Rural Land Administration

Level – III

Based on March 2022, Version- II Occupational Standard

Module Title: - Maintaining Surveying Equipment

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Introduction to the Module

Surveying Equipment module covers the competence required to perform basic proper field procedures, care and handling of surveying equipment, operate surveying equipment for basic measurements.

LG #09	LO #1- Site Inspection

Instruction sheet-1

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

- OHS requirements
- Surveying equipment
- Undertaking Site orientation
- Identifying site and adjacent site features
- Identifying site grades

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

- Undertake Site orientation
- Identify site and adjacent site features
- Identify site grades

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet-1

1.1 OHS requirements

In this section use of personal protective equipment according to OHS requirements will be discussed. To ensure the safety and well-being of employees and visitors in the workplace, there are certain Occupational Safety and Health (OHS) requirements that must be met by employers. These requirements often vary by country or region and may include things like providing appropriate personal protective equipment, maintaining a clean and hazard-free work environment, implementing proper emergency response planning, providing adequate training for employees, and regularly assessing and addressing potential risks and hazards. Does that help answer your question? PPE (Personal Protective Equipment) is equipment or clothing such as hard hats, Safety boots, Coveralls, Gloves, Safety glasses, Earplugs, Lifejackets, fall protection and respirators worn by workers to help protect them from workplace hazards.

Types of Personal Protective Equipment

1. **Hearing Protection**

- Hearing protection should be worn in work environments where noise levels exceed 85 decibels. In limited circumstances, a worker may be exposed to noise levels above 85 decibels without wearing hearing protection, but the acceptable duration of such an exposure will vary depending upon the noise level (in decibels).
- There are many types of hearing protection, including earplugs or muffs. Hearing protection that is suitable for the work environment and provides adequate noise reduction should be chosen.

Figure 1.1 Ear protector

2. **Respiratory Protection**

There are many types of respirators available to protect against a variety of atmospheric hazards. It is important that the respirator being used for a particular job protects against the hazard in question. Using the wrong respirator can be as dangerous as not wearing one at all. All respirators must fit well and provide a proper seal with the wearer's face in order to provide adequate protection.

1) Disposable respirators should be used where dusts, mists and fumes may be present. They must not be used in oxygen deficient atmospheres.

2) Chemical cartridge respirators should be used to filter out gases and organic vapors. These respirators are hazard-specific, meaning that a cartridge designed to filter out a

particular gas will not protect a worker from exposure to a different gas. They must not be used in oxygen deficient atmospheres.

3) Powered air purifying respirators should be used where there may be excessive dust levels or pesticides. These respirators:

- Have replaceable cartridges that are hazard-specific
- Are operated by battery
- Have a constant air flow, facilitating breathing
- Must not be used in oxygen deficient atmospheres

4) Gas masks should be used for high concentrations of specific gases. They usually have a full face piece and canister attached. They must not be used in oxygen deficient atmospheres.

5) Supplied air respirators should be used in highly toxic and oxygen deficient atmospheres. Users should be well trained. Such equipment:

- Comes with the air supply in a tank
- Comes with a small emergency bottle
- Has positive pressure for use in toxic atmospheres
- Should never be used alone
- Should be used according to confined space entry procedures.

Figure1.2 Respiratory Protection

3. **Eye Protection**

Eye protection should be used where there is a danger of flying objects, particles, liquids, sprays or other matter entering the eyes. Protection can take many forms including:

- Safety glasses,
- Goggles, or
- Full face protection.

Figure 1.3 Safety goggles

4. Foot Protection

Foot protection is usually in the form of steel-toed work boots, with a steel shank to protect the bottom of the foot from puncture wounds. In wet environments, steel-toed boots that are waterproof and slip-resistant may be necessary. The hazards that workers are exposed to will determine what type of foot protection is most appropriate for the job.

Figure 1.4 Safety shoes

5. **Hand Protection**

Gloves offer good protection for the hands. They may be made of many different materials--cotton, leather, rubber, or other materials impervious to liquids. Gloves should be chosen for the specific hazard and job task.

Figure 1.5 Hand protection

6. Head Protection

Hard hats, bump caps, or helmets are types of protection that should be considered if there is a hazard of head injury. Head injuries can occur under various circumstances including as the result of a slip or fall, working with unpredictable animals, working in confined areas or where there are low ceilings or where there may be falling objects.

Figure 1.6 Head protection

7. Body Protection

Body protection may be required in various situations including dusty environments or when spraying liquid pesticides or handling dangerous chemicals. The hazard to be controlled will determine the type of protection that is most appropriate, for example, an apron, coveralls or a full rain suit.

Figure 1.7 Body Protection

8. Fall Protection

Fall protection includes the use of safety belts, harnesses and lifelines to prevent injury due to a fall from a height.

- What worker education and training for PPE are required?
  - ✓ How the PPE provides protection from specific hazards
  - ✓ How to properly fit and wear it
  - ✓ When it must be worn
  - ✓ How to take care of it

- ✓ how to care for PPE and identify when it requires repair, cleaning or disposal
- ✓ How PPE provides protection and the consequences of not wearing it

- How does PPE fit into your OHS program?

You must include a PPE program as part of your OHS program. Topics include education, training, and selection, use, maintenance, and storage of PPE.

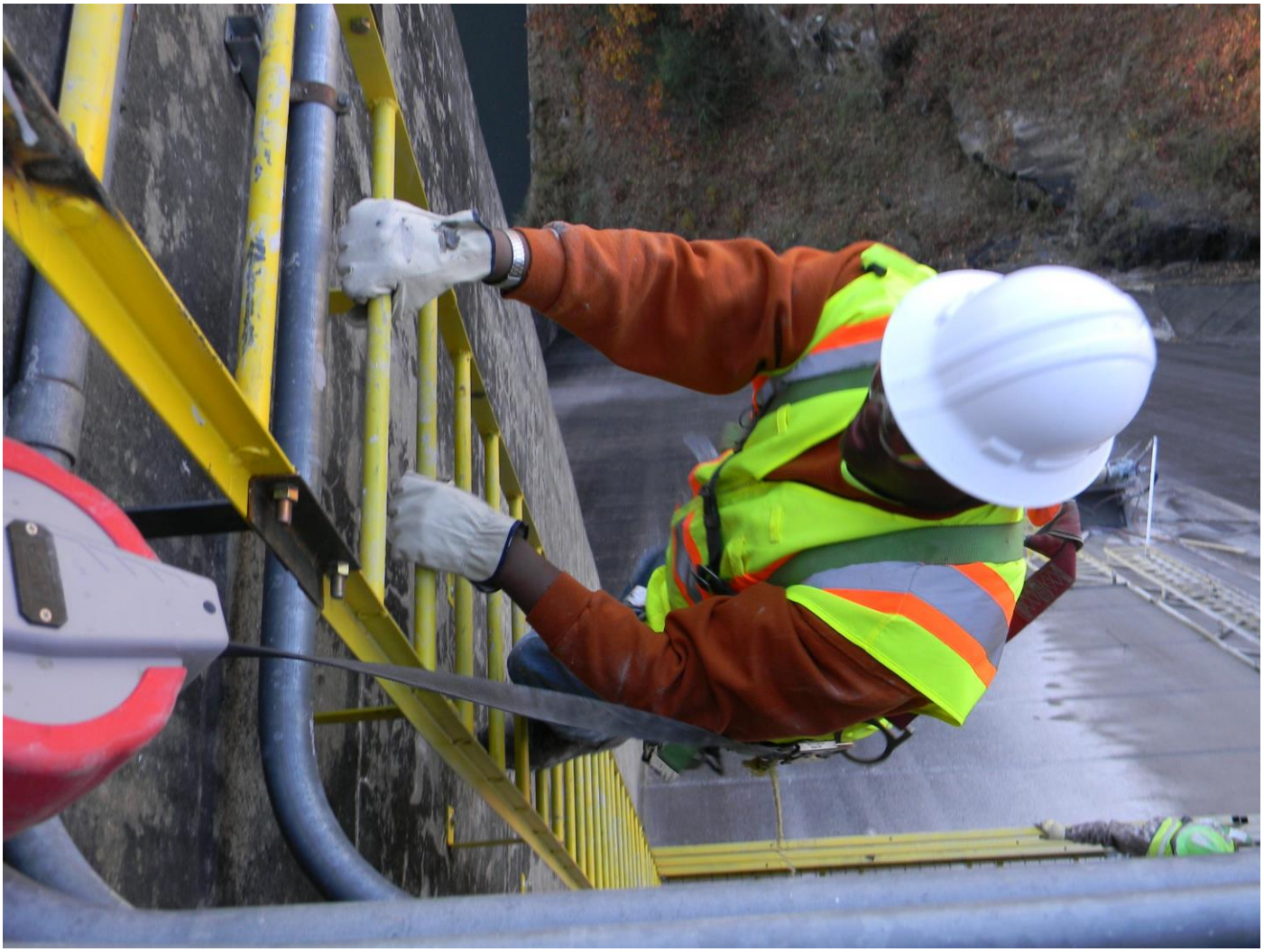


Figure 1.8 Fall Protection

1.2 Surveying equipments or Instruments

Surveying equipment is being used under most stressful conditions. The equipment is exposed to extreme weather conditions, used in dusty construction areas and is subject to bumpy transportation. Proper care in the methods by which equipment is used, stored, transported, and adjusted is a major factor in the successful completion of the survey. Lack of good maintenance practices not only causes unjustified replacement costs, but also can seriously jeopardize the efficiency and accuracy of the entire survey.

The crew leader is responsible for training all crew members in the use of equipment for its intended purpose and the maintenance of all surveying instruments, equipment, tools, and supplies. Should there be a need for additional assistance or training to deal with problems that arise during the course of the survey, a supervisor should be notified about it.

Various instruments are available from old technology to present day technology to measure direction, distance angles and height, Some of surveying instruments used on present day are shown in the following slide.

Figure 1.5 GPS

Figure 1.6 Leica 1200 total station

Figure 1.9 Automatic Level AP-7

Figure 1.10 Electronic Theodolite

Figure 1.11 Compass

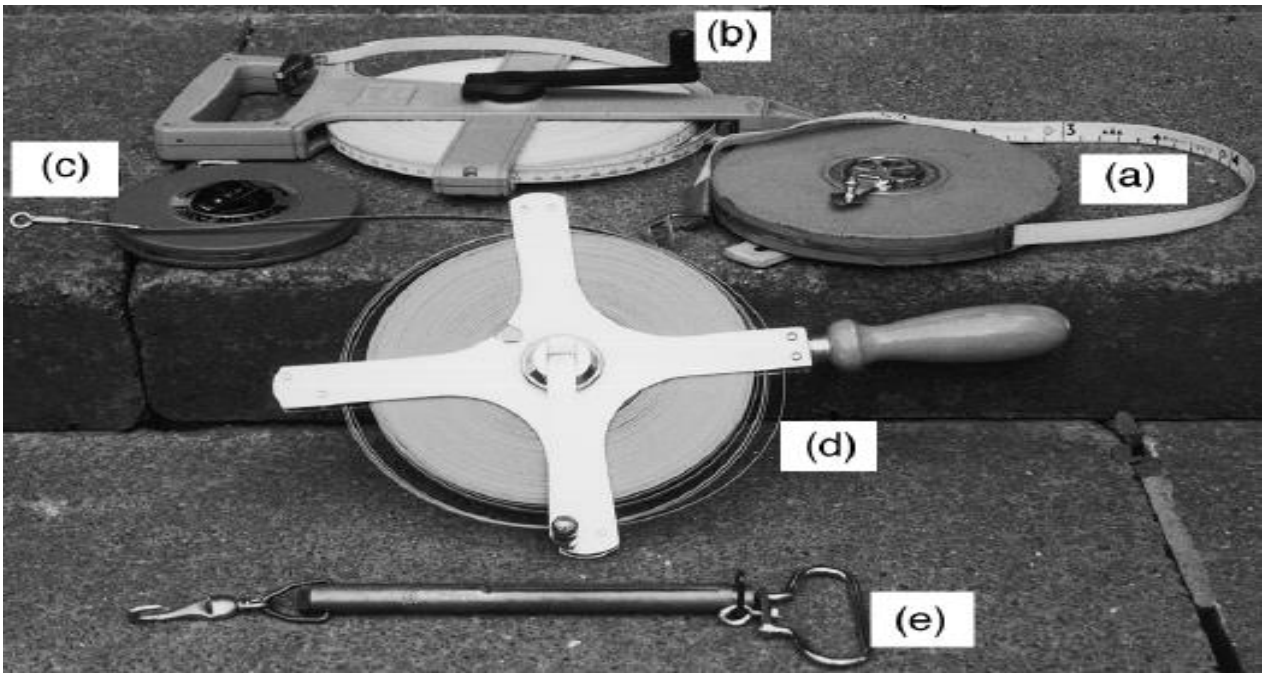


Figure 1.12 a) Linen tape, b) Fibre Glass, c) Steel, d) Steel Band, e) Spring Balance

1.2.1 Angle Measuring Instruments

Theodolites and mainly total stations are today's primary angle measuring instruments, particularly on all baseline and control surveys. Angular measurements by a theodolite or a total station are done essentially following the same procedure. The main difference between them is that a total station has battery operated electronic devices to display the measured angles, measure distances and perform on board computation. In general, they are also similarly built with many common features which are necessary to assure accurate and reliable operation.

Due to its low accuracy and inefficiency, the transit is not being used in today's survey work. Only theodolites and total stations will be discussed in this section.

1.2.2 Distance Measurement Instruments

Virtually all distance measurements are made today with an electronic instrument such as an EDM or GPS. Tapes are used only when very short distances have to be measured (i.e. on a construction site).

A. Total Stations and EDM's

Most electronic distance measuring instruments (EDM's) are used in combination with a total station. The EDM is either integrated into a total station or mounted on top of it. Some theodolites have special brackets for mounting an EDM on top of them as well.

Each EDM should be checked on a calibration baseline at least once every year, with results documented and filed at office. Most EDM's have approximately the same distance measuring accuracy when operated in accordance with the manufacturer's instructions, with the proper reflector systems. Every instrument, whether radio or light beam measuring, has an inherent plus or minus error in every measurement, plus a small error based on parts per million of the distance measured. These errors are generally insignificant in the overall survey, but the surveyor should be aware that they are present and that there is no such thing as an exact measurement.

B. Tapes

Surveyor's tapes are available in various lengths, of different materials, and with many methods of graduations. Although EDM's have replaced tapes for longer measurement, every crew should have both metallic and non-metallic tapes available. Tape reels for metallic or fiberglass tapes save time and help prevent damage to the tape, particularly if used in construction or heavy traffic areas.

1.2.3 Accessories for Angular and Distance Measurement Instruments

A. Tribrachs

A tribrach is the detachable base of all theodolites, total stations, forced centering targets, and most EDM's. Tribrachs are equipped with a bull's eye bubble for leveling and optical plummets for setting up precisely on a survey mark. The discussion on tribrachs is conducted in a separate section because they are being used with a wide variety of surveying equipment

Figure 1.13 Tribrachs

Use of Tribrachs

The ability to "leapfrog" backsight, instrument point and foresight by using interchangeable tribrachs increases the speed, efficiency and accuracy of the traverse survey. Whenever possible, the tribrach should be detached from the instruments and placed on the tripods for either theodolite or EDM setups. This procedure speeds up the setting up process and protects the instrument from accidents. In some cases, the same tribrach can be used to perform angular and/or distance measurements, as well as GPS observations from the same survey point.

B. Tripods

Tripods provide a fixed base for all types of surveying instruments and sighting equipment.

Figure 1.14 Tripod

Types of Tripods

In the past, different equipment required different tripods. However, due to standardization by instrument manufacturers, most of today's equipment utilize the same tripod. The same tripod can be used for total station, levels, and GPS. Tripods are made of either metal or wood. Wooden tripods are recommended for precision surveys to minimize errors because of expansion and contraction due to heat and cold.

1.2.4 Sighting Equipment

Surveyors use a wide range of sights for a variety of survey operations. The main purpose of a sight is to provide a reference that is visible to the instrument operator for either referencing from a survey point or establishing a survey point. In this context, sights may be required for line, distance, or a combination of line and distance.

A. Plumb Bob

The plumb bob string with Gammon reel is the old standard short distance sighting method, particularly for establishing temporary points. Steadiness of the holder can be enhanced by the use of braces or any type of framework. Various types of inexpensive string line targets are also available.

Figure 1.15 Plumb Bob

B. Range Poles

Range poles are the most common sight used by offices and are made in several cross-sectional shapes, of various materials and in different lengths or combinations thereof. Some are solid, some tubular, and others laminated. Most poles are approximately 25 millimeters (1 inch) in diameter. Smaller diameter "lining poles" may be made from small diameter pipe or rod. Electrical conduit suitably tipped and painted makes a good light weight sighting pole.

The use of a bull's eye rod level is an essential option when any type of range pole is "hand held" or guyed.

Figure 1.16 Range Poles

C. Forced Centering Targets

The tribrach mounted traverse target sets are recommended for all baseline traverse surveys, and other control surveys, when they are available. The tribrach contained optical plummet and target configuration provide the most positive daytime sight available. Several illumination kits, consisting of a light bulb case and battery case, are available for nighttime surveys.

Figure 1.17 Forced Centering Targets

D. EDM Prisms

Each manufacturer of EDM's supplies special prisms and prism holders that are compatible with its equipment. The single lens, tiltable holder with provisions for direct connection on the top of a sectional or telescoping plumbing pole is the most common type used in most survey work. Such prism holders are generally equipped with a sighting target mounted above or below the prism to provide parallel sight between the sighting and measuring beams. The maintenance of parallel sight becomes more significant in the accuracy of measurements as the distance is decreased. The use of the tiltable holder, with properly mounted target, maintains the parallel sight relationship, particularly in rough terrain. The surveyor should understand the necessity for parallel sights and know what the telescope aiming point is for the type of EDM being used. The various EDM's have different methods of transmitting, receiving and computing the light beam. Some light beams may be transmitted and returned to the instrument on the same path, while others travel to one side of the prism and return from the other side in a rectangular pattern. The pattern determines from which part of the prism the beam will be measured and, thus, affects the prism constant relationship between the EDM and prism being used. The position of the prism relative to the vertical axis of the sight also affects the prism constant. It is important that the proper prism constant is used; otherwise a systematic error will be introduced in all the measurements made between a particular EDM and prism. The best way to verify that true measurements will be made is to test the EDM and prism on a baseline of a previously established distance.

For longer measurements, cluster holders are available to provide an enhanced light return to the EDM. The clusters are generally arranged in groups of three prisms per holder with facilities to stack up to nine or more prisms on a common sighting plane. The sighting point for such distances is not critical. The surveyor should use his or her best judgment as to where the vertical sighting point should be. Most cluster holders are equipped for mounting on a tribrach by means of a standard tribrach adapter.

Figure 1.18 EDM Prisms

1.2.5 Leveling Instrument

Most surveyors maintain a hand level as part of their personal equipment. Hand levels are useful in level "runs" for quick location of turn and instrument points and to determine differences in elevation when chaining. They are also quite useful for rough elevation checks during grading operations. As with any other level, the level bubble can become out of adjustment and should be checked periodically. A quick check can be made against a good carpenter's level and adjusted similar to a regular level instrument.

Although the Department inventory shows dumpy and wye level instruments still in existence, pendulum type automatic levels are the standard leveling instruments used on Department

surveys. The principal of operation is essentially the same in all makes. The line of sight is maintained perpendicular to the direction of gravity through a system of prisms, called a compensator. Pendulum levels are fast, accurate and easy to maintain. Proper care and service is required to ensure continuous service and required precision. Do not disassemble instruments in the field. Only attempt those adjustments set forth in the instrument manual.

Leveling Rods

Leveling rods are made of wood, metal, or fiberglass and are graduated in feet or in meters. The foot rod can be read directly to 0.01 feet, whereas, the metric rod is usually read to 0.01 m. More precise reading can be made with add-on accessories such as a Vernier or an optical micrometer. Since leveling rod graduations come in a wide variety of patterns, the crew must become familiar with the specific rod used. Digital levels use a special leveling rod that has a bar code, instead of a numerical scale, for reading the elevation.

Leveling rods come in one, two or three sections. The multi-section rods can be extended to their full length in different ways. Some have hinges that accommodate folding of the sections, some have sliding sections that can be locked at the proper length, while others are folded telescopically and can be pulled open. The sole of the rod is a metal plate that will withstand the constant wear and tear of the leveling activities.

For very precise work, a one-section Invar rod is used. Invar rods are precision rods, which have been calibrated and are to be used in control surveys, deformation surveys, precise surveys and resetting or referencing surveys for benchmarks.

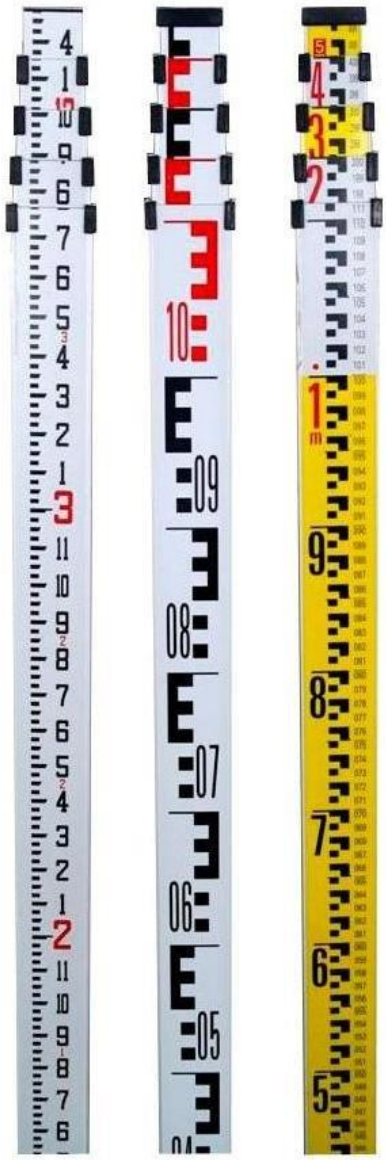


Figure 1.19 Leveling Rod

1.2.6 Miscellaneous Accessories

A. Hand Held Radios

Modern survey equipment and techniques have made the hand-held radio an essential part of a survey crew's equipment. The statewide mobile radio system may be used to keep the crew in contact with the office and relatively short-range hand-held radios are used to maintain contact between members of the survey crew. Although units are generally ruggedly constructed, they require special care and maintenance.

Figure 1.20 Hand Held Radios

B. Batteries

Hand held radios and EDM's operate on rechargeable NiCad batteries. Battery failure is the cause of most problems with the operation of radios and such failures can completely disrupt the crew's effectiveness. Some EDM's are provided with alligator connections for temporary use of the vehicle battery.

A. The need to retain a vehicle at the instrument point can often disrupt the crew's normal procedures. Therefore, the care and maintenance of batteries is an important part of the crew operation and one member of the crew should be assigned that responsibility.

B. NiCad batteries have a tendency to develop false "bottoms" when they are only partially discharged between charging cycles. Periodically, the radio (or instrument) should be left "on" to discharge the battery to almost bottom. Over discharging could cause a reversal in polarity.

Figure 1.21 Surveying Equipment Battries

Limitations of Surveying Equipment

Despite many advantages, surveying using only total stations or GPS has disadvantages. Surveying with a total station, unlike GPS surveying, is not disadvantaged by overhead obstructions; however, it is restricted to measurements between inter-visible points. GPS is frequently used to bring control to the survey site before continuing the survey with a total station in areas with overhead obstruction that limit the use of GPS.

1.3 Undertaking Site orientation

Since a worksite is associated with many risks, site orientation must be carried out before the work commences. Contractors and employees must be equipped with thorough training and complete an online site orientation. This orientation needs to be employed to minimize incidents on the site.

It aims at ensuring that the contracted employees comply and reduce fatalities. Employees agree to report hazards, practice safety protocols and adhere to policies and procedures by having the orientation. Every contractor wishes to accomplish work with minimal accidents and within the speculated time.

Site Orientation Setups are:

1. **Potential hazards**

The contractor should know what hazards will befall while executing the task. Neither the contractor nor the employer should assume zero incidents; thus, all hazards must be documented and given to the contractor.

2. **Site location**

The contractor is unaware of the site location at the negotiation time and needs direction for reaching the site. The employer should include details of the site location and, when possible, pin it for the contractor to trace it easily.

3. Training

The contractor and employees must be factored in for training to avoid incidents. Training prepares them to counter challenges from previously stored knowledge. The training also equips them with knowledge of how to use personal protective equipment since some are complicated.

4. Emergency evacuation measures

The employer should include evacuation plans for injured employees. Evacuation alarms should be installed at locations many employees can reach to ring the alarm in case of a fire or gas breakage. Emergency maps need also be provided for the workers to run for safety.

5. Communication channel

Construction projects usually have several stakeholders who generate information daily. The contractor should have one communication channel for delivering information to the workers and the employer. Communication is critical in site orientation since the contractor is new to the site and needs frequent clarifications.

Introducing the contractor to the site gives a clue about the environment and critical features like the soil structure, drainage, topography, and weather. The first step of site orientation is important as the construction phase, so contractors and employers should not assume it.

1.4 Identifying site and adjacent site features

In the construction industry, a site survey is a detailed study performed to supplement and verify site information provided by the client and site appraisals performed by the consultant team. They could start with a simple walkthrough survey and then progress to more detailed surveys focusing on specific issues.

A site survey in construction may be performed by members of the consultant team who have the necessary skills, or it may be commissioned by specialists. The consultant team should determine which surveys are required (usually after preliminary feasibility studies have been completed) and seek client approval to either carry out those surveys or submit them to the commission for approval.

A construction site survey may include the following items:

- Dimensions and area of your site;
- The location and terms of any easements that may burden or benefit your property;
- The topography of your land and the adjacent land;
- Trees on the property and adjacent land;
- Drainage on and near the land;
- The location of underground services on and near the property;
- The location of adjacent buildings, as well as their roof heights, window/door openings, and heights in relation to the land.

1.5 Identifying site grades

Site grading in surveying refers to the process of leveling, shaping, and preparing a site for construction or other uses. It typically involves measuring the elevation and slope of the land, and then using heavy equipment to remove or add soil as needed to create a level surface with proper drainage and stability. Site grading is an essential part of any construction or development project, as it helps ensure that the site is safe and suitable for its intended use.

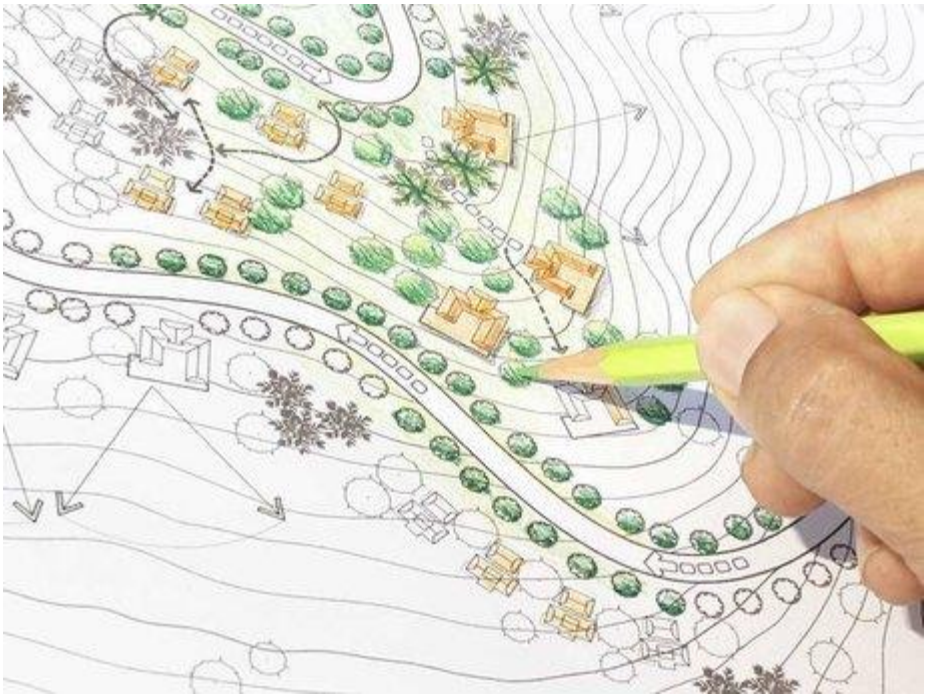


Figure 1.22 Site Grading Plan reading

Self-check 1	

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

Part I: Write True if the statement is correct and False if not.

1. Surveying equipment is being used under most stressful conditions.
2. The crew leader is responsible for training all crew members in the use of equipment

Part-II: Choose the correct answer

3. Which one of the followings are Site Orientation Setups?

   A. Potential hazards

   B. Site location

   C. Emergency evacuation measures

   D. Communication channel

   E. All of the above

Part-III: Answer the following questions accordingly

4. List down care and adjustments made for level, distance and angle measuring instruments.
5. Write and discuss the Types of Personal Protective Equipment
6. _____refers to the process of leveling, shaping, and preparing a site for construction or other uses.

LG #10	LO #2- Maintaining Equipment

Instruction sheet-2

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

- Identifying and check faulty equipment
- Adjustment and maintain equipment
- Instrumental set-up and operation procedures
- professional code of ethics

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

- Identify and check faulty equipment
- Instrumental set-up and operation procedures
- Adjust instruments
- Adjust and maintain equipment
- Apply professional code of ethics

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the information Sheets
- Accomplish the Self-checks
- Perform Operation Sheets
- Do the “LAP test”

Information Sheet-2

2.1 Identifying and Check Faulty Equipment

Organizing and maintaining equipment and supplies/accessories are required before starting principal work activities according to the specifications and organizational guidelines. It is very important for every surveyor to have all of their equipment ready for the job ahead. One missing item could cost your organization time and money. Prepare the following items: Tripod, Tribrach, Total Station, Survey Controller, Power Cable, Communication Cable, Battery Pack, Survey Controller, Stake w/nail and survey marker, Hammer and etc. You shall select tools, equipment and supplies/accessories and check the equipment to ensure as it is in safe working. You should consider contingencies and risk management processes when using equipment and supplies/accessories. Arrangements are made for the transport of equipment and supplies/accessories. Personnel are instructed to operate equipment according to manufacturer specifications and user manual. Adjustment, calibration and maintenance of equipment are arranged. Unsafe or faulty equipment is identified & arrangements are put in place for the operational maintenance of equipment. Repair work is organized for unsafe or faulty equipment under direction of relevant personnel and according to organizational guidelines. Tools, equipment and batteries are stored safely in an appropriate location and according to manufacturer's specifications.

Performing surveying tasks in good manner is prioritize by identify, check and arrange unsafe or faulty equipment in the proper manner. Because knowing the safety of surveying equipment has a lion's share to accomplish surveying works. This is done by preparing:

1. **Record keeping:** The simple fact that a piece of equipment was calibrated is in itself a good start, however unless this fact is recorded and filed in the proper format the process becomes exercise in uselessness. All calibration work shall be recorded in the prescribed manner.
2. **Reporting**: If any piece of measuring equipment is found to be 'out of calibration', this must be reported to the responsible stake holders at once. If the faulty equipment can be

successfully calibrated or adjusted in the field so that is no longer out of calibration, the procedure may be performed. The 'incident' must still be reported in order that appropriate steps can be taken to ensure that the particular piece of equipment in question can be inspected and cleared for further use. At this point we have covered the 'why' and the 'what'. We can now move on to the 'how'.

2.1.1 Concepts of Specifications and Principal Work Activities

Before using an instrument, make a visual inspection for any damages. Check for any exposed machine surfaces including the polished faces of lenses. The instrument motions should be checked to ensure they have a smooth operation. The interior of the instrument should be cleaned regularly in accordance with the specifications given by the manufacturer. If the dirt in the instrument is left to accumulate, it may lead to uneven motion in the horizontal and vertical movements. Use a camel's-hair brush and clean soiled non-optical parts with a soft cloth or with a clean chamois to remove the dirt.

The external lens surface should also be cleaned using a lens tissue using liquids such as pure alcohol. Take care not to scratch lenses or their coating. Never touch optical glass with your fingers.

2.1.2 Checking serviceability and safety of surveying equipment

Proper care and respect for all equipment should be the hallmark of every survey party. The chief surveyor is responsible for his/her equipment whether it is in a safe mode and needs serviceability or not. He/she shall train all members to properly care for this equipment and delegate the responsibilities for such care. The Chief expert shall also see that the equipment is used for its intended purpose. Surveyor members must understand the absolute necessity of using the proper equipment, in the proper condition, for given tasks.

2.1.3 Selecting and Preparing Tools, Equipment and Supplies/Accessories

The surveyor should regularly do adjustment to the equipment to ensure the equipment is properly functioning and that accuracy of work is maintained. The following are good practices while using the surveying instruments:

- Tape should be straight when used and avoid stepping on it. Clean it regularly.
- The instrument should be removed and returned to its box carefully.
- Survey chain should be checked for its links, rings and length before its use.
- The instruments with mechanical parts should be protected from vibration and impact.
- The dirt and dust should be regularly cleaned from movable parts of the instrument.
- The clamping and adjusting screws should not be tightened far more than necessary.
- The objective and eye piece lens should not be touched with fingers.
- Raise the magnetic needle off the pivot of the instrument when not in use.
- Recharge the battery after its use in the field. Also, carry a spare battery for field work.
- Shelter total station against harsh weather elements using an umbrella.
- Charge the GPS station after a day's work.
- When transporting a total station/theodolite for long distances, return carefully into casing box. For medium distances release from tribach clamp and carry from top handle. For short distances move it holding it vertically upright.
- Select instrument stations that won't put instrument man, instrument or team at danger during field work.
- Conduct daily inspection on the equipment used.
- Never leave the instruments unattended.
- Never point the total station/ theodolite directly at the Sun.
- Keep the shoes of the tripods clean and dirt free.

2.1.4 Checking and storing of tools, equipment and batteries

The care, organization, and general housekeeping of a survey equipment, generally, are good indications of the attitude of the entire party. Any equipment or material stored in the store room should be neatly and firmly secured. A good rule to follow is - "A place for everything and everything in its place." Loose equipment and tools and general clutter are safety hazards. The Occupational Safety and Health Act require that survey equipment, "be kept a safe condition".

A checklist of the equipment is therefore prepared before embarking on further field work procedures. The checklist details the following items:

- Date/ time of picking the item
- Return date/time of the item
- Name of team party leader in charge of the equipment
- Equipment name and number of items collected from storage
- Officer in charge of the storage room
- Condition of the item taken

2.1.5 Considering Contingencies and Risk Management Processes

Survey equipment should be taken care of with utmost caution and in the correct manner. The chief party is responsible for his party's equipment. Care must be taken against some of the following potential risks that may affect the equipment adversely:

- Adverse weather conditions e.g. rain, strong winds and high temperatures
- Wrong use of the equipment, for example sitting on the equipment cover case
- Setting up the equipment at dangerous positions e.g. near the edge of a valley, river bank or next to a busy road.
- Leaving equipment in an unsecured location.
- Transporting the equipment in the wrong way.

- Lack of routine care practices e.g. inspecting, cleaning and safely storing the equipment.

2.2 Adjustment and Maintain Equipment

It is a set of test procedures to be used frequently for elimination of gross errors. Such tests should include a check of items such as the levels, optical plummet, and tripod. In the field, adjustments should only be made when the instrument results are poor or require excessive manipulation. Normally, each instrument should be periodically checked at a facility where the best conditions for testing are possible. Only the adjustments described in the manual for the instrument should be made in the field or shop. Do not "field strip" (dismantle) instruments.

When an instrument has been damaged or otherwise requires major adjustments, it will need to be sent to an authorized repair shop. The instrument should be accompanied by a written statement indicating the types of repairs needed. In the case of electronic devices, the request should describe conditions under which the instrument does not function properly, i.e., 38 coldness, dampness, etc. If a "loaner" is needed, this should also be indicated. Wherever possible, the instrument should be "double cased" for shipping, with its case packed inside a cardboard container.

Maintenance may includes the planned, preventive, emergency, as well as the unplanned or reactive maintenance required to provide a safe, healthful, and secure equipment operation. It is the upkeep of equipment and tools. It consists of those activities necessary to keep equipment and systems operational in good working order. Whereas repair means to restore equipment and their components to working.

Figure 2.1 Adjustment of equipment

2.2.1 Field Adjustments

The crew leader should develop a set of test procedures to be used frequently for elimination of gross errors. Such tests should include a check of items such as the levels, optical plummet, and tripod. In the field, adjustments should only be made when the instrument results are poor or require excessive manipulation.

Normally, each instrument should be periodically checked at a facility where the best conditions for testing are possible. Only the adjustments described in the manual for the instrument should be made in the field or shop. Do not "field strip" (dismantle) instruments.

2.2.2 Major Adjustments

When an instrument has been damaged or otherwise requires major adjustments, it will need to be sent to an authorized repair shop. The instrument should be accompanied by a written statement indicating the types of repairs needed. In the case of electronic devices, the request should describe conditions under which the instrument does not function properly, i.e., coldness, dampness, etc. If a "loaner" is needed, this should also be indicated.

Wherever possible, the instrument should be "double cased" for shipping, with its case packed inside a cardboard container.

2.2.3 Routine Care and Maintenance of Surveying Equipment and Tools

Before making the first set-up of the day, visually inspect all surveying instrument for damage. You never know what might have happened the day before.

The following general principles of care should be applied as a routine matter for all survey equipment and supplies:

A. All equipment and tools should be kept as clean and dry as practicable, particularly if they are to be transported or stored for any length of time.

B. Wooden surfaces should be wiped clean of caked mud or moisture prior to returning the equipment to the vehicle. The original painted or varnished surfaces should be repaired as often as needed to keep moisture from entering the wood.

C. Metal surfaces should be cleaned and wiped as dry as practicable. A coat of light oil should be applied to tapes and the metal parts of tools to prevent rusting during storage. Excess oil should be wiped off.

D. Frequently clean the instrument externally. Any accumulation of dirt and dust can scratch the machined or polished surfaces and cause friction or sticking in the motions.

E. Dirt and dust should be removed only with a clean soft cloth or with a camel hair brush.

F. Non-optical parts may be cleaned with a soft cloth or clean chamois.

G. Clean the external surfaces of lenses with a fine lens brush and, if necessary, use a dry lens tissue. Do not use silicone treated tissues, as they can damage the coated optics. It is permissible to breathe on the lens before wiping it, but liquids, such as oil, benzene, 45 water, etc., should never be used for cleaning purposes. DO NOT loosen or attempt to clean the internal surfaces of any lens.

H. Cover an instrument whenever it is uncased and not being used for any length of time, particularly if there is dust or moisture in the air.

I. After an instrument has been used in damp or extremely cold situations, special precautions must be taken to prevent condensation of moisture inside of the instrument. When working with the instrument in cold weather, it should be left in the carrying case in the vehicle overnight. If stored in a heated room overnight, the instrument must be removed from the carrying case. If the instrument is wet or frost covered, remove it from its case, and leave it at room temperature to dry out.

J. Keep the battery terminals clean and free of corrosion. Do not leave batteries in the unit for an extended period

K. Each type of surveying equipment requires proper care and proper handle safely. Let us see some surveying equipments how they are equipped and taken as care.

Care of Surveying Equipment and Tools

1. Care of Theodolites and Total Stations

Although the instruments are ruggedly built, careless or rough use and unnecessary exposure to the elements can seriously damage them. If handled reasonably, they will provide consistently good results with a minimum of downtime for repair or adjustment. Some general guidelines for the care of instruments are:

A. **Lifting** - Instruments should be removed from the case with both hands, gripping the micrometer knob standard and base on the older instruments. Newer instruments are equipped with a carrying handle; the other hand should support the base. One hand should continually support the instrument until the tribrach lock is engaged and the tripod fixing screw secured.

B. **Carrying a Tripod** - In most cases, the instrument should be removed and re-cased for transportation to a new point. If the point is nearby, the instrument should be carried in the vertical position (tripod legs pointing straight down). An instrument should never be "shouldered" or carried horizontally.

C. Adjusting Collimation - The collimation error of theodolites and total stations is determined by following the procedure outlined in the user's manual. If the collimation

error is found to be consistently in excess of ten seconds on the horizontal and twenty seconds on the vertical, the instrument should be adjusted. The collimation adjustment should be made in the field only by a specially trained individual. Otherwise, the instrument should be returned to an authorized repair shop.

2. Care of EDM's

A. EDM's are designed, constructed, and tested to withstand normal field conditions. They are, however, precision instruments and should be handled with the same degree of care required for other types of precision survey equipment.

B. Secure EDM's in vehicles in padded compartments with substantial tie downs so movement and jarring are minimized. Cushion with firm polyfoam or similar material. Do not use soft foam rubber. The instruments should be stored and transported in the position indicated on the case.

C. Required maintenance of most EDM's is minimal. However, protection from the elements and routine external cleaning is necessary.

D. NEVER point an EDM directly at the sun. The focused rays of the sun can damage sensitive internal parts.

E. Protect EDM's from excessive heat. Heat can cause erratic readings and deterioration of components. Do not leave instruments in closed vehicles that are parked in the sun. Avoid rapid changes in temperature, particularly from extreme cold to warm, which can cause condensation in the internal parts of the instruments. Condensation can normally be avoided by leaving the instrument in its carrying case for at least 10 minutes and then opening the case to allow any trapped moisture to evaporate. An instrument taken from a warm office or vehicle to an extremely cold operating environment may require some time to adjust itself. The same type of precautions should be taken to let the instrument cool off slowly.

F. Although EDM instruments are water resistant and well shielded, keep them as dry as practicable. The case should be opened and the instrument allowed to dry in a warm dry room when not in use.

G. Frequent partial discharge and charge of batteries could cause the battery to lose its ability to hold power. Periodically, batteries should be discharged completely and then recharged overnight, or for the specified charge time. Effective usage of batteries will also decrease at low temperatures. An EDM in the tracking mode position will discharge the battery quite rapidly, so it is important to be able to charge batteries to their maximum capacity. In general, one should follow the user's manual instructions on how to maintain the batteries for top performance. If the batteries still fail to hold power, they should be re-celled or replaced.

3. Care of Tapes

Routine care extends tape life. The following are basic guidelines for the care of tapes:

A. Do not place a tape where it can be stepped on or run over, unless the tape is flat, taut, and fully supported on a smooth surface. Keep the tape straight when in use. When pulling a slack tape, a loop can develop into a kink and easily break the tape. Avoid pulling a tape around poles or other objects, as a hard pull can stretch or break the tape.
B. Do not wind tapes overly tight on their reels, as it can cause unwanted stresses and lead to stretching of the tape.
C. After the day's work, clean tapes that are soiled. In wet weather, dry before storing. Clean rusty tapes with fine steel wool and cleaning solvent or kerosene. Use soap and water when tape is dirty or muddy. To prevent rust after cleaning, oil lightly and then dry the tape.
D. Avoid storing in damp places.

4. Care of Tribrachs

Tribrachs are an integral part of the precision equipment and should be handled accordingly. They should be transported in separate compartments or other containers to prevent damage to the base surfaces, bulls eye level, and optical plummet eye piece. Over tightening of the tripod fastener screw can put undue pressure on the leveling plate.

Although the leveling screws are covered, dirt or dust can work into the threads and cause wear. The tribrach should be carefully disassembled, cleaned, and lubricated with light instrument oil whenever the threads appear to be binding. Such repairs should be done in the shop by someone experienced in such work.

Adjustments of Tribrachs

An out of adjustment tribrach can cause small random errors and each tribrach should be routinely checked for centering. Careful adjustment with a plumb bob is quite fast and should

provide a centering accuracy within 1 millimeter. A more accurate method is to rotate the tribrach 120 degrees over a smooth markable surface. For the first sighting, a soft pencil line is drawn on the tripod head around the tribrach base. The tribrach is carefully leveled and the sighting point marked. The tribrach is then rotated 120 degrees, carefully set in the pencil marks, re-leveled, and a new sighting point marked. Repeat this procedure. If the tribrach is slightly out of adjustment, the three rotational marks should form a triangle. The plummet should be sighted to the center of the triangle and the optical plummet adjusted to that setting. The test should be repeated to verify the adjustment.

5. Care of Tripods

A stable tripod is required for precision in measuring angles. A tripod should not have any loose joints or parts which might cause instability. Some suggestions for proper tripod care are:

A. Maintain firm snugness in all metal fittings, but never tighten them to the point where they will unduly compress or injure the wood, strip threads or twist off bolts or screws.
B. Tighten leg hinges only enough for each leg to just sustain its own weight when legs are spread out in their normal working position.
C. Keep metal tripod shoes tight and free of dirt.
D. Keep wooden parts of tripods well painted or varnished to reduce moisture absorption and swelling or drying out and shrinking.
E. Replace top caps on tripods when not in use.

The most damage occurs to tripods when being placed in or taken out of survey vehicles. The life and usefulness of tripods can be significantly extended if compartments are constructed so that the tripods are not riding on or against other equipment.

6. Care of Sighting Equipment

As with any survey equipment, proper care will extend the useful life of sighting equipment.

A. Range or sighting poles should be kept straight and well painted. Whenever possible, poles should be sheathed or carried in a separate compartment when being transported. Never use range poles for vaulting or spears.
B. Bull's eye rod levels should be checked periodically, or whenever there is any indication that they may be out of adjustment. A quick check against a pre-checked door jamb will indicate if the level is out of adjustment.
C. Forced centering target sets should be treated as any other precision equipment. They should be transported in their carrying case in the proper compartments. They should never be put away wet or dirty. The tribrachs should be kept in the same adjusted condition as theodolite or EDM tribrachs.
D. When not in use, keep prisms in their proper containers with face covers in place. They should be kept clean and moisture free to ensure maximum light return. Clean the reflective surface with a camel hair brush or soft lens tissue.

7. Care of Levels

A level in adjustment establishes a horizontal plane of sight when the telescope is revolved about a vertical axis. The principal lines of the dumpy level, as illustrated in Figure A-1, are

(a) axis of sight,
(b) axis of the level bubble,
(c) axis of the level bar, and
(d) Vertical axis.

For perfect adjustment it is necessary that the axis of sight, the axis of the level bubble, and the axis of the level bar be parallel to each other, and perpendicular to the vertical axis. There are two adjustable parts: the cross hairs and the level vial. The adjustments should be made in the order given.

Review the previously stated guidelines for the care of instruments. These guidelines are also generally true for the proper care of pendulum levels. Additional guidelines are:

A. Do not spin or bounce pendulum levels, as such movement can damage the compensator.

B. Protect the level from dust. Dust or foreign matter inside the scope can cause the compensator's damping device to hang up.

C. Frequently check the adjustment of the bull's eye bubble. Adjust the bull's eye to the center, not almost to the center. Make certain it is adjusted along the line of sight and transversely as well. Proper adjustment reduces the possibility of compensator hang up.

D. To check for compensator, hang up, slightly tap the telescope with a pencil or operate the fine movement screw jerkily to and fro. If the instrument has a push button release, use it. If the compensator is malfunctioning, send the instrument to an approved repair service for servicing. Do not attempt compensator repair in the field.

8. Care of staff

In land surveying work:

Do not

- Allow nails to project from discarded timber.
- Enter unsupported trenches.
- Look into a laser beam.
- Run - but walk and work steadily.
- Signal a chairman to move into danger.

Do

- Wear an approved protective safety helmet without a brim.
- Wear high visibility waistcoats.
- Wear approved safety footwear.
- Correct immediately any dangerous practices or emissions.

9. Care of Leveling Rods

Leveling rods should be maintained and checked as any other precision equipment. Accurate leveling is as dependent on the condition of the rods as on the condition of the levels. Reserve an old rod for rough work, such as measuring sewer inverts, mud levels, etc. The care requirements common to all types of rods are:

A. Protect from moisture, dirt, dust and abrasion.
B. Clean graduated faces with a damp cloth and wipe dry. Touch graduated faces only when necessary and avoid laying the rod where the graduated face will come into contact with other tools, objects, matter, or materials where damage might result.
C. Do not abuse a rod by placing it where it might fall, throwing, dropping, dragging, or using it as a vaulting pole.
D. Keep the metal shoe clean and avoid using it to scrape foreign matter off a bench or other survey points.
E. If possible, leave a wet rod uncovered, unclosed, and extended until it is thoroughly dry.
F. Store rods, either vertically (not leaning) or horizontally with at least three-point support, in a dry place and in their protective cases.
G. Periodically check all screws and hardware for snugness and operation.
H. Periodically check accuracy by extending the rod to its full length and checking its scale with an accurate tape. This should be done at the beginning of control level surveys. If the rod indicates a tendency to be "off", it should be checked each time it is extended.

10. Care and Use of Radios

A. Radios should be kept in the carrying case at all times. Avoid laying radios in precarious places where they could be blown off or knocked to the ground.
B. When one radio is being used for most of the transmission, battery life can be extended by switching radios during the day. Transmission causes considerably larger discharge than reception only. Battery life of the receiving radio can be extended by simply pressing the transmission button to acknowledge receipt of a message.
C. All messages should be as short and to the point as possible.
D. It has been found that radio transmission can affect measurements of EDM’s. No transmission should take place near the instrument while measurements are being made.

11. Care for Batteries

Hand held radios and EDM's operate on rechargeable NiCad batteries. Battery failure is the cause of most problems with the operation of radios and such failures can completely disrupt the crew's effectiveness. Some EDM's are provided with alligator connections for temporary use of the vehicle battery.

A. The need to retain a vehicle at the instrument point can often disrupt the crew's normal procedures. Therefore, the care and maintenance of batteries is an important 51 part of the crew operation and one member of the crew should be assigned that responsibility.

B. NiCad batteries have a tendency to develop false "bottoms" when they are only partially discharged between charging cycles. Periodically, the radio (or instrument) should be left "on" to discharge the battery to almost bottom. Over discharging could cause a reversal in polarity.

2.2.4 Use and Care of Instruments in the Field

Careful attention to suggestions given herein will save needless wear on instruments and reduce the dangers of accidents to a minimum, besides increasing the quality and quantity of the work.

A. Equipment should be stowed in the survey vehicle in a manner that will eliminate unnecessary wear. Instruments should not be subjected to severe jolts (shake) The self-leveling level must be transported on a cushion of shock absorbent material, never on the floor of the vehicle. When the self-leveling level work is completed on any given project it will be turned back into the area Survey Supervisor. The area Survey Supervisor will assign these high accuracy levels where needed, they are not to be kept in the survey vehicles.

B. **Tripod**: Inspect the tripod legs and shoes. The leg of the wide leg tripod is of proper tightness if, when lifted to an elevated position, it sinks gradually of its own weight.

C. **Instrument/Instrument case:** Handle the instrument gently in removing it from and returning it to the case. It is best to place the hand beneath the Tribrach base in handling the detached instrument. Considerable patience is sometimes required to close the lid after

returning the instrument. If properly placed, the lid closes freely. Never force the lid; look for the obstruction and correct it.

D. **Mounting Level:** See that the instrument is securely attached to the tripod. Undue haste may sometimes result in costly accidents. When screwing the instrument on tripod head, it should first be turned in a counterclockwise direction until a slight click is heard, indicating that the threads are properly engaged.

E. **Eyepiece**: Before beginning the observations, focus the eyepiece perfectly on the cross hairs. This is best done by sighting the sky.

F. Special care must be exercised so as not to sight the sun directly. Doing so can damage the Total Station. This repair is very expensive.

G. **Setting up in field:** When setting up in the field, bring the tripod legs to a firm bearing with the plates approximately level. Give the tripod legs additional spread in windy weather or in places where the instrument may be subjected to vibration or other disturbances. On side-hill work, place one leg uphill. With the level, place two leveling screws in the general direction of the line of levels. On pavement in sunny weather, or under most winter conditions, use "shoes" (flat wooden slats) under each leg to prevent settlement.

H. Use instrument cover provided when conditions warrant. If the instrument should get wet, thoroughly wipe it dry before returning it to the case. Take the instrument indoors at night for further drying if necessary.

I. **Proper care of instrument:** Cultivate from the very beginning the habit of delicate manipulation of the instrument. Rough and careless treatment of field instruments is characteristic of an unskilled operator.

J. **Plate leveling screws**: In leveling the instrument, the leveling screws should be brought just to a snug bearing. If screws are too loose, the instrument rocks and accurate work cannot be done. If too tight, the instrument is damaged and the delicacy and accuracy of the observations are reduced. Much needless wear of leveling screws may be avoided if the tripod head is brought about level when the instrument is set up. Upon completion of setup,

leveling screws must be returned to a neutral position. Leveling screws in a tribrach must not be over extended.

K. **Lenses**: Do not remove or rub the lenses of the telescope. If necessary to clean lens,dust first with a soft, clean camels hair brush and use a very soft cloth with caution to avoid scratching or marring the polished and coated surfaces.

L. The apparent cause for the major portion of survey equipment repair costs is the direct result of carelessness or the lack of adequate consideration in surmount obstacles such as stone walls, all types of fences, rocky precipitous areas, shallow stream beds with unstable footing, snow covered as well as icy areas, etc. It is the sole responsibility of the instrument person to anticipate the seriousness of these obstacles when carrying a precision instrument and to utilize assistance of other members of the crew to assure absolute security of the instrument. It is also the responsibility of the Crew Chief to insist constantly the above precautionary measures be fulfilled.

Care and security of equipment, Fundamentals:

A surveyor is responsible for the care and security of his equipment used
on site. In land surveying work:

Do not

- Leave instruments unattended on site.
- Leave instruments set up in the site offices.
- Put an instrument away until it has dried out after rain.

Do

- Store equipment carefully in a dry place.
- Inspect all instruments before work commences.
- Make a list of equipment taken from security.
- Return a complete set of equipment on completion.
- Make sure that the equipment is used in a manner which does not endanger it or people.
- Adopt procedures which ensure the instrument achieves the accuracy for which it is designed.

- Clean and oil tapes and chains at regular intervals.

Care of Tools: Improperly maintained tools can be a source of annoyance, as well as being a safety hazard. Each employee is responsible for keeping his or her tools and equipment in good condition. To prevent loss of small equipment and tools, avoid laying them on the ground, on vehicles, or on equipment which might be moved. When not in use, carry them in scabbards and pouches.

- Repair or replace any driving tool that is burred or fractured on any part of the striking or driving face. Many surveyors have been injured by the "shrapnel" effect from gads and sledges which had ragged edges. The same is true for "bull points" or other tools which are driven.
- Crooked or warped handles can cause injury as well as mishitting and damage to the tool. Promptly replace such handles and those that are cracked or broken. Handles should be firmly secured in all cutting and driving tools.

Details

Surveying instruments are only then completely effective, if they are carefully and conscientiously treated as well as professionally operated. The directions which are included should not only be read but also be followed. More than ever, this holds true for electronically instruments, GPS-equipment and other surveying equipment with electronic parts. If the methods match the characteristics of the instruments, then they are effectively utilised.

When use equipment’s personally, one should have to follow the following general procedures;

- Identify equipment’s for necessary purpose
- Make sure the equipment is not faulty
- Collect the equipment in proper way through casing and un casing way as the manual directed
- Transporting them in a safety manner
- Place them in dry place

- Set the equipment properly to overcome risks related to weather condition,ϖ topography, animal, and other hazardous causes
- stretch tapes or ropes
- Make sure the tapes is not faultyϖ Avoid error of parallax/change in when reading measurement
- Avoid error of transposing figures on papers

2.2.5 Instrument Storage

Surveying instruments should be stored inside their respective container in dust free rooms without large temperature changes. In humid climate, they have to be removed from the tightly sealed containers so that the air can circulate freely around them.

In large collections, instruments and equipment are usually registered in a card file. It is expedient to prepare an instrument passport. It contains producer, type, description and technical data as well as a record on the calibration results.

In extremely cold areas the instrument should not be taken into a heated shelter as long as it is needed for measurements, but rather remain exposed to the outside temperature at some protected location. This prevents vapour formation on the optical and interior elements of the instrument when work is being resumed.

When storing a compass for a longer period of time, the position of the unlocked needle should be checked in order to maintain its magnetic characteristics.

2.2.6 Instrument Inspection and Checks

Instruments should be carefully inspected and checked for their suitability for a specific task before they are issued from the storage area. Furthermore, it should be checked whether the auxiliary equipment in the container is complete and operational.

At the beginning of each field season, the instruments should be tested and, when needed, adjusted according to the directions provided. It is recommended to repeat this test after completion of the field work, or after extended work interruptions or long distance transportation. In this manner, work stoppage due to faulty equipment can be prevented.

Instruments should only be adjusted when it is really necessary and only according to directions. When tightening adjustment screws, care has to be taken as to not create stresses.

2.2.7 Transport of Instruments

The major portion of damage to equipment and tools occurs when they are being placed into or taken out of the survey vehicle. Other damage occurs during transport, when equipment is jostled against other tools or equipment. Compartments (lined with carpeting, when possible) should be provided to keep equipment and supplies separated. This not only keeps the equipment from being damaged, it facilitates finding such items more rapidly. Heavier items should be carried in the lower parts of vehicles and they should never be in direct contact with other tools or equipment below them.

A. The care, organization, and general housekeeping of a vehicle are good indications of the attitude of the entire survey crew. Keep passenger compartments free of unnecessary clutter and equipment. Any equipment or material carried in the passenger compartment should be firmly secured.
B. Transport and store instruments in positions that are consistent with the carrying case design. Many instrument cases indicate the position in which they should be transported. Treat optical targets, prisms, and staffs with the same consideration.
C. Transport the instruments in their carrying cases placed in a compartment cushioned with firm poly foam or similar material to protect them from jolting or excessive vibrations.
D. Remember, loose equipment, out of place tools, and general clutters not only contribute to damage of the items, they also waste crew time in locating them and are a safety hazard.

Before transporting instruments, one should first check whether the clamps are evenly tightened and then close the container and perhaps lock it. The keys have to be kept at a safe place. When lifting or moving in vehicles, jerky movements should be avoided and shocks dampened. It is best to hold the container with the instruments upright on ones lap, possibly wrapped in a soft blanket. For longer transportation on land - sea - or air the container with the instrument is placed inside a padded crate. During transport the crate has to stand upright. When using pack animals,

the instrument is fastened upright, usually hanging. Generally the instruments are to be protected against fall, shock and heavy vibrations.

Rods are to be transported in their crates. In any ease they have to be packed like instruments so they are not exposed to sudden blows. When walking, the pointed ends of tripods, range poles etc. have to be kept in view. Rods should not be touched at their graduation, and protected from heavy blows. This is especially important for Inver rods.

2.3 Instrumental set-up and operation procedures

Whenever possible, the instrument should be used in areas where operation is not dangerous to the instrument operator or the instrument**.**

Here is some procedures that you follow to set up:

1) Select stable ground for the tripod feet.
2) Do not set an instrument in front of or behind a vehicle or equipment that is likely to move.
3) In cold or hot weather when vehicle climate controls are used, survey instruments should be acclimated to outside condition for an adequate period of time prior to final setup adjustments.
4) Firmly set the tripod with its legs spread wide. Push along the legs, not vertically downward. Extra precautions should be taken on smooth surface.
5) Always have the tripod firmly set before removing the instrument from its carrying case.
6) Immediately secure the instrument to the tripod.
7) If a total station/GPS is to be used, remove the instrument from the tribrach.
8) Center and level the instrument over the mark using only the tribrach.
9) Then place the total station/GPS in the tribrach for final leveling and verification that the instrument is still centered above the mark. 53
10) Never leave an instrument or its tribrach on the tripod without securing either to the tripod. Moderate pressure on the fastener screw is sufficient.
11) Excessive tightening causes undue pressure on the foot screw and on the tribrach spring plate; Make sure the tribrach clamp is in the lock position.

2.3.1 Care During Instrument Setting ups

Whenever possible, select instrument stations where operation is not dangerous to the instrument operator, the crew, or the instrument. Select stable ground for the tripod feet. Do not set an instrument closely in front of, or behind, a vehicle or equipment which is likely to move. Take a safe route to all setups.

A. At the site, firmly plant the tripod with its legs widespread. Push along the legs, not vertically, downward. On smooth surfaces, use some type of tripod leg restrainer to keep the legs from sliding outward.

B. Always have the tripod firmly set over the point before removing the instrument from its carrying case. Immediately secure the instrument to the tripod with the instrument fastener.

C. Never leave an instrument or its tribrach on the tripod without securing either to the tripod. Moderate pressure on the fastener screw is sufficient. Excessive tightening causes undue pressure on the foot screws and on the tribrach spring plate. Make sure the tribrach clamp is in the lock position.

D. Repair or replace any driving tool that is burred or fractured on any part of the striking or driving face. Many surveyors have been injured by the "shrapnel" effect from gads and sledges which had ragged edges. The same is true for "bull points" or other tools which are driven.

E. Crooked or warped handles can cause injury as well as mishitting and damage to the tool. Promptly replace such handles and those that are cracked or broken. Handles should be firmly secured in all cutting and driving tools.

At the survey location, warning signs and -flags should be erected, and industrial safety rules have to be observed. It is of advantage to have the back of the rods and the tripods painted in bright colour, such as red and white.

The tripod is to be set up solidly and in such a way that its legs are not in the way when observing certain directions. The tripod legs should be extended so that the observations can be made with ease. Their pointed ends have to be firmly pressed into the ground. One should also

watch that the top of the tripod is approximately level and, for angular and distance measurements, is centred above the station.

When unpacking an instrument one should note its arrangement within the container . A figure showing the arrangement of the various parts when properly packed should be inside the container. In any case, the given directions should be followed. Prior to unpacking, all clamps should be loosened. Then theodolites and tachymeters are lifted at the right standard - never on the side which houses the index bubble! - levels at the tribrach.

The instrument is then placed on the tripod and fastened to the tripod head while still being held with one hand. An instrument may never stand loosely on the tripod. Only after it is fastened, the hand can be taken away. For centring and levelling, the fastening screw is to be loosened somewhat to reduce the pressure on the thread of the foot screws. It will be tightened again afterwards.

If the instrument temperature differs significantly from the field temperature, the instrument has to be left on the tripod until its temperature conforms. For 10°C temperature difference this requires about 5 minutes.

2.3.2 Care of the instrument during measurements

The instrument and the whole tripod are to be protected from direct sunlight and rain with an umbrella. if work is interrupted due to rain, the instrument has to be protected with a cover. Drops of water should be blotted with a soft clean rag. Optical parts may not be touched with fingers. Dust should be carefully removed with a soft hair brush to the edge and then with a dust- and spot free soft cloth or soft chamois. Other dirt should be removed with hygroscopical cotton, never with liquid.

Whenever work stops, the instruments are to be protected against rain or dust with a hood or other cover. Prior to measuring, instruments with graduated circles should be rotated several times around both vertical and horizontal axes, so that the lubrication in the bearings is distributed. When measuring, touch only the solid parts of the instruments, never the eyepiece.

Stress on the instrument should be avoided. Clamps should be tightened slowly and evenly. When measuring horizontal directions, the vertical clamp does not need to be tightened. Finite

fine motions should only be operated clockwise, so that the part is moved by the screws and not the spring, thus avoiding back lash.

When connecting upper and lower theodolite part with a repetition clamp of the Mahler type, one should press vertically on the clamp and counteract this movement with a fingertip. if the clamp is not needed, it should remain open.

Bends in tapes, caused for instance by vehicles driving have to be avoided. When rolling up the tape extra loops cannot be tolerated. Invar wires have to be protected from shock and reeled carefully. Their metal parts have to be cleaned daily with a soft rag and then rubbed with acid free grease. Prior to measuring, the grease has to be removed again.

Even though the human eye is not directly endangered when working with laser instruments, because of their low power (construction laser up to 5 mW, laser diodes), one should never look directly into a laser beam. If the laser beam is directed through a telescope, one should not look into the eyepiece as long as the laser is operating. If necessary, protective eye glasses should be worn. The laser should be screened off as much as possible, and never be without supervision when running.

When using instruments with mercury, one has to be extremely careful. Especially inside closed rooms, mercury should not be spilled. If this should happen, mercury drops can be lifted with copper sticks and then treated with sulphur for chemical bonding.

Casing and Uncasing

Before removing an instrument, study the way it is placed and secured in the case. The instrument must be replaced in the same position when returned to the case.
In removing the instrument from the case, carefully grip it with both hands, but do not grip the vertical circle standard or where pressure will be exerted on tubular or circular level vials.

2.3.3 Instrument Transport between Stations

Do not "shoulder" or carry a tripod mounted theodolite or electronic distance measuring equipment (EDM). These instruments should always be removed from the tripod and secured in their carrying cases when moved.

These precautions are necessary because the center spindle (center spigot or standing axis) of a theodolite is hollow and relatively short. When carried horizontally while on the tripod, the alidade's weight is an excessive load for the hollow centerpiece to bear. Instrument damage can result if the above precautions are ignored. Also, the instrument fastener can break, causing the theodolite to fall.

Figure 2.2 Instrument Transport between Stations

2.3.4 Care of instruments after the measurements

Before packing of the instrument, its clamps should be loosened. Once the instrument is correctly in the container, they are tightened evenly.

The pointed ends of tripods and range poles are to be cleaned with rag, brush or bushel of grass.

Tapes which have got wet have to be dried with a cloth, and then greased lightly with acid free oil or fat. If there are rust spots, do not use sand or sand paper but wood ash soaked with kerosene.

Instruments that got wet have to be unpacked at home and left out until they are completely dry. Occasionally the producer supplies with the instrument a little bag of Silicon-gel (highly hydroscopic grains of amorphous quartz). The grains are blue when dry and pink when saturated. Since they absorb water from the air, the instrument container has to be closed except when packing or unpacking. Pink grains can be regenerated when placing them directly on a heatable plate and heating it above the boiling temperature (check with a water drop: hiss-test). If the temperature is too high, the grains crack. The now blue grains are placed again into their bag after they are cooled down.

The tripod head, and the threads of the foot screws and the fastening screw should be kept clean and lightly oiled.

The bottom parts of rods have to remain free of dirt and dust and should be greased lightly.

After completion of the field season, the instruments should be thoroughly inspected. Damages are to be fixed by the mechanic.

If you need batteries for your work, care for them and load on daily (accu). Watch, that accus are already unloaded (memory effect).

2.4 Professional code of ethics

1 Professional Land Surveyors shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.

2 Make sure you perform services only in the areas of their competence.

3 Issuance of public statements should be only in an objective and truthful manner.

4 Professional Land Surveyors shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.

5 Professional Land Surveyors shall build their professional reputations on the merit of their services.

6 Professional Land Surveyors shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of their profession.

7 Professional Land Surveyors shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those under their supervision.

Self-Check – 2	

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Part I: Write True if the statement is correct and False if not.

1. Adjustment and Maintain Equipment is a set of test procedures to be used frequently for elimination of gross errors.
2. The major portion of damage to equipment and tools occurs when they are being placed into or taken out of the survey vehicle.
3. Instruments should be carefully inspected and checked for their suitability for a specific task before they are issued from the storage area.

Part-II: Choose the correct answer

4. _____are required before starting principal work activities
   - **A.** Surveying
   - **B.** Reconnaissance
   - **C.** Organizing and maintaining equipment and supplies/accessories
   - **D.** None of the above
   - **E.** All

Part-III: Answer the following questions accordingly

5. What is the difference between Record Keeping and Reporting?
6. Discuss about the Care of Surveying Equipment and Tools
7. How can we care during the instrument Setting ups, measurements and after measurement?
8. What are the Professional code of ethics for maintaining and Operating Surveying Equipments?

Operation Sheet -1

1.1. Procedures of Instrumental setting-up and operation

A. Tools and Equipments

I. Theodolite
II. Tripode
III. Ranging pole
IV. Tape
V. Peg
VI. Permanent Marker

B. Steps to be taken

1) Select stable ground for the tripod feet.
2) Do not set an instrument in front of or behind a vehicle or equipment that is likely to move.
3) In cold or hot weather when vehicle climate controls are used, survey instruments should be acclimated to outside condition for an adequate period of time prior to final setup adjustments.
4) Firmly set the tripod with its legs spread wide. Push along the legs, not vertically downward. Extra precautions should be taken on smooth surface.
5) Always have the tripod firmly set before removing the instrument from its carrying case.
6) Immediately secure the instrument to the tripod.
7) If a total station/GPS is to be used, remove the instrument from the tribrach.
8) Center and level the instrument over the mark using only the tribrach.
9) Then place the total station/GPS in the tribrach for final leveling and verification that the instrument is still centered above the mark. 53

10) Never leave an instrument or its tribrach on the tripod without securing either to the tripod. Moderate pressure on the fastener screw is sufficient.

11) Excessive tightening causes undue pressure on the foot screw and on the tribrach spring plate; Make sure the tribrach clamp is in the lock position.

LAP TEST-1	Performance Test

Name……. ID……Date ……

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **1** hour. The project is expected from each student to do it.

Task-1 Perform Instrumental setting-up and operation

LG #11	LO #3- Task execution

Instruction sheet-3

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

- Perform measurements
- Checking measured survey data for comparison
- Validation and recording measurements
- Corrections and precaution measures

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

- Identify components to be measured
- Perform measurements
- Check measured survey data for comparison
- Apply accuracy and precision requirements
- Validate and record measurements
- Apply corrections and precaution measures
- Determine technological requirements
- Apply OHS requirements

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the information Sheets
- Accomplish the Self-checks
- Perform Operation Sheets
- Do the “LAP test”

Information Sheet-3

3.1 Perform measurements

Generally surveying can be defined as the art and science of determining the relative position of various points on, above or below the surface of the earth.

These relative positions of points or the position of one point to another point or the reference point can be defined by making some kind of surveying measurements of these measurements the basic ones are classified in to four:

1. Horizontal distance
2. Vertical Distance
3. Horizontal Angles and
4. Vertical Angles.

For more information Refer level_2 Linear and Angular Measurements and Calculations Module.

3.2 Checking measured survey data for comparison

Engineering drawing is a two-dimensional representation of three-dimensional objects. In general, it provides necessary information about the shape, size, surface quality, material, manufacturing process, etc., of the object. It is the graphic language from which a trained person can visualize objects. Drawings prepared in one country may be utilized in any other country irrespective of the language spoken. Hence, engineering drawing is called the universal language of engineers. Any language to be communicative should follow certain rules so that it conveys the same meaning to everyone. The ability to read drawing is the most important requirement of all technical people in any profession.

Field notes are records that are kept of the field work that has been carried out. They typically contain measurements, sketches, descriptions and many other items of miscellaneous information. In the past, field notes were prepared exclusively by hand

lettering in field books or special note pads as the work progressed and data were gathered. However, automatic data collectors, also known as electronic field book and survey controllers, have been introduced that can interface with many different modern surveying instruments. As the work progresses, they create computer files containing a record of observed data. Data collectors are rapidly gaining popularity, but when used, manually prepared sketches and descriptions often supplement the numerical data they generate. Regardless of the manner or form in which the notes are taken, they are extremely important.

The surveyor should adhere to project specifications as spelled out in the contract document which sets the required tolerances for different setting out operations. This is easily achieved by using the most suitable equipment and technique(s).

3.3 Validating and Recording Measurements

Measurement involves extracting feature counts, lengths, areas and volumes. Count is done from the database because of its indexing feature. Measurements on vector data sets achieve better quality as compared to raster ones since the data has more discrete representation.

Accurate field work may be canceled by careless recording. The carelessness may be happened through tired, lack of concentration reading, and leaving responsibilities for others are some major causes. Even if, after obtaining correct measurements the recording data may also varies in from obtaining data. Therefore recording 65 measurement should always recognize and check as soon as possible in the field work. Making measurements and subsequent computations and analyses using them are fundamental tasks of surveyors. The process requires a combination of human skill and mechanical equipment applied with the utmost judgment. No matter how carefully made, however, measurements are never exact and will always contain errors. Surveyors, whose work must be performed to exacting standards, should therefore thoroughly understand the different kinds of errors, their sources and expected magnitudes under varying conditions, and their manner of propagation. Only then can they select instruments and procedures necessary to reduce error sizes to within tolerable limits.

Saving and keeping of measurements backup

Handling measurements/ data in single or one copy format is a necessary condition but not sufficient condition. Because recording measurements may loss /disappear through different risks/hazardous. To overcome this unexpected situation; preparing back up is the corner stone of keeping measurements in consistent way. This action helps for any stake holder; being responsible, transparent, and liable and role model for their own customer. The backup may be taken daily, weekly, two times in a weak. It depends the working environment. Some back upping equipment includes:

- External portable hard drive
- CD/DVID
- USB Flash disk….etc

3.4 Corrections and precaution measures

3.4.1 Errors in Measurement

The word measurement is derived from the Greek word "metron," which means a limited proportion

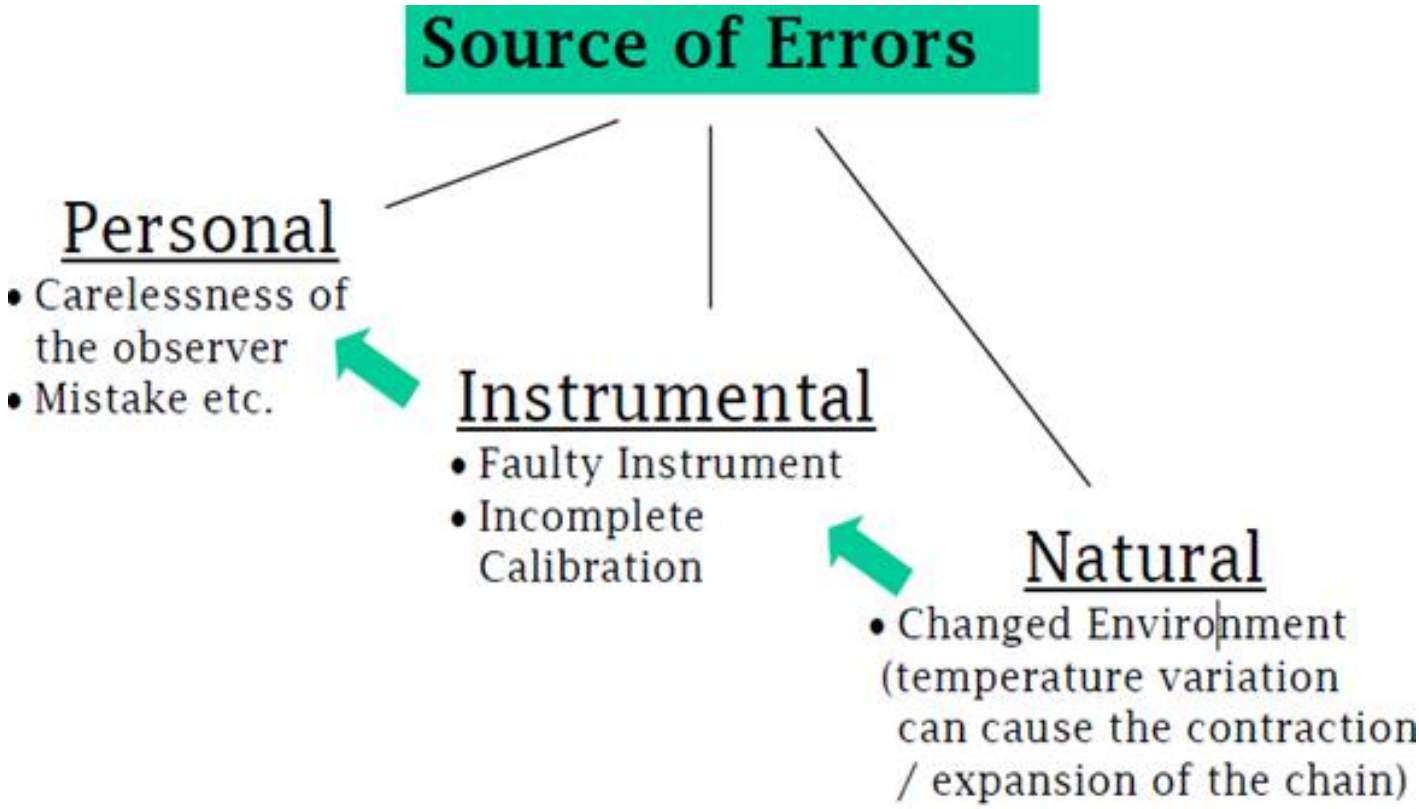
- In science, measurement is the process of estimating or determining the magnitude of a quantity
- The term measurement can also be refers to a specific result obtained from a quantity
- A measurement usually differs from its true value

Surveying results can never be exactly true due to:

- Surveying equipment manufactured to a certain level of precision.
- Surveyors are trained to get the most out of their instrumentation, but no observer can make perfect measurements.
- All survey measurements are subject to external factors, for example ‘tape’ will vary with temperature.

- The difference between a **measured** and its **true value** is called the **measurement error**
- Thus, if **x** is a given measurement and $\mathbf{x_t}$ is the true value, then the error **e** is given by:
  - ✓ $e = x - x_t$
  - ✓ error = measured value – true value
- Correction is the term more popularly being used to define the magnitude of error but opposite in sign

3.4.2 Source of Errors



(1) Natural errors caused by variation in or adverse weather conditions(Strong wind, Temperatures variations), loose muddy , humidity and swampy areas, Curative, refraction, un modeled gravity effects and magnetic field of the earth.

(2) Instrumental errors caused by imperfect construction, adjustment of the surveying instruments used and movement of their individual parts..

Example: Sag, Vertical and horizontal Axis, lateral and collimation error plate level test, cross hair ring Test, collimation in azimuth test, vertical circle, Index Test.

(3) Personal errors caused by the inability of the individual to make exact observations due to the limitations of human sight, touch and hearing.

Example: Mistakes in reading and recording, focusing, setting up, holding staffs

3.4.3 Types of Errors

The surveyor's task is to keep errors in measurement with in prescribed limits. In order to do so, he/she must know source of errors, types of errors, the effects of errors and how to evaluate his/her results. There are three basic types of errors. These are;

1. **Mistakes (Gross errors)**
2. **Systematic errors**
3. **Accidental /Random errors**

Table 3.1 Types of Errors

Mistakes (Gross) Errors	Systematic Errors	Random (Accidental) Errors
• Blunders due to human mistakes, malfunctioning instrument and wrong measurment methods. • Do not follow certain rule • Large in magnitude • Outlier detection method is required	• Follows certain physical/mathematical rules • Instrument, physical environment, human factor • Poor accuracy • Cumulative nature	• random in nature • Caused by unknown and unpredictable human factors, instrument errors, etc. • Poor precision • Difficult to detect but easier to remove since they are statistical errors and can be removed by statistical methods like averaging

3.4.4 Identify and explain errors

It should now be apparent that position fixing simply involves the measurement of angles and distance. However, all measurements, no matter how carefully executed, will contain error, and so the true value of a measurement is never known. It follows from this that if the true value is never known, the true error can never be known and the position of a point known only with a certain level of uncertainty.

3.4.5 Application of corrections and precaution measures of errors

It is possible to correct measure of random errors by the following methods.

1. **Probability Distribution**

If a large number of measurements have been taken, the frequency distribution could be considered to be the probability distribution.

2. **Most Probable Value**

Different conditions, under which the measurements are made, cause variations in measurements and, therefore, no measured quantity is completely determinable. A fixed value of a quantity may be conceived as its true value. The difference between the measured , i.e.,**ε** is known as error **τ** quantity and its true value

$$\tau = x - \varepsilon$$

Can **ε** Since the true value of a measured quantity cannot be determined, the exact value of never be found out. However, if a best estimate **x̂** which is known as the most probable value of **τ,** can be determined, can be used as a reference to express the variations in **x**. If we define **ν** as residual then

$$\nu = \hat{x} - x$$

The residuals express the variations or deviations in the measurements.

3. **Standard deviation**

Standard deviation also called the root-mean square (R.M.S.) error, is a measure of spread of a distribution and for the population, assuming the observations are of equal reliability.

4. **Variance**

Variance is most often used to determine some level of importance for any given observation. If the data varies a lot, (high variance), it is difficult to draw a conclusion based on any single point. At the same time, if there is little variance, a data point that is very different may raise some eyebrows. Usually, this leads an investigator to:

1) Gather more data (this reduced variance),

2) Determine that statistics is not a good way of describing whatever it is they want to describe (the characteristic in question is just too inherently variable (random), or

3) Do it anyway.

5. Standard Deviation of the Mean

Standard deviation is a measure of how spread out the data points is. A set with a low standard deviation has most of the data points centered around the average. A set with a high standard deviation has data points that are not so clustered around the average.

6. Most Probable Error

The most probable error is defined as the error for which there are equal chances of the true error being less and greater than probable error. In other words, the probability of the true error being less than the probable error is 50% and the probability of the true error being greater than the probable error is also 50%.

7. Confidence limit

After establishing the sample mean as estimate of the true value of the quantity, the range of values within which the true value should lie for a given probability is required. This range is called the confidence interval, its bounds called the confidence limits. Confidence limits can be established for that stated probability from the standard deviation for a set of observations. Statistical tables are available for this purpose. A figure of 95% frequently chosen implies that nineteen times out of twenty the true value will lie within the computed limits. The presence of a very large error in a set of normally distributed errors, suggests an occurrence 71 to the contrary and such an observation can be rejected if the residual error is larger than three times the standard deviation.

8. Weight

This quantity ω is known as weight of the measurement indicates the reliability of a quantity.

It is inversely proportional to the variance (σ^2) of the observation, and can be expressed as

$$\omega = K/\sigma^2$$

Where k is a constant of proportionality. If the weights and the standard errors for observations x1,x2,,…..,etc. are respectively ω1 , ω2 ….., etc., and σ1 , σ2, …..,

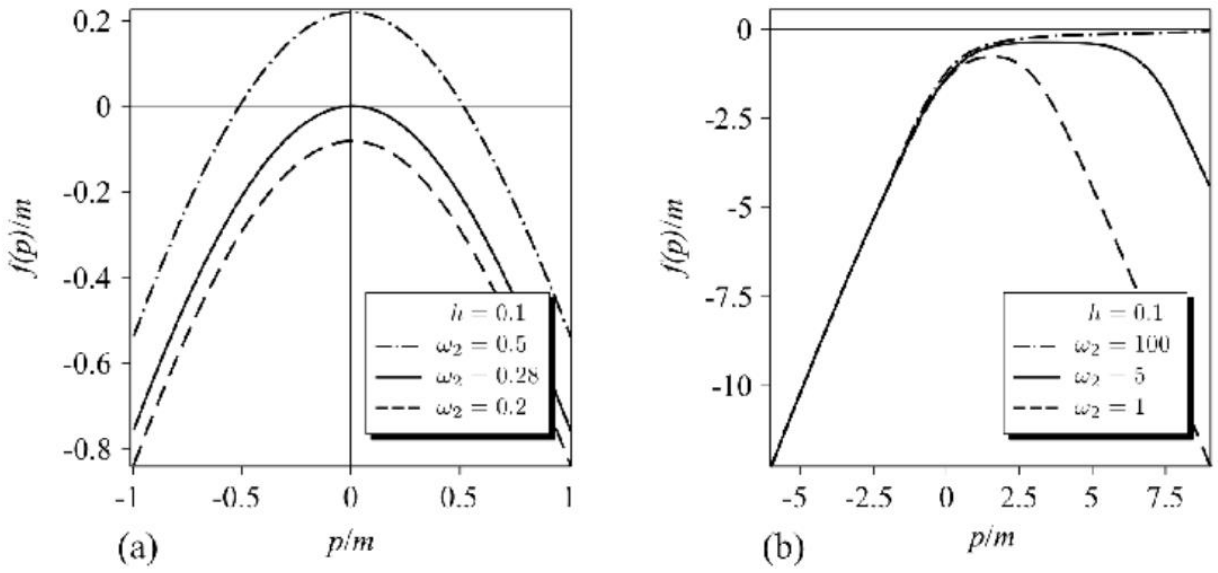


Figure 3.1 weighted proportionality

9. Error Propagation

The calculation of quantities such as areas, volumes, difference in height, horizontal distance, etc., using the measured quantities distances and angles, is done through mathematical relationships between the computed quantities and the measured quantities. Since the measured quantities have errors, it is inevitable that the quantities computed from them will not have errors. Evaluation of the errors in the computed quantities as the function of errors in the measurements is called error propagation.

10. Least Square Adjustments

Least squares method is a classical method which defines the optimal estimate x by minimizing the sum of the weighted observation residuals squared:

$$\sum_{i=1}^{n} p_i \, \widehat{\varepsilon}_i^{\,2} = \text{minimum}$$

Where pi denotes the weight of li , εi denotes the estimated error of li (also called the residual of li) for i = 1, 2, 3 …..n. the above condition applies when the observations li are uncorrelated .

Self-Check – 3	

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Part I: Write True if the statement is correct and False if not.

1. Surveying can be defined as the art and science of determining the relative position of various points on, above or below the surface of the earth.
2. Measurement is the process of estimating or determining the magnitude of a quantity

Part-II: Choose the correct answer

3. Which one of the following is an example of instrumental source of error?
   A. Changed Environment
   B. Mistakes
   C. In complete calibration
   D. Faulty instrument
   E. C and D
4. One of the following methods is not possible to correct measure of random errors.
   A. Probability Distribution
   B. Most Probable value
   C. Confidence limit
   D. All

Part-III: Answer the following questions accordingly

5. _____can be defined as the art and science of determining the relative position of various points on, above or below the surface of the earth.
6. Briefly describe the types of errors and clearly differentiate them.

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