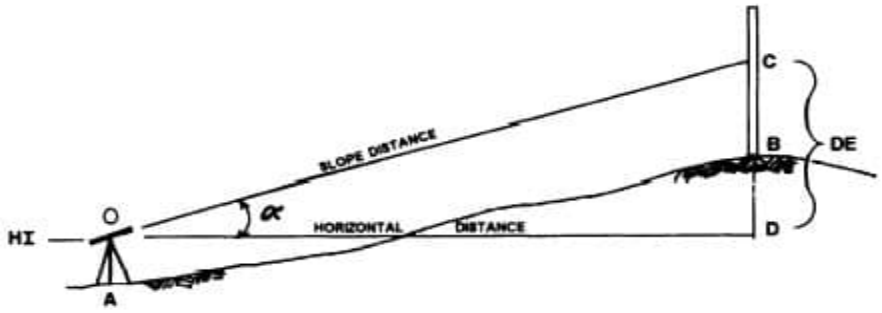


- **Precise leveling:** Precise leveling is similar to differential leveling but in this case higher precise is wanted. To achieve high precise, serious observation procedure is performed. The accuracy of 1 mm per 1 km is achieved.
- **Reciprocal leveling:** When it is not possible to locate the leveling instrument in between the inter visible points, reciprocal leveling is performed. This case appears in case of ponds or rivers etc. in case of reciprocal leveling, instrument is set nearer to 1st station and sighted towards 2nd station.



2.1.2: Trigonometric Leveling

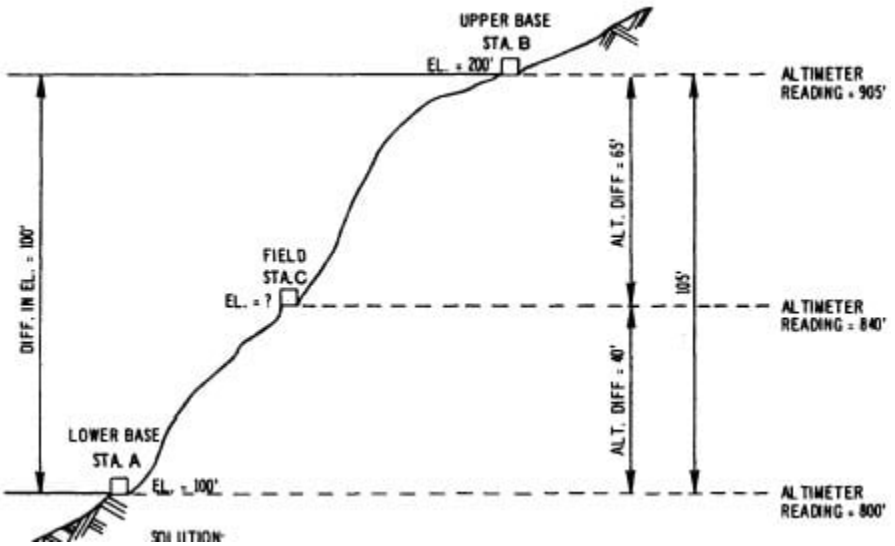
The process of leveling in which the elevation of point or the difference between points is measured from the observed horizontal distances and vertical angles in the field is called trigonometric leveling.



In this method, trigonometric relations are used to find the elevation of a point from angle and horizontal distance so; it is called as trigonometric leveling. It is also called as indirect leveling.

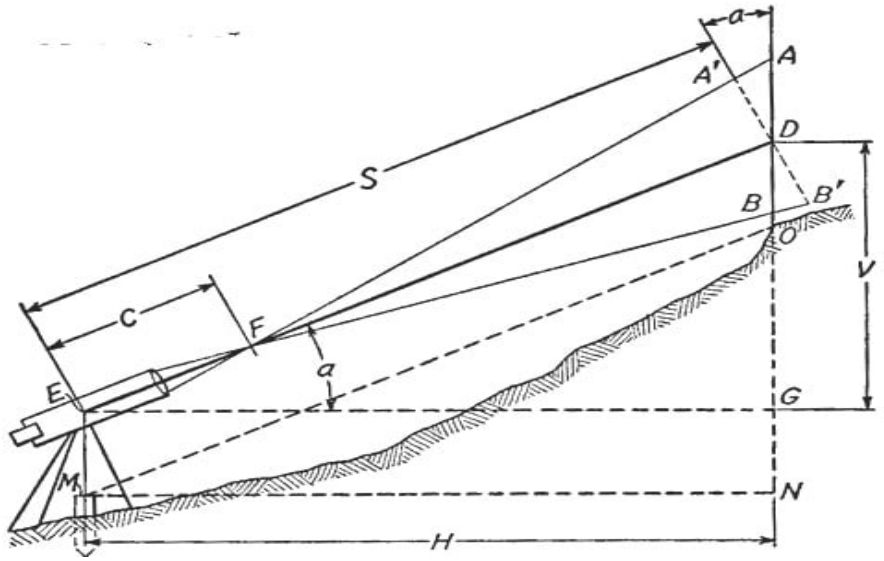
2.1.3: Barometric Leveling

Barometer is an instrument used to measure atmosphere at any altitude. So, in this method of leveling, atmospheric pressure at two different points is observed, based on which the vertical difference between two points is determined. It is a rough estimation and used rarely.



2.1.4: Stadia Leveling

It is a modified form of trigonometric leveling in which Tacheometer principle is used to determine the elevation of point. In this case the line of sight is inclined from the horizontal. It is more accurate and suitable for surveying in hilly terrains.



2.2 Preparing work procedures to perform surveying techniques.

2.2.1: Preparing work procedures:

To perform any surveying techniques it is essential to prepare work procedures. Accordingly, any leveling activities in surveying may include the following procedure:

- Identifying the application area or purpose of the surveying technique
- Plan and prepare work
    - ⇒ Identifying and selecting suitable surveying equipments
    - ⇒ Identify the site to be surveyed
    - ⇒ Preparing appropriate field notes
- *Checking on instrumental errors*: In surveying leveling activities checking on the arithmetic calculations does not tell you how accurate your survey has been. To fully check on your accuracy, level in the opposite direction.
- Establishing Benchmark (BM):
- Conducting land surveying and leveling activity
- Conducting arithmetic calculations and checking for errors
- Carrying out sketches and/or drawings and designs
- Recording and document data

2.2.2: Following work instructions

Whenever you're given instructions for a task or project, you'll need to make sure that you clearly understand what you have to do. Instructions may be provided in written or verbal form, or sometimes a mix of the two.

Being able to give and receive instructions effectively is an important part of communication on the worksite. Here are a few tips to help you out if you're given instructions that are unclear or incomplete or if you have trouble understanding them.

- ☞ Take notes. It's hard to remember everything by keeping it in your head. Writing a few notes helps remind you what needs to be done.
- ☞ Ask questions. Don't be afraid to ask for more information or for clarification on something. Something simple like, 'I don't quite get what you mean by…' or 'Could you tell me a bit more about how to…' is a good way to get the details you needed.
- ☞ Be aware of language. You may be teamed up with people from other countries or cultures who don't speak English as well as you do. This can sometimes make communication difficult, but be patient. Listen carefully, speak clearly, take notes and ask

questions until both you and the other person(s) are sure the instructions and/or information have been communicated correctly.

- ☞ Confirm the instructions before you start the task. Never walk away feeling unsure about what you've got to do. A good way of confirming is to say something like, 'OK, before I go, I'll just check I've got this right…', then refer to your notes, run through the key points or steps, and ask for confirmation that you've got all the information you need.
- ☞ Sequence the instructions. Putting instructions and/or steps into the order you'll be completing them makes them much easier to follow.

2.2.2: Applying quality requirements

As with all the surveying tasks there are quality requirements related to carrying out leveling operations. If you're unsure about quality requirements whether in relation to the work you're doing, the materials you're using, or some other area – always check with your supervisor.

Although there is no specific Standard for leveling, information related to carrying out leveling operations can be found in some of the Standards for construction elements that rely on correct establishment of ground level.

2.3 Applying surveying techniques according to work place procedures

There are many different land surveying techniques, there are five fundamental ones that are used the most often. These five techniques can be used alone or, most often, in a combination of some form or another.

- **Triangulation** – This technique uses a series of fixed points or stations in the area to be measured. These stations are connected as triangles, joining and overlapping each other. From these points, angles are measured. This is the most commonly used of the land surveying techniques and is also the most efficient in that it minimizes the number of different measurements that are needed.
- **Trilateration** – Using the same principles as described in the triangulation method of land surveying techniques, trilateration adds electronic distance measuring equipment. This allows for faster and easier mapping of uneven and rough terrain.
- **Leveling** – This technique is used to determine land elevations. It begins with a fixed point such as a metal pole and uses a leveling instrument to move up and down an area, determining height at specific points along the way. Each one of these points provides part of the calculation, which is a determined using trigonometry method. The most common use for this type of land surveying technique is in determining information for elevation maps.

- **Traverse** – The method in which a series of lines with predetermined and measured distances and lengths are used to connect together at various points in determined location. These traverse lines can be open or closed and can be easily moved around uneven terrain or obstacles that are in the way. This technique is most often used in the surveying for new roads, railroads, pipe lines, canal networks and other such linear projects.
- **Radiation** – Most commonly used along with a plane table, this land surveying technique is often used in conjunction with triangulation and traverse methods of measurement. This method takes a fixed position above a ground location in which various points are taken along the boundary line then drawn out on paper. Once drawn out, the distance is measured and converted to the necessary scale on the survey sheets.

Self-Check #2	**Written Test**

Name: _____ Date: _____

Directions: Answer all the questions listed below.

1. List and explain the different leveling methods in surveying? (**10pts)**
2. Write the procedures for surveying and leveling? (**10pts)**
3. Write the five land surveying techniques?(**10pts)**

Note: satisfactory Rating-15 and above pts. Unsatisfactory Rating-below 15 pts
You can ask your teacher for the copy of the correct answers

INFORMATION SHEET#3	**Establish offsets for civil works**

3.1: Establishing offset and recovery pegs from survey controls

3.1.1 Survey controls

The connection between a construction plan and the real world of a construction site it represents must be clear and accurate.

To be able to relate a plan to actual land and construction, the mapmaker locates the known position (latitude, longitude and height) of a feature that can be seen clearly on the map. These positions are known as the survey control, and they are used to establish offsets for civil works.

Before you establish offsets, make sure you know what the survey control feature or features are so that the offsets are set in the correct position according to plan

3.1.2 Establish offset and recover pegs

Offset pegs are used to re- establish the original lines and design points of the proposed structure. This is because, for example when doing foundation constructions, the corner pegs will be lost once excavation starts. To avoid this, extra pegs called offset pegs are used. It is good practice to install all offset pegs within the construction site boundary.

Check site plans to identify where these offsets need to be placed and at what distance.

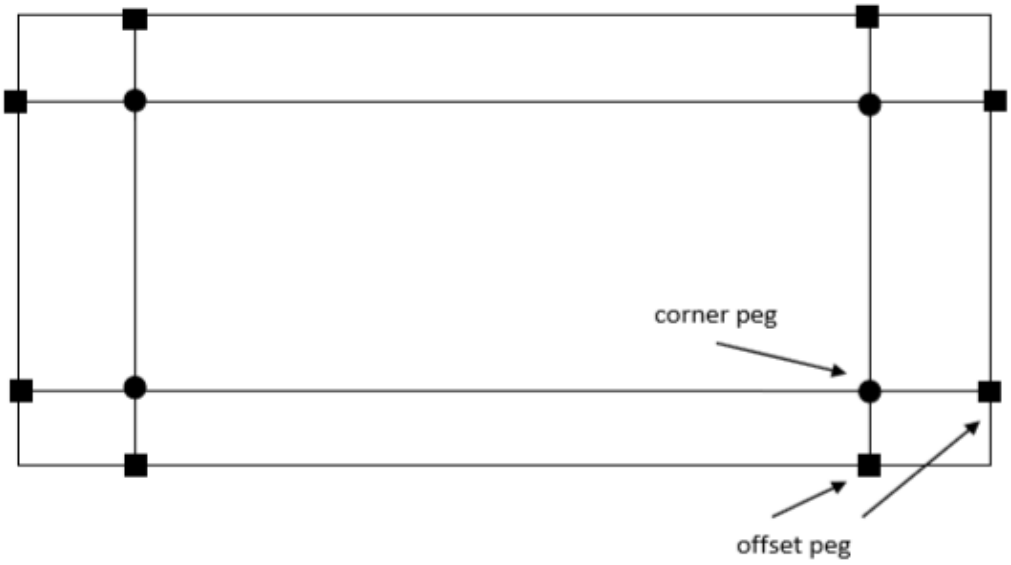


Figure_: Example: Offset pegs in a foundation construction.

3.2 Re-establishing earthwork and pavement control lines

The depth of earthworks or placing materials on top of original ground line will mean that levels will have changed.

Once the level after construction work is higher or lower than the starting point, control lines will need to be re-established. It is important when doing this that the same datum or benchmark be

used from preliminary surveys is used to re-establish the earthwork and payment control lines. It is therefore important that this control point remains stable and unmoved throughout the construction to be used as a reference point for these reestablishment calculations.

The time and cost that is required for resetting these control lines can be reduced if easy to use reference markers are set before construction is started.

It is important that these re-established markers are placed in stable, undisturbed ground.

3.3 Establishing drainage offsets from survey control

Drainage offsets are established using similar principles. Drainage offset pegs should be installed prior to beginning drain excavation, according to site plans.

Offset pegs are positioned and located in an area least likely to be disturbed from the trenching work. This distance to the offset peg should be read from the site plan; and the offset distances for the pegs should be kept the same.

The offset distance should also take account of where excavated material will be placed and the space required for the free movement of plant.

Self check #3	Knowledge questions

Name: _____ Date: _____

Directions: Answer the following questions in the space provided

1. Explain in your own words the purpose of the following: (6 points)
   a) What recovery pegs are used for? _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _
      _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ —
      _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _
   b) What offset pegs are used for _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _
      — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _
      _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _
   c) What drainage offsets are used for_ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _
      _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ —
      _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _
2. Explain why the offset and recovery pegs must be linked to the survey control. **(4 points)**

   _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ —
   _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _
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   — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _ — _ _ _ _ _ _

   Note: satisfactory Rating-5 and above pts. ***Unsatisfactory Rating-below 5 pts***
   You can ask your teacher for the copy of the correct answers

INFORMATION SHEET#4	Set up and use leveling device

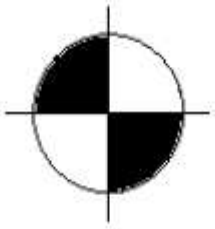
4.1. Identifying heights to be transferred /established

Heights or levels includes:-

- ✓ drawing/sketch,
- ✓ verbal or written instructions,
- ✓ datum/survey peg,
- ✓ chalk or nail mark and mark on vertical surface
- ✓ Reading levels from plans or instructions etc.

Therefore to identify the heights or levels using plans are technical drawings drawn to scale. They include all the details about the dimensions of the design for what is being constructed. They include all aspects of a project from less technical aspects such as a map of the site to cross-sectional plans and longitudinal plans.

Your work will involve reading heights (and depths) of construction or structures from project plans or instructions. It will be your task to take these and make them happen in reality. All plans can be aligned to a worksite using a predetermined point called the datum. As mentioned previously, a datum is the 'initial point' of reference, which has a set latitude, longitude and elevation on the worksite. This is one of the most important reference points on any plan. The location of the datum can be represented on plans in a number of ways but is generally shown like the following example:



Example of a datum symbol

A datum is on a plan so there is always a reference to find out the exact position of everything that features on the plan. The best way to read a level from a plan is to locate a real plan of an existing construction and look at the levels from the plan and see how they look in the actual real construction. Do this for three or four different measurements on the plan to get familiar with looking at the paper version and what it then looks like in reality when construction has been completed.

4.2. Setting-up leveling instruments

Set up and use leveling instruments is important that leveling instruments are used according to manufacturer's instructions to make sure all levels measured are accurate. Some leveling tools require special setting up. Laser leveling equipment requires special care.

Common error sources

- ✓ level rod not vertical or not held straight
- ✓ leveling rod not fully extended or incorrect length
- ✓ level instrument not level
- ✓ instrument out of adjustment
- ✓ environment – wind or heat
- ✓ incorrect reading, incorrect recording

Setting up the tripod

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.

1. Using an optical level

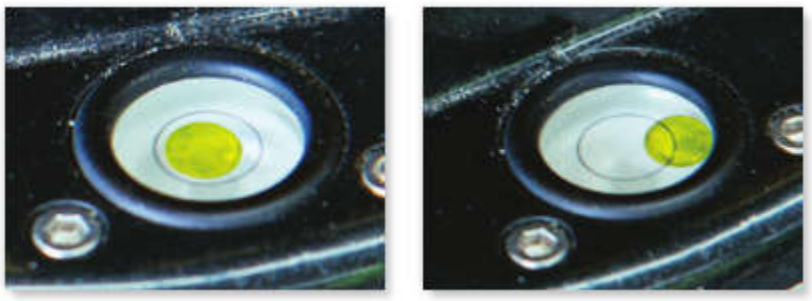
As an optical level is a very simple instrument, there is little difference in the way the various types are used to take a measurement. However, there are variations in the process of setting up and adjusting the instrument for accuracy.

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

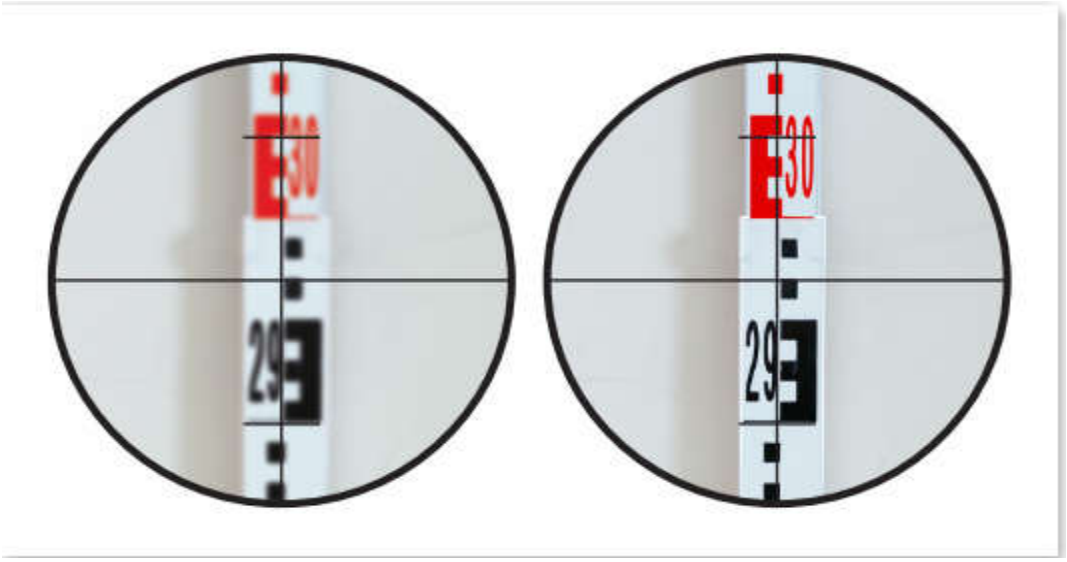
Setting up

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 centre.

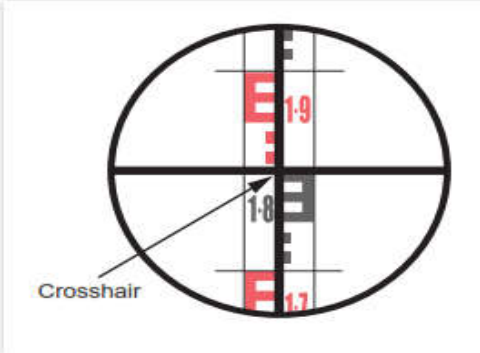


b) Swing the optical level around 180° and centre the bubble again.
c) Return the optical level to the starting position and recheck the bubble.
Adjust as necessary until the optical level is accurate in all directions. As long as the bubble in the circular level is central, the automatic compensators 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 clear.



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

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.



2. *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.

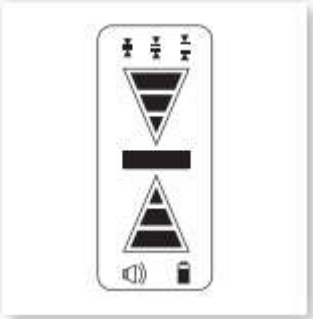
The following information is a basic guide to setting up and taking level readings with a rotating laser level as these are the most commonly used on Australian building sites.

Setting up

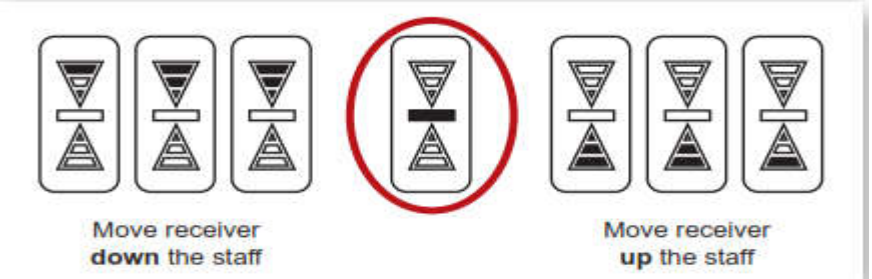
1. Securely mount the laser level on a tripod or suitable surface.
2. Press the power button on the instrument, allowing enough time (approximately 60 seconds) for the laser to self-level. The laser head may begin to rotate before the self-leveling is complete.
3. Select the required rotation speed.

Taking a reading

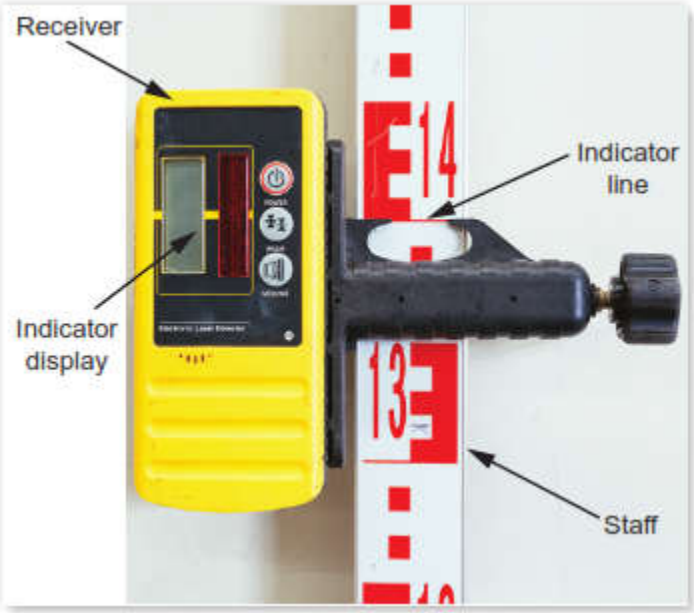
1. Mount the laser receiver on the staff at the measurement position, turn it to face the laser beam then press the receiver's power button.
2. Slowly move the receiver in an upwards and downwards direction until the laser beam indicator arrows appear and you hear an audible signal.



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 precisely level with the receiver.



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



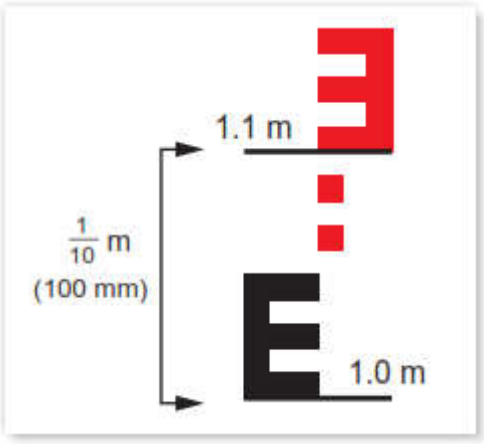
3. Using a staff

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

Reading an E-staff

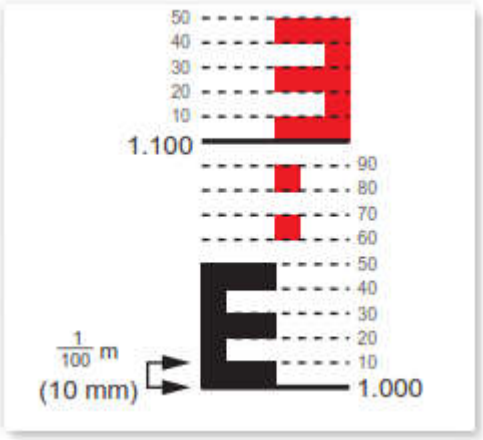
An E-staff has a series of 'E' shapes printed at set intervals along its length, with two small squares between each. These shapes are used like the lines on a ruler or tape measure but are easier to see at a distance.

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.

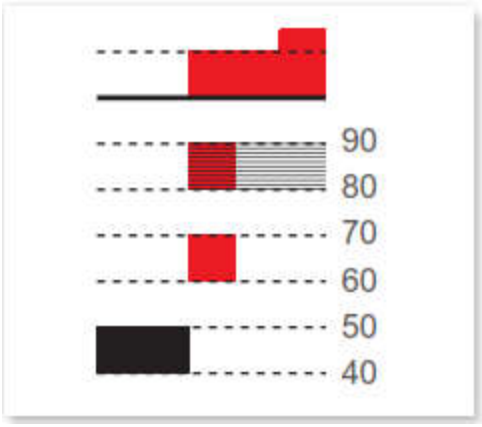


Each vertical block of color (and space between) in the shapes is **one hundredth of a meter** (10 mm) high. There are 10 separate blocks of color (and space) between each numerical label (10 × 10 mm = 100 mm).

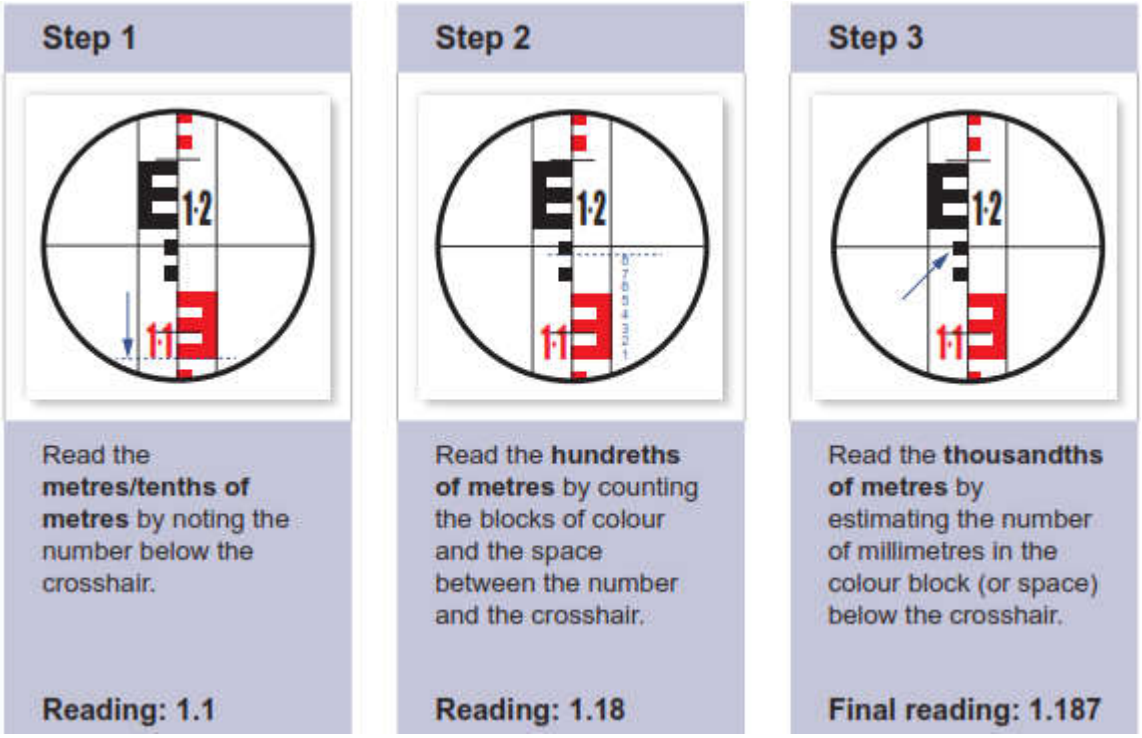
Note: You will notice that each E-shape is 50 mm (5 × 10 mm).



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



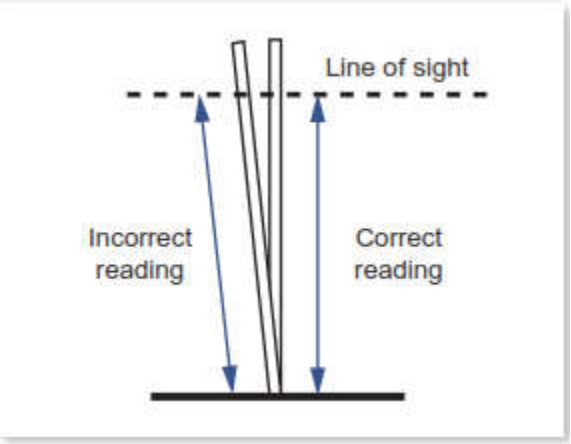
The process for taking a level reading on an E-staff is completed in three steps.



Holding a staff

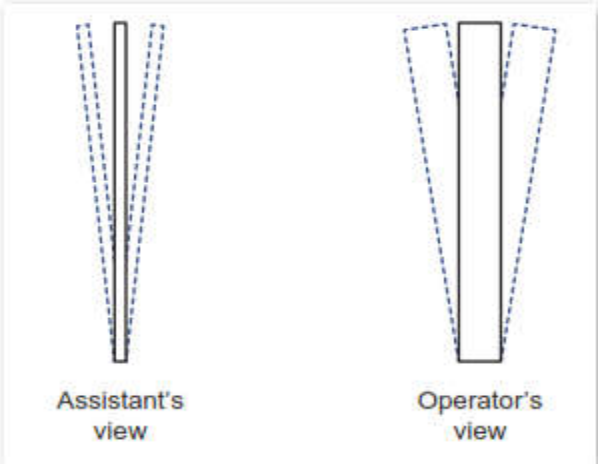
Taking a level with an optical leveling instrument usually requires an operator to look through the telescope and take the reading, and an assistant to hold the staff at the measurement point.

A land surveyor's assistant is also known as a chain person because surveyors 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 behind the staff, neither the assistant nor the instrument operator can tell whether the staff is vertical from the side.
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.



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. 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.

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

When you're working with people from different backgrounds who speak different languages and have had experiences and work methods, what can you do to make sure you are communicating effectively? List five strategies.

1. _____
2. _____
3. _____

4. _____
5. _____

4.3. Transferring heights from the known to the required

In your work you will need to look at heights on plans and transfer these to the actual work site. The height will be marked on the plan and you will need to transfer this reading to the 'real world'. At times you may also have to do the reverse; you may have to create plans from an existing building or worksite, taking measurements and marking these on a plan.
When transferring heights:

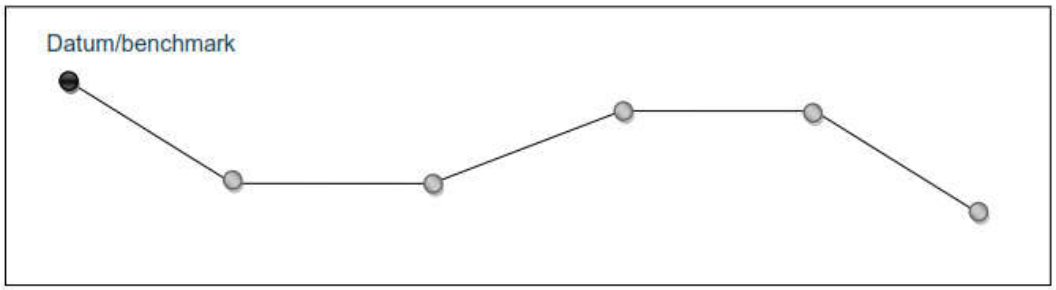
- ✓ make sure you read the plan correctly
- ✓ use the correct measurement method, mm or meters are normally standard but double check
- ✓ start at the right point indicated on the plan
- ✓ if you are unsure about anything on the plan check with your supervisor
- ✓ start with the reference point (e.g. datum or benchmark) as the starting point for measurements
- ✓ some leveling tools become inaccurate over longer distances so care should be taken with selecting the correct method and tool for the task
- ✓ always consult your supervisor or trainer when unsure about methods or tools

4.4. Documenting results of leveling procedure and closing out

A. Open and close traverse

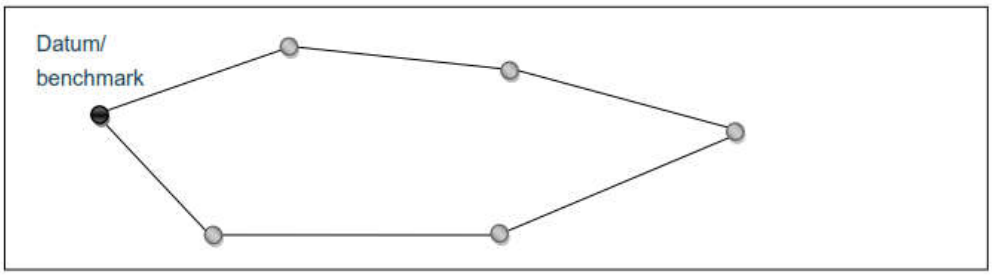
Open traverse

An open traverse is a series of linked traverse lines as outlined below, which do not return to the starting point.



Closed traverse

Always **start** and **end** a closed traverse on the same datum/benchmark. More reliable as finishing on the same point allows for error checking.

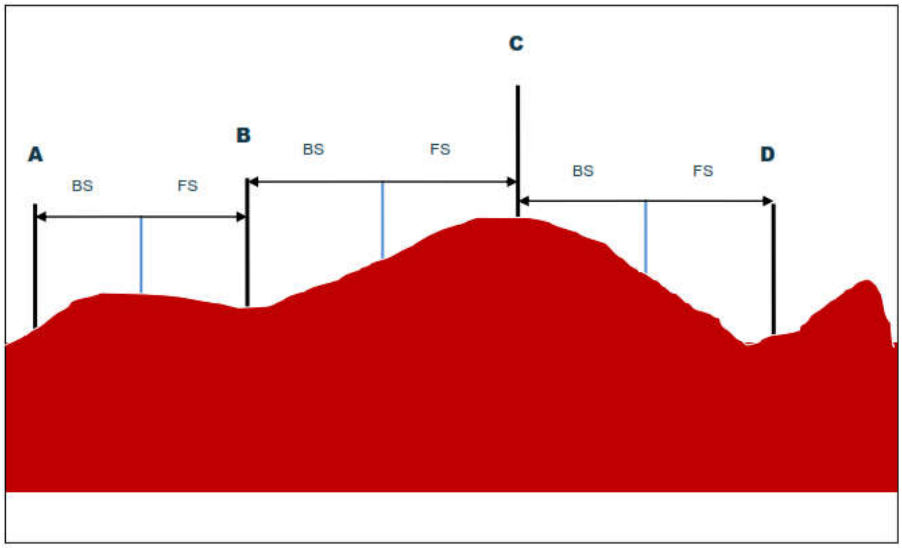


B. Rise and fall methods of reduction

This is a method of recording heights taken in leveling, such as an open or close traverse.

As the levels are taken at different sites, using the example below from point A to point D, the heights rise and fall. This provides the basics behind rise and fall method for finding out elevation of unknown points.

So, the difference between the staff level readings shows a rise or a fall at the point is smaller or greater than the point before it. A simplified example of this is outlined below.



	Backsight (BS)	Foresight (FS)	Level
A		From A measure B	a to b = rise
B	From B measure A	From B measure C	b to c = rise
C	From C measure B	From C measure D	c to d = fall
D	From D measure C		

A back sight is a reading from where you have come from, and a foresight reading is in front of you where you haven't been yet.

When using this method double check all measurements and calculations. Make sure readings are entered into the correct space. Check mathematical calculations while still on site.
As measurements are never 100% accurate there is a 'tolerance' allowance for error. This is the amount of error that is acceptable. This allowance should be set by the project coordinator or as an acceptable level by the worksite and should be checked.

C. Mathematical calculations

It is important to get the calculations used in leveling correct. This is especially important when you are doing an open or closed traverse or the rise and fall method of reduction as these involve a series of calculations and if one calculation is incorrect then the series will not be correct.

Example:

You are at a worksite when the council has a temporary benchmark of 20.5m. You have four locations for measurements. One of the first tasks is to find out the height of the temporary benchmark plus the height of the instrument you are using. This is done taking a 'backsight'. In this case the back sight is 1.5m.

Temporary bench mark: 20.5m Backsight: 1.5m Instrument height: 20.5 + 1.5 = 22 m

Readings taken around the site recorded as follows:

Location	**Reading**
A	1.55
B	1.75
C	1.86
D	1.45

With the readings, now you need to 'reduce' the levels. 'Reduce' the levels means that what you are doing is finding out the height of the ground at the base or bottoms of the staff.
As you know the height of the instrument level all you have to do is subtract the staff reading to find out the actual height of the level on the ground.
This can be recorded in the table as seen below.

Temporary bench mark: 20.5m Back sight: 1.5m Instrument height: 20.5 + 1.5 = 22 m

Location	Reading	Reduced
A	1.55	22-1.55=20.45
B	1.75	22-1.75=20.25
C	1.86	22-1.86=20.14
D	1.45	22-1.45=20.55

When recording heights and performing mathematical calculations, make sure:

- ✓ Readings are checked carefully before marking the position
- ✓ Take a second reading to be sure
- ✓ If you are unsure of a reading, you may want a colleague to double check for you
- ✓ You don't 'transpose' numbers. This is done by changing the order of the numbers from a reading – for example writing 2.32 as 2.23, where the 2 and 3 after the decimal point are swapped around

Self-check -4	**Written test**

Name _____ **Date**_____

1. List and explain the main parts of the surveying instrument? (**5pts**)
2. How to Set-Up a Total Station to Conduct Surveying Operations? (**5pts**)
3. Explain the difference between an open traverse and a close traverse leveling?(5pt)
4. When transferring heights from the known to the required? (**3pts**)
5. Write the procedure to documenting results of leveling and closing out. (2**pts**)
6. Demonstrate or explain the rise and fall method of reduction. Make notes if needed to clarify your explanation. (10Pt)

Note: Satisfactory Rating; 25 and above unsatisfactory rating: below 25
You can ask your teacher for the copy of the correct answer

Operation Sheet	**Set up and use theodolite device**

- **Objective**: how to Set up theodolite device using different leveling methods.

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Materials, Tools and equipments used :-are surveying set.

Procedures

- The following procedures should be taken into account to set up and use theodolite device
  1. Gather the Survey Equipment, Stake, and Tools.
  2. Establish a New Temporary Benchmark.
  3. Set-up the Tripod.
  4. Attach the Tribrach and Course Level the Tripod Over the tripod.
  5. Continue to Level and Adjust the Tribrach As Necessary.
  6. Set the Instrument on the Tripod.
  7. Connect Power Supply and Communication Cables it may be.
  8. Power-on the Instrument and Controller to Access the Fine Level.
  9. Fine Level the Instrument and Compensate.
  10. You're ready to Survey.

INFORMATION SHEET#5	**Clean up**

5.1 Clearing work area and disposing or recycling materials

5.1.1 Clearing and disposing in working area

A workplace should be kept clean during operations and also cleaned up once operations have been completed. The benefits of a clean and tidy workplace include:

- Injuries in the workplace can be prevented
- Positive attitude is created for health and safety issues
- Work efficiency and employee morale is improved
- Work productivity can be increased

5.1.2 Disposing of waste

Generally you will be asked to dispose of materials during the cleaning up stage of a job when it has been completed.

During clean-up there are environmental controls which organizations must follow or face punishment such as fines or even jail terms.

Your organization must have the policy and procedures in place to correctly dispose of all the types of waste that are produced. For example, some materials will be:

- ☞ Recycled
- ☞ Disposed of as rubbish
- ☞ Used for future jobs

There will be a project environmental management plan that will direct how to dispose of materials.

If there is a problem with a system that you are asked to follow, you must notify the appropriate person, such as your supervisor or manager. It is everyone's responsibility to continually improve environmental methods and procedures in the workplace while following all environmental laws.

5.1.3 Environmental protection requirements

When undertaking your work activities you must take into account any environmental protection requirements. For example, when you are cleaning up after work activities you must dispose of waste according to workplace policy. This will involve recycling materials such as paper, plastic, wood and steel, while safely disposing of material that may require special attention such as liquid waste.

You should obtain these environmental requirements from the project environmental management plan at your workplace and speak to your supervisor regarding these requirements.

5.2 Cleaning, checking, maintaining and storing tools and equipment

5.2.1 Checking and keeping equipment clean

You should maintain your equipment in a good condition. You have a greater chance of noticing any defects and any maintenance required when you clean equipment after use. After you have finished with equipment, always return it to its allocated place so it can be easily found when required.

5.2.2 Maintenance of equipment

There will be workplace documentation that states when equipment is to be serviced or checked. Basic maintenance requires that equipment is cleaned and checked for any faults and that faults are reported to your supervisor.

Injuries can occur when tools are not maintained correctly.

5.2.3 Storing equipment

Storing equipment when not in use is also a part of safe work practices. You should always return equipment to its designated place after use. It will not then get in the way of others working in the area or cause an accident. For example if an electric piece of equipment is left on a bench use it, it could:

- Be accidentally switched on and cause someone serious injury
- Be knocked off the bench and hurt someone
- Become a tripping hazard if the lead is left plugged in
- Be used by an unqualified operator
-

Self check # 5	Knowledge questions

Name: _________________________ Date: _______________

Directions: Answer the following questions in the space provided

1. What are the benefits of cleaning tools after use? (***3 points***) _
2. What should you do with waste (rubbish) at the end of the project? (***4 points***) _
3. How should leveling tools and equipment be cleaned and stored? (***3 points***) _

Note: satisfactory Rating-5 and above pts. ***Unsatisfactory Rating-below 5 pts***
You can ask your teacher for the copy of the correct answers