Instructors Manual

for

Construction Surveying and Layout

Third Edition

Part One - Surveying Field Practices

Chapters 1-10

Prepared by

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Chapter 1 - Construction Surveying

QUESTIONS AND PROBLEMS

1. List 10 personal tools carried by a field engineer.

1) Plumb bob
2) Hand level
3) Gammon reel
4) Fieldbook
5) 25' or 5 meter tape
6) marking scribe
7) marking pens
8) pencils
9) calculator
10) safety vest

2. Why do you think a safety belt or harness is needed in construction layout?

It is needed whenever working in high places. Either above a deep excavation, on structural steel, or on bridges.

3. On a word processor, prepare a poster that could be hung on the wall, denoting the personal items you would use for construction layout.

This can be any size that fits the situation. Possibly make it a checklist type of poster to remind what needs to be taken to the field

4. Prepare a bar chart of your daily schedule for a busy day of the week. Determine if it keeps you from forgetting activities.

This can be broken into hour or smaller time slots to show detailed activities that re-occur. Any size is acceptable.

5. Review the success characteristics of a field engineer and determine which are most important to you.

This is a personal evaluation. See the characteristics on page 1-8.

6. Describe the relationship between the field engineer and the superintendent.

The field engineer works for the superintendent. Depending on the company structure, the field engineer helps the superintendent in any way possible.

If the field engineer is from an outside company, that individual still is responsible to whatever the superintendent needs done.

7. Describe the duties of the office engineer.

Project documentation, Shop drawings checking, Preparing submittals for procurement of materials, Providing input to schedules, Keeping track of trend curves, and Assisting in the preparation of Information requests to the designer.

8. Describe the role of the field engineer in quality control.

Field Engineers are the eyes of the superintendent on the jobsite. The Field Engineer is in the midst of the work and can see the materials being placed and the craftsmanship that is being performed. The field engineer can see when something is wrong and may be able to get it corrected before it becomes permanent.

9. Establish a goal (save money, lose weight, etc.) and use a trend chart to keep track of your progress towards that goal.

This is a personal activity. I can attest that it works very well for weight loss…provided you exercise and stick to a diet!!

10. Contact a Registered Surveyor in your area and find out what it takes to become licensed.

Most registered surveyors would be glad to discuss their profession. If a local surveyor cannot be contacted, find out the name of the state surveying society. Visit the website of the American Congress on Surveying and Mapping for the address of every state society. http://www.acsm.net/.

Chapter 2 - COMMUNICATIONS

QUESTIONS AND PROBLEMS

1. Analyze your communication habits and methods and write down five ways you could improve yourself.

1) Listen better
2) Be prepared
3) Concentrate
4) Be understanding
5) Eliminate distractions

2. What is the key to oral communication?

Listening

3. Develop a poster that you could use to remind yourself to be a better communicator.

COMMUNICATION IS KEY

- Communication is the most important part of every action.
- To develop trust on the construction site, be honest in all communications.
- To be an effective person, master the art of listening well.
- Effective letter writing is concise, makes sense, includes necessary information, and cannot be misunderstood.
- Be polite, and be on time for meetings.
- Hand and arm signals are an effective method of communicating on the construction site.
- For safety reasons, be able to communicate with a crane operator.
- Construction stakes are the communication tool used to locate the project.
- Line and grade marks are used to communicate to the craftsperson.
- Use abbreviations to reduce the size of writing on stakes.

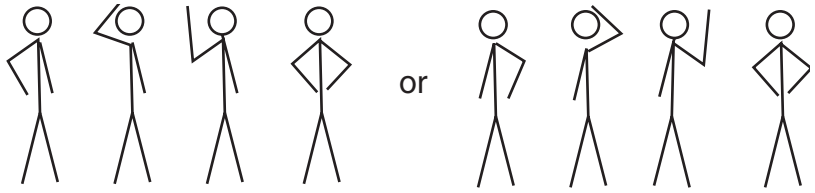
4. What number is represented by the following sequential hand signals?

2 5 0 1

5. What number is represented by the following sequential arm signals?

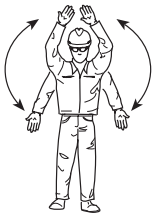
4 8 3 6

6. Using stick figures, draw out the number 3456.

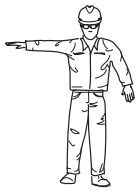


7. What field operations do the following arm signals represent?

Give me line

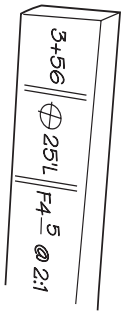


Good



Move right or left

8. Draw the top 10" of a 2"-wide stake on a piece of paper and place the following information on it: Station 3+56, Offset 25 feet Left of centerline, Fill 4.5 feet at a 2:1 slope. Use your best lettering techniques.



9. Develop an 8.5 inch x 11 inch poster of a color code system for the following types of points: primary control, secondary control, working control, benchmark, temporary benchmark, slope stake, centerline, offset point.

Numerous answers could be correct for this problem. The point is that all of the types of points should be listed and a color code system developed.

10. Develop your personal "mark" for communicating grade on a jobsite.

There is no wrong answer. Be creative in developing your own mark just like cowboys were creative in developing ranch brands on cattle.

Chapter 3 - Fieldwork Practices

QUESTIONS AND PROBLEMS

1. What personal protective equipment should a field engineer use?

Hard hat, safety glasses, ear protection, proper clothing for the climate and conditions, safety shoes, safety harness.

2. Regarding cutting tools, why is a sharp tool safer than a dull tool?

The amount of effort it takes with a sharp tool is less. Therefore there is greater control with a less powerful swing.

3. List 5 mistakes that commonly occur in surveying measurement.

Cutting a foot, dropping 100 feet, pressing "zero set" at the wrong time when using a total station, transposing numbers, sighting onto the wrong backsight, etc.

4. Explain how you would describe to someone the difference between mistakes and errors.

Mistakes are large. One mistake can cause the structure to be off.

Errors are small. One error will not cause the structure to be off. But many cumulative errors could.

5. Describe a layout situation on a construction site where you would need both accuracy and precision.

All layout situations require both accuracy and precision. Accuracy to get the building in the correct location, and precision to keep the components of the building within the tolerance required for construction.

6. List the cardinal rules of field book use.

Record data exactly	Keep fieldbook safe	Leave no room for interpretation
List references	Use a hard pencil	Provide identification information
Provide a table of contents	Provide a legend of symbols	Provide a title page
Provide a North arrow	Use sketches freely	Provide date, time and weather
Don't crowd the data	Do not erase	Record everything

7. Describe why erasures are not permitted in a field book.

Fieldbooks may be used in a court of law. Any erasures may result in the book being tossed out of court.

8. Develop a poster on equipment care that you would place on your job as a field engineer.

TAKE CARE OF YOUR EQUIPMENT

- Transport equipment in its case.
- Keep an empty case closed
- Attach the instrument securely to the tripod
- Do not touch the lenses.
- Allow wet instruments to air dry outside of their case.
- Establish a wide foundation
- Never force any part of an instrument
- Keep the instrument clean.
- Climatize the instrument when there are extreme weather conditions.

9. Discuss methods that you would use to keep instruments clean.

Keep the empty case closed

Brush dirt off of the instrument with a shaving brush.

Use compressed air to blow dirt off of an instrument.

Clean the lenses with camera cleaning supplies.

10. How is the care of electronic instruments different from other instruments?

The must be kept drier. Electronic contacts must not get wet.

11. What common food storage aid could be used to keep a calculator dry and clean on a dirty, wet construction site?

Zip-lock bag

12. Develop an "instrument care and maintenance" chart to be used to regularly clean equipment.

Equipment Care Schedule

Maintenance Item	*Daily*	*Weekly*	*Monthly*	*Yearly or at Seasonal Temperature Changes*	*Start of New Job*	*When New*
Wipe Clean						
Deep Clean						
Lubricate (Dry Teflon Spray only)						
Check and Correct Calibration						
Check Instrument Constants						
Lens Cleaning						

13. Describe why the left-thumb rule works.

This works because of the construction of the the threads on the leveling screws. Clockwise rotation with the leveling screw causes the leveling screw to extend and force that side of the instrument to move up. This causes the bubble to move towards that leveling screw.

14. Describe why it is important how the level bubble is oriented in relation to the leveling screws.

If the level bubble is not directly over the leveling screw or parallel to a line between two leveling screws, the maximum movement will not be achieved. Additional movement will need to be made with another leveling screw.

15. Outline the process used to set up an instrument with an optical plummet.

1. Rough-set the tripod
2. Attach the instrument to the tripod
3. Center the optical plummet
4. Adjust the tripod legs up or down to center the bull's-eye bubble on the instrument
5. Confirm the position
6. Center the bubble
7. Check the relation of the optical plummet to the point
8. Loosen the instrument attachment clamp on the tripod slightly
9. Tighten the attachment clamp and recheck the plate level

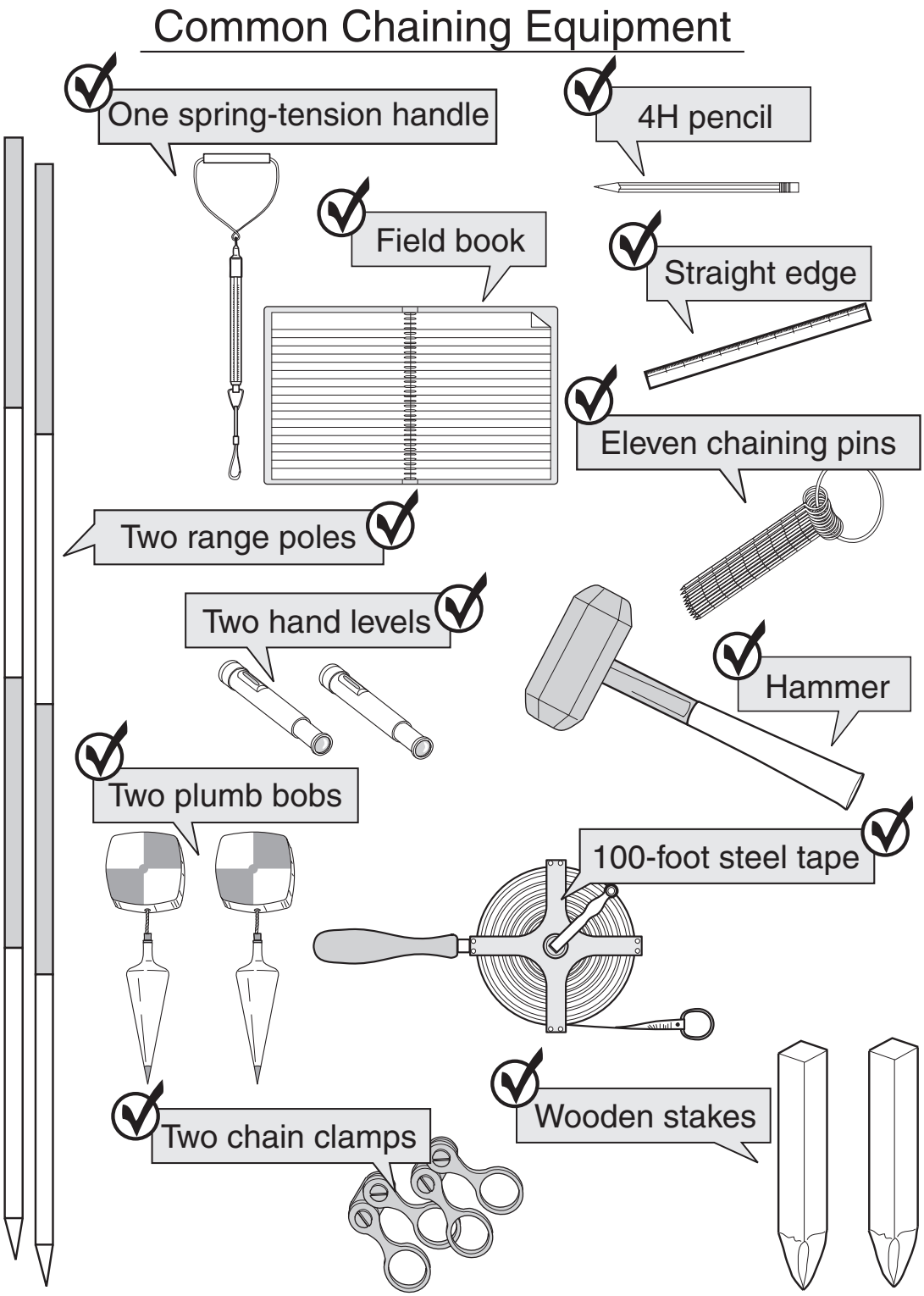
Chapter 4 - Distance Measurement - Chaining

QUESTIONS AND PROBLEMS

1. Describe the difference between a tape and a chain.

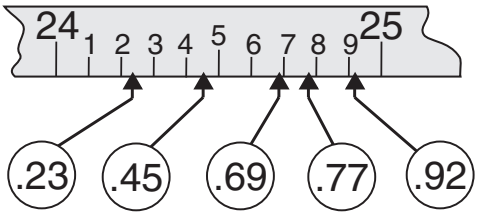
These are unofficial definitions. Tape to a construction person generally means the 25 foot measuring device they clip on their belts. Chain means a 100 foot measuring device that is used for surveying control measurement.

2. Develop a checklist poster for equipment needed for chaining a distance.



3. Draw at a reduced scale a one-foot section of an engineer's chain, labeling the foot marks and the tenth marks on the chain.

4. On the chain length you drew, mark the following with an arrow. x.23, X.45, X.69, X.77, X.92.



5. Write out, in sentence form, the chain reading 53.67 feet, 64.78 feet, and 89.43 feet.

Fifty-three point sixty-seven feet.

Sixty-four point seventy-eight feet.

Eighty-nine point fourty-three feet.

6. Describe the effect on a building that is laid out if the chain is not kept horizontal.

The building will be small because the slope distance measurement will have the effect of shortening the horizontal distance that is laid out.

7. If you have a typical chain that requires 20 pounds of tension applied for the full length, how much tension should be applied for a distance of 15 feet?

There is no specific amount. The full 20 pounds does not need to be applied. However, some amount needs to be applied to keep the sag out of the chain. A rule of thumb would be to apply pull hard enough to take out the sag. That will probably be about 12 pounds.

8. What is the #1 mistake made in chaining distances?

Cutting a foot.

9. Why is it necessary in chaining to measure forward and back?

Measuring both ways is a check of the measurement. If only one way is measured, any mistake will not be found.

10. Describe situations where it will be necessary to violate the "Rule of Thumb" of only plumbing at one end of the chain.

Measuring over bushes, over a rock, over a wall or fence, etc.

11. What is the key to chaining?

Communications is the key. It is necessary for persons 100 feet apart to communicate what is being done at their end of the chain so the other person can properly perform their tasks.

12. How should chaining pins be inserted into the ground?

At 45º to the ground so that the plumb bob can be suspended over the point where the pin goes in the ground. And, at 90 degrees to the chain so that the measurement can be made to the center of the pin.

13. If the forward distance measured is 1234.56 and the back distance is 1234.67, what is the discrepancy ratio?

$$1234.56 - 1234.67 = 0.11$$

$$(1234.56 - 1234.67)2 = 1234.615$$

$$\frac{0.11}{1234.615} = \frac{1}{\chi}$$

$$\text{Ratio} = \frac{1}{11223}$$

14. What is the source of error if a chain is labeled as a 100-foot chain, and it is actually found to be 100.01 when compared to a calibration baseline?

Instrumental

15. List 5 random errors that might occur because of "human limitations."

Reading the distance incorrectly.

Inserting the chaining pin,

Plumbing over the pin.

The plumb bob moving because of an unsteady hand.

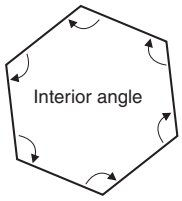
Plumbing at both ends of the chain.

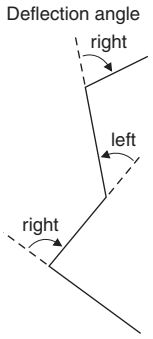
Etc.

Chapter 5 - Angle Measurement

QUESTIONS AND PROBLEMS

1. Draw and describe the difference between an interior angle and a deflection angle.





2. State why it is important to turn angles direct and reverse.

This processes eliminates systematic errors in the instrument. The error may cause the angle to be larger when it is turned direct and it will cause the measured angle to be shorter when it is turned with the instrument reverse. Therefore, the error is balanced out and a better estimate of the true value is obtained by averaging out the angle.

3. How can closing the horizon check your measured angle?

Since it is known that there are 360º in a circle, the summation of the angles around a point should add to 360º within the tolerance of the instruement.

4. Describe three differences between a transit, theodolite, and total station.

The Transit is an open instrument that has two bubbles, a metal circle, an upper and lower clamp, a compass, a four-screw leveling system, and generally is set over a point with a plumb bob. The theodolite has a single bubble, glass circle, various clamp arrangements from one clamp to two clamps, a three screw leveling system and an optical plummet. It is generally much more compact and enclosed than a transit. The total station has many of the features of the theodolite but the angles and distances are measured electronically and the plummet may be a laser.

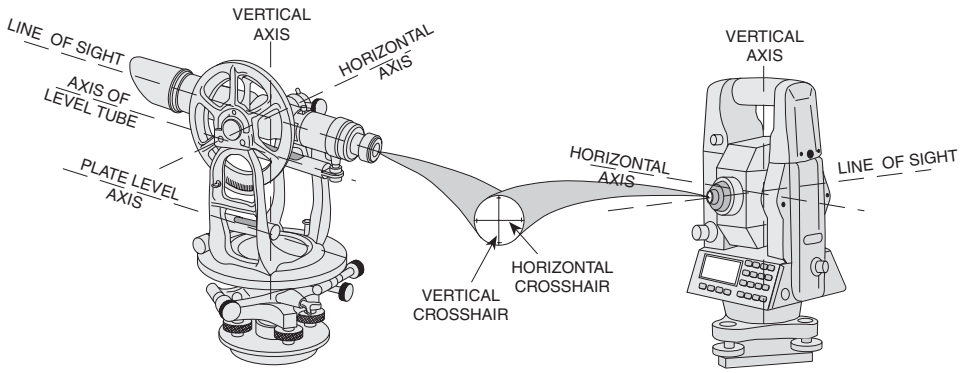
5. What is the main difference between a digital theodolite and a total station?

Digital theodolite just measures angles while the total station measures both distance and angle.

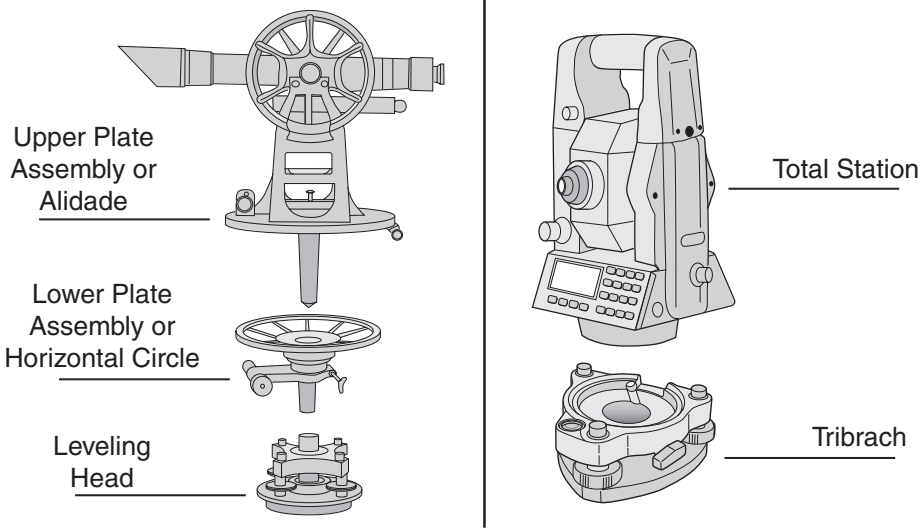
6. Why is a total station called a total station?

Because it is capable of all measurements, including: slope, horizontal and vertical distances, horizontal and vertical angles, coordinate displays, numerous coordinate geometry routines that can be accessed in the field, and often times data collection.

7. Draw or trace an instrument, and show the principle lines and geometric relationships.

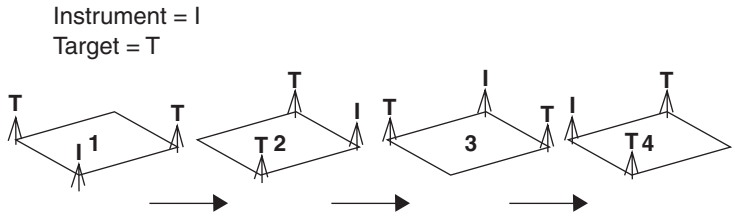


8. Identify the basic components of any instrument.



9. Describe the tribrach and identify how it is useful for rapid angle measurement on control points.

The tribrach is a detachable base used on modern surveying instruments. This system allows interchangeability between instruments, prisms, and targets. This allows for "leapfrogging" the instrument from tripod setup to tripod setup quickly without having to reset the tripod each time. Three tripods and tribrachs are generally used in this procedure.



10. Discuss the function of clamping systems and how they are correctly used.

Clamps allow the instrument to be locked onto the backsight or foresight and also to set the instrument to zero as well as measure and hold the angle. Clamps vary from instrument to instrument. Each instrument should be studied carefully to determine how it works before taking it to the field.

11. List the standard practices that should be followed when measuring horizontal angles.

Communicate, read the owner's manual, have solid setups, set up over the point, keep the instrument level, focus onto the objective. Focus onto the crosshairs, have good targets, sight exactly onto the points, check calibration of the instrument.

12. Describe why good targets are important to the angle-measurement process.

Good, clear, distinct targets allow for repeated exact sighting onto the point.

13. List and describe three "helpful hints" for reading angles.

Set zero exactly, read both ways, read in the correct direction, close the horizon, use direct and reverse.

14. Describe any difference that exists in the process of measuring an angle direct and measuring an angle reverse.

Scope is right side up when sighting direct, and the scope is upside down when turning reverse angles.

15. What geometric formula is used when comparing traverse angles to a closed figure?

(n-2)180 where n is the number of angles in the closed figure.

16. What is the basic difference between measuring an angle and laying out an angle?

Measuring is determining the angle from a existing backsight point to an existing foresight point.

Layout is measuring a calculated angle off of an existing backsight to establish a line or point at the value of the angle.

17. Identify the single greatest mistake that can occur in angle layout.

Sighting onto a bad backsight (moved) or sighting onto the wrong backsight.

18. What is the difference between a vertical angle and a zenith angle?

Vertical angle is measured off of the horizon with up being positive and down from the horizon being negative.

Zenith angles are measure down from the zenith point directly above the instrument. Positive and negative are not needed.

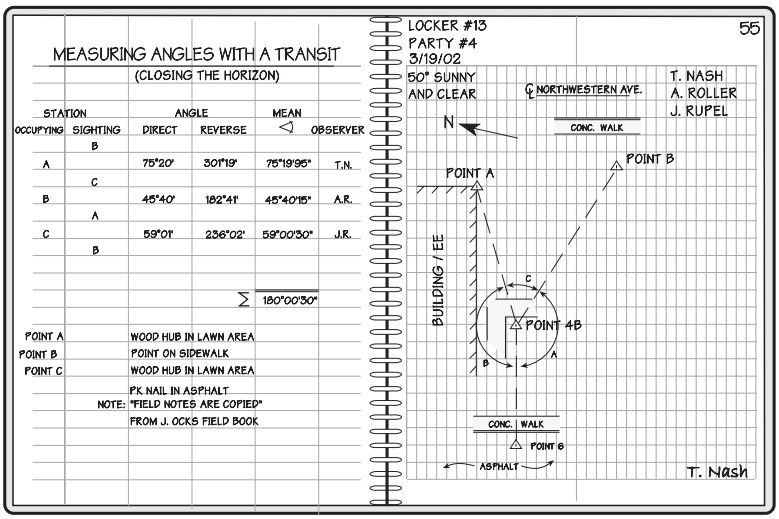
19. Which crosshair is used when measuring horizontal angles, and which crosshair is used when measuring vertical angles?

The vertical crosshair is used when measuring horizontal angles.

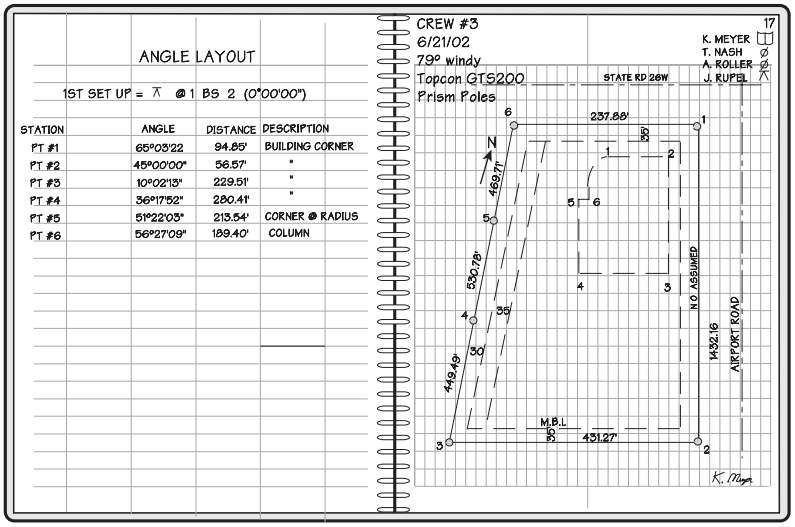
The horizontal crosshair is used when measuring vertical angles.

20. Prepare a sample set of field notes for recording measured angles, and another sample for laying out angles.

Notes for recording measured angles



Notes for laying out angles



Chapter 6 - Total Station

QUESTIONS AND PROBLEMS

1. Describe why the total station is the instrument of choice on the construction site.

Versatile, rapid, greater productivity in the measurement and layout of angles and distances.

2. List and describe five advantages of using a total station.

Instant horizontal distance, quick checking of work, single instrument with great capabilities, easy to use, provides a computer in the field, data storage, etc.

3. How is a total station different from a digital theodolite?

Digital theodolite just measures angles while the total station measures both distance and angle.

4. Visit the World Wide Websites of three surveying equipment manufacturers and research the measurement and functional capabilities of typical one-second total stations that are available. Develop a table comparing a total station from each manufacturer.

www.leica.com

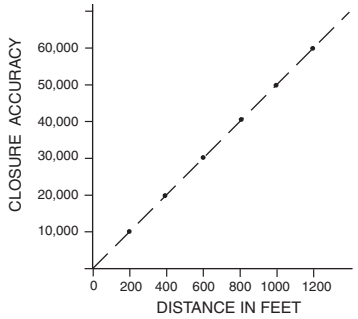
www.sokkia.com

www.topcon.com

www.nikon.com

5. Describe how the relative precision of total stations would affect the layout work on a construction site.

Distance measurement with a total station is best for longer distances. At short distances, the precision is poor.



6. Visit the World Wide Web and research the various types of total stations that are available from one manufacturer. List and describe the types.

www.leica.com

www.sokkia.com

www.topcon.com

www.nikon.com

7. What is actually measured by the total station?

Time that it takes for the wavelength to go out and return to the instrument.

8. Why is it important to sight exactly onto the prism (target) when using a total station?

Not sighting exactly may result in poor angles measured.

9. What major mistake could occur with the zero set feature of a total station?

Pushing the "zero set" button at the wrong time during the measuring sequence can result in a huge error.

10. Describe the relationship of the prism to the center of the rod when the prism has a –30 mm offset.

The center of the prism is 30 mm in from of the center of the rod.

11. What is inputted to determine the parts-per-million correction factor?

Air temperature and barometric pressure

12. For the total station available to you, set up a table that lists the step-by-step procedure for preparing the total station for measuring.

Go to your owner's manual.

13. Outline the basic procedure for measuring a distance and an angle.

1) Set up over the point and prepare for measurements.
2) Measure the height of instrument.
3) Sight onto the backsight and set the direction.
4) Loosen the horizontal clamp and turn to the prism pole held at the foresight.
5) Sight onto the prism.
6) Measure the Distance.
7) Read and record the distance and angle.
8) Double-check.

14. From the step-by-step procedure on measuring, which person is most important to the process?

Both are equally important in performing the task. It is often said however, that the most experienced person should be the one at the prism because anyone can be taught in a few hours to use the total station, whereas it takes months of experience to be good at the various duties at the prism pole (rod holder)

15. Develop a list of equipment that is used in total station measurement.

Total station, prism pole, prism , target, tripods, case for instrument, case for prisms, chain for checking distances, tape for measuring instrument height, hammer, hubs, tacks.

16. Describe the fundamental difference between measuring and layout.

Measuring is determining the distance between two points that are already in the ground.

Layout is the establishment of points on the ground from distances on the plans.

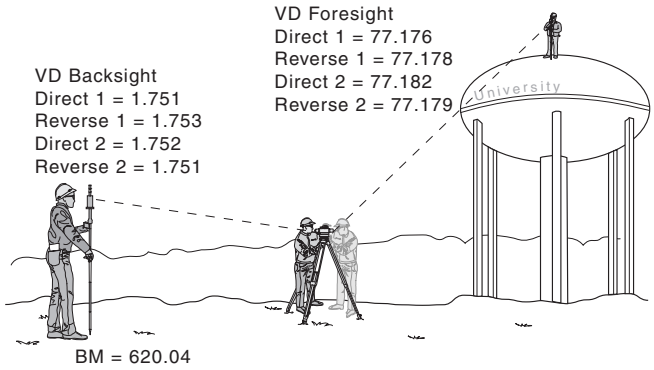
17. List some activities on a construction site where trigonometric elevations would be useful.

Height of pier, height of building, height of dirt pile, establishing elevations throughout the site, depth of excavation, etc.

18. Why is it important to turn direct and reverse to obtain precise elevations in trigonometric leveling?

Again, this averages out any error.

19. Given the following data, what is the elevation of the top of the water tower?



Mean of VD readings on BS = 1.751750

Mean of VD readings on FS = 77.17875

Elevation difference = FS –BS = 77.17875 – 1.751750 = 75.427

BM + Elev Diff = Top of Water Tower

620.04 + 75.427 = 695.467

20. Discuss the advantages and disadvantages of data collectors.

Advantages:

- Eliminates human errors
- Time savings
- Work smarter
- Job Closure
- Point comparison

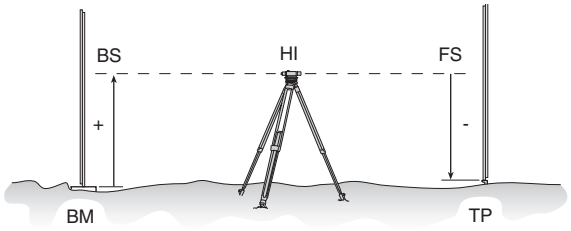
Disadvantages:

- Battery-dependent
- Hand-held data collectors can be expensive
- Non-coordination

Chapter 7 - Leveling

QUESTIONS AND PROBLEMS

1. Illustrate the basic theory of differential leveling.



2. List the formulas to calculate the HI, and to calculate an elevation

BM + BS = HI

HI - FS = TP ELEV

3. Think about and identify when a foresight would be positive.

A foresight is positive when the point is above the line of sight. The rod will be inverted and the reading added to the HI to get the elevation of the bottom of the rod.

4. Define the following leveling terms. Elevation, Datum, Benchmark, Backsight, Height of Instrument, Foresight, Turning Point.

Elevation – Vertical distance above a datum

Datum – A reference surface for leveling. Generally mean sea level.

Benchmark – a permanent solid object of known elevation.

Backsight – a reading on a rod held on a point whose elevation is known. This reading is used to determine the Height of instrument

Height of Instrument – the elevation of the line of sight of the instrument.

Foresight – a reading onto a point whose elevation is unknown. This reading is performed to determine the elevation of a point.

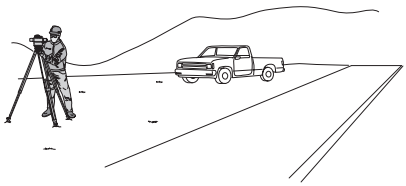
Turning Poing – A point that is used in the leveling process to temporarily hold the elevation while the instrument is moved around the point.

5. Describe why a closed loop is necessary in leveling.

Closing the loop is the primary method of checking to be sure rod readings were correct.

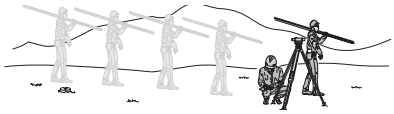
6. Describe the step-by-step differential leveling procedure.

STEP 1 - Set up instrument and level it.

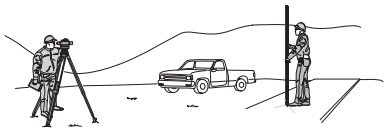


STEP 2 - Hold the rod on known elevation point and record to the nearest 0.01 ft. the backsight reading, with the rod person holding the level rod plumb over the point.

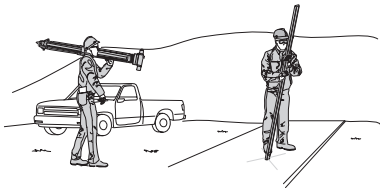
STEP 3 - Advance the rod person to the turning point (an equal distance from the instrument as the backsight station).



STEP 4 - Hold the rod on the turning point and read and record the foresight reading.



STEP 5 - Repeat previous steps until the elevation of the designated point has been determined.



STEP 6 - Close the loop by repeating the process back to the benchmark.

7. State why the distance from the instrument to the backsight and the instrument to the foresight must be the same. (Balanced)

If there is an error in the line of sight causing it not to be horizontal, making sure the distance from the instrument to the Backsight and the distance from the instrument to the forsight is the same (balanced) will result in this error being canceled. In other words, the error would be added in with the backsight and and equal error would be subtracted out with the forsight if the line of sight is not horizontal. If they are not balanced, the errors will not be the same and they will not cancel.

8. For leveling on a small construction site such as a home, which type of level would be a good choice to establish the footing elevations with?

Builders level

9. For establishing elevations on a large site with lots of equipment and a need to perform the operations quick, which level would be best?

Automatic level

10. If running benchmark levels on a site where the elevations must be precise, which level(s) could be used and why?

Digital level because it can read very precisely.

11. Describe why selection of the instrument setup location is critical to efficient leveling.

This is because an instrument setup can be located where it would be difficult to balance the backsights and foresights. If they are not easily balance, extra setups may be needed. Using a hand level is a great tool to assist in locating instrument setups.

12. How is parallax eliminated in a leveling instrument?

Turn the objective focus completely out of focus. Aim the scope at a light colored object and focus the crosshair so it is a crisp and dark as possible. Then, turn the objective focus to the object.

13. State how a rod persons could always insure that the rod is fully extended.

Look at it foot by foot. Or, lay it on the ground and measure it with a 25' tape.

14. Describe the ideal turning point.

Solid and rounded on the top.

15. Describe how profile leveling is different and similar to differential leveling.

Profile is the determination of the elevations along a defined line on the ground. Differential is the determination of the elevation at specific points on a jobsite.

16. Describe how profile leveling is different and similar to cross-section leveling or grid leveling.

Profile is along the centerline of a route and cross-sectioning is perpendicular to the centerline. However, they are the same in that they are both used to determine the elevations of points along a defined line on the ground.

17. Identify any standard practice of differential leveling that is not followed when performing profile, cross-section, or grid leveling.

The most obvious one is that the sights taken in the process of profile, cross-section or grid leveling are not balanced from the instrument. Also, there are typically not as many turning points as in differential leveling.

18. On what type of project might three-wire leveling be used?

One in which a long distance is to be leveled and accuracy is paramount. Three-wire leveling should if performed properly eliminate rod reading errors and result in greater accuracy and precision.

19. Look out a window and describe five objects that would be good benchmarks.

Fire hydrant, curb, sidewalk, manhole cover, base of light pole, etc.

20. Calculate the following differential leveling notes. Provide an arithmetic check.

Level Loop from BM Birch to BM Moose

Station	*+BS*	*HI*	*-FS*	*-SS*	*Elevation*
BM Birch					1420.520
Inst.	6.113	**1426.633**			
TP # 1			7.188		**1419.445**
Inst	5.776	**1425.221**			
TP # 2			4.324		**1420.897**
Inst	6.734	**1427.631**			
BM Moose			9.717		**1417.914**
			Return		↓
BM Moose					**1417.914**
Inst	9.586	**1427.500**			
TP # 3			10.417		**1417.083**
Inst.	11.647	**1428.73**			
BM Birch			8.204		**1420.526**
Check Σ =	**39.856**		**39.850**		

Difference between starting and ending elevation = 1420.520 – 1420.526 = 0.006

Difference between Sum of BS and Sum of FS = 39.856 – 39.850 = 0.006 Checks

21. Calculate the following differential leveling notes. Provide an arithmetic check.

Level Loop from BM 338 to BM 441

Station	*+BS*	*HI*	*-FS*	*-SS*	*Elev*
BM 338	6.659	**241.772**			235.113m
TP # 1	5.431	**241.086**	6.117		**235.655**
TP # 2	5.135	**237.487**	8.734		**232.352**
TP # 3	5.321	**233.657**	9.151		**228.336**
TP # 4	3.197	**224.898**	11.956		**221.701**
TP # 5	0.355	**214.486**	10.767		**214.131**
BM 441	11.772	**217.880**	8.378		**206.108**
TP # 6	12.919	**225.348**	5.451		**212.429**
TP # 7	14.185	**231.757**	7.776		**217.572**
TP # 8	12.717	**232.877**	11.597		**220.160**
TP # 9	10.239	**232.345**	10.771		**222.106**
TP # 10	9.636	**236.854**	5.127		**227.218**
BM 338			1.736		**235.118**
Check	**97.566**		**97.561**		

Difference between starting and ending elevation = 235.113 – 235.118 = 0.005

Difference between Sum of BS and Sum of FS = 97.566 – 97.561 = 0.005 Checks

22. Calculate the following profile leveling notes. Provide an arithmetic check.

Profile Level Notes of Barcus Orchard Road

Station	*+BS*	*HI*	*-FS*	*-SS*	*Elev*
BM 3055	4.56	**4414.580**			4410.02
TP # 1	2.43	**4407.690**	9.32		**4405.260**
0+00				4.6	**4403.1**
0+50				4.2	**4403.5**
1+00				3.2	**4404.5**
1+50				1.7	**4406.0**
TP # 2	5.68	**4412.48**	0.89		**4406.800**
2+00				7.5	**4405.0**
2+50				3.8	**4408.7**
2+76				6.5	**4406.0**
3+00				2.7	**4409.8**
Tp # 3	3.75	**4413.53**	2.70		**4409.78**
TP # 4	7.62	**4415.49**	5.66		**4407.87**
BM 3055			5.45		**4410.04**

Difference between starting and ending elevation = 4410.02 – 4410.04 = 0.02

Difference between Sum of BS and Sum of FS = 24.04 – 24.02 = 0.02 Checks

23. Calculate the following profile leveling notes. Provide an arithmetic check.

Profile Level Notes of Camp Rotary Road

Station	*+BS*	*HI*	*-FS*	*-SS*	*Elev*
BM 325	2.562	**443.582**			441.02m
TP # 1	2.430	**442.179**	3.833		**439.749**
0+00				4.63	**437.55**
0+20				5.23	**436.95**
0+40				3.82	**438.36**
0+55				1.75	**440.43**
1+45				0.54	**441.64**
Tp # 2	3.958	**443.367**	2.770		**439.409**
1+50				1.82	**441.55**
2+76				3.65	**439.72**
3+00				4.79	**438.58**
TP # 3	3.621	**441.352**	5.636		**437.731**
BM 325			0.336		**441.016**
BS + FS	**12.571**		**12.575**		

Difference between starting and ending elevation = 441.02 – 441.016 = 0.004

Difference between Sum of BS and Sum of FS = 0.004 Checks.

24. Calculate the elevations of the grid points. Provide an arithmetic check.

Elevations of XYZ Building Site Prior to Excavation

Station	*+BS*	*HI*	*-FS*	*-SS*	*Elev*
BM 926	1.75	**622.03**			620.28
TP1	3.44	**620.91**	4.56		**617.47**
A1				4.7	**616.2**
A2				4.6	**616.3**
A3				4.5	**616.4**
A4				4.4	**616.5**
B1				5.2	**615.7**
B2				5.0	**615.9**
B3				5.0	**615.9**
B4				4.7	**616.2**
C1				5.6	**615.3**
C2				5.2	**615.7**
C3				4.8	**616.1**
C4				4.5	**616.4**
D1				5.8	**615.1**
D2				5.1	**616.8**
D3				4.8	**616.1**
D4				4.6	**616.3**
TP 2	5.67	**622.88**	3.70		**617.21**
BM 926			2.59		**620.29**
BS + FS	**10.86**		**10.85**		

Difference between starting and ending elevation = 620.2802 – 620.29 = 0.01

Difference between Sum of BS and Sum of FS = 10.86 – 10.85 = 0.01 Checks.

25. Calculate the elevations of the grid points. Provide an arithmetic check.

Elevations of XYZ Building Site after Excavation

Station	*+BS*	*HI*	*-FS*	*-SS*	*Elev*
BM 926	2.59	**622.87**			620.28
TP1	4.44	**621.63**	5.68		**617.19**
A1				9.7	**611.9**
A2				9.6	**611.3**
A3				9.6	**611.3**
A4				9.7	**611.9**
B1				9.7	**611.9**
B2				9.6	**612.0**
B3				9.5	**612.1**
B4				9.7	**611.9**
C1				9.8	**611.8**
C2				9.6	**611.3**
C3				9.7	**611.9**
C4				9.8	**611.8**
D1				9.7	**611..9**
D2				9.6	**611.3**
D3				9.8	**611.8**
D4				9.7	**611.9**
TP 2	3.83		3.71		**617.92**
BM 926			1.49		**620.26**
BS + FS	**10.86**		**10.88**		

Difference between starting and ending elevation = 620.28 – 620.26 = 0.02

Difference between Sum of BS and Sum of FS = 10.88 – 10.86 = 0.02 Checks.

26. The grade foreman on the utilities just called. He doesn't like decimal parts of a foot represented on grade stakes. He wants the offset stake tops to be a whole number of feet (XXX.00) above foundation forms. Having gathered the following data, how much deeper must this stake be driven until it is a whole number of feet above the form elevation of 658.00? What elevation is it driven to? When the stake is at the desired grade, what will be your reading on the rod?

Top of Form = 658.0'	
BM #1= 664.71	BM #2 = 665.32
BS on BM #1 =7.23	BS on BM #2 = 6.62
Initial Rod Reading on Stake = 11.34	

Answer:

HI#1 = 664.71 + 7.23 = 671.94

HI#2 = 665.32 + 6.62 = 671.94

This confirms that the Benchmarks have not moved, the readings were correct, and the math was correct. The HI is 671.94.

HI - Rod Reading = Elevation on Stake.

671.94 - 11.34 = 660.60.

660.60 - 658.00 = 2.60' above the form elevation.

To get the mark on the stake an even number of feet above 658.00, drive the stake 0.60' down so that the rod reading on the stake will be

11.34 + 0.60 = 11.94.

Checking...671.94 - 11.94 = 660.00. The stake is exactly 2 feet above the formwork and has been driven to elevation 660.00.

Chapter 8 - Lasers

QUESTIONS AND PROBLEMS

1. What is LASER an acronym for?

Light **A**mplified by **S**timulated **E**mission of **R**adiation

2. List advantages of lasers as a construction tool.

Ease of use, productivity, versatility, fewer human errors, accurate, dependable.

3. Explain why lasers are so versatile.

Many kinds, horizontal lines, horizontal planes, vertical lines, vertical planes, slope lines, slope planes and compound planes are possible with various types of lasers.

4. What benefits do lasers bring to the construction site?

Manny applications of the laser are possible on the construction site. See answers above.

5. What types of lasers are available?

Visible beam and electronic levels.

6. Distinguish between fixed, rotating, and utility lasers.

A fixed laser projects a single line, for example a pipe laser.

A rotating laser projects a beam that can be seen 360º around the instrument.

A utility laser projects fixed or rotating lines.

7. List the various classes of lasers and their accuracy.

Fixed = + 1/16th per 100 feet.

Rotating = + 1/16th per 100 feet

Utility = + 1/16th per 100 feet.

8. List five uses of a pocket laser on a jobsite.

- Square a room
- Project a line onto a ceiling
- Create a horizontal line
- Project a straight line
- Locate the center of a room, etc.

9. Describe why a utility laser is such a versatile instrument.

Utility has all the functions and planes available on it.

10. Explain why having two or more lasers set up on a construction site could cause major mistakes.

Two planes could be projected and the wrong line could be picked up by a sensor.

11. List five sources of mistakes that could occur in laser use on the jobsite.

- Two lasers used at the same time
- Signal reflection off of a surrounding building
- Laser bumped
- Weather deflection of line
- Wrong Benchmark used

12. Under what conditions might a laser become unusable due to weather.

Heavy rain, fog, snow

13. Besides a normal level rod, what can a sensor be attached to when establishing elevations?

Direct elevation rod, 2 by 2 lumber, 2 by 4 lumber

14. Describe how it is possible to establish grade (elevations) with one person, using a direct elevation rod and Laser

Set BM elevation at the line of sight of the laser on the rod. Read elevations of FS onto Turning Point directly on the rod. Repeat as needed for each instrument setup. This is time-consuming, but it is do-able by one person.

15. What type of laser does not have to be checked for calibration?

None. All should be checked.

Chapter 9 - GPS Field Procedures

QUESTIONS AND PROBLEMS

1. What makes GPS unique from other measuring tools?

It determines position via satellite signals. No physical measurement (such as chaining) is made between points.

2. In what ways has GPS revolutionized surveying?

One person surveys are possible. Position can be determined anywhere on the surface of the earth. Intervisibility between points is not needed, etc.

3. List 5 uses of GPS other than those listed in this text.

- Farming
- GEOCACHE games
- Military
- Ship navigation
- Mountain climbing, etc.

4. How many satellites are used in the GPS system?

24 plus 6 in reserve

5. List 5 advantages of GPS over conventional surveying techniques.

- Intervisibility not needed
- Instant positioning
- Day or night use
- Flexibility
- Simple operation.

6. Describe 5 significant disadvantages of GPS.

- Obstacles such as trees, buildings
- Satellite positioning limits time and day for strongest signals
- No underground system
- Can't be used under bridges
- Battery dependent, etc

7. Why isn't GPS used for all types of surveying and construction layout?

Not precise enough for all types of layout.

8. Research in a library or on the Internet the different types of GPS surveying (static, rapid static, kinematic, stop and go, and RTK) and their uses in surveying.

Please visit the library for this answer.

9. Describe the basic theory of DGPS.

Establish a GPS base station that communicates with a rover GPS unit. The difference between positions can be very accurately determined.

10. Identify why good GPS surveying starts in the office and not in the field.

Planning must be the first step of a GPS survey. Determine the location, time, obstacles, obstructions, etc., to make system work as efficiently as possible.

11. List 10 standard practices that will improve the field procedures of GPS surveys.

- Consistancy
- Planning
- Reception
- Calibration
- Flexibility
- Reconnaissance
- Orientation
- Checklists of personal equipment
- Checklists of equipment
- GDOP
- Security

12. On a word processor, develop your own personal checklists for GPS surveying.

This is a personal list.

13. What is the most important part of GPS planning?

Availability of satellites.

14. Based on the items discussed in this Chapter, go to a local construction site and prepare a skyplot of obstructions that would affect GPS work on that site.

Personal observations.

15. Prepare a checklist that could be used to check all of the equipment used in a GPS survey to ensure that it is in good shape.

This could be done in a table on a word processor. The answer is dependent on the type of equipment available.

16. Visit the World Wide Web and locate websites that present GPS satellite availability times for your location.

Personal observation of WWW resources.

17. Distinquish between the various DOP's that affect the GPS survey results.

PDOP – precision in position

HDOP – horizontal position

GDOP – Geometric position of satellites

VDOP – Vertical position

18. Locate a local baseline for calibrating GPS equipment.

Personal observation in your area.

19. Develop a GPS log sheet for recording the observation data.

Project Name:		Project ID:	
Company:			
Crew:			
Date:	Day:	Start Time:	End Time:
Weather:	Temp:	Pressure:	
Station Name:		ID:	#
Equipment:		Observer:	
Model:		Antenna: Fixed or Variable	
Receiver S/N:		HI of Fixed Pole:	
Antenna S/N:		Satellites Tracked: Circle	
Antenna Model:		1 2 3 4 5 6 7 8 9 10	
Data Collector S/N:		11 12 13 14 15 16 17 18	
Tripod Type: Fixed Adjustable		19 20 21 22 23 24 25 26	
Cable Condition Lengths		27 28 29 30	
File Name			
Backup Yes No			
Sketch on Back? Yes No			
Problems Encountered:			

20. What is the most important rule of thumb regarding the downloading of GPS data?

Back it up. Download as soon as possible.

Chapter 10 - Equipment Calibration

QUESTIONS AND PROBLEMS

1. Describe what the components of an ideal area would be for testing angle-measuring instruments.

Avoid obstacles, flat, open area

2. Describe what an ideal area for testing leveling instruments.

Flat open area for testing leveling equipment

3. When is the best time of the day to perform calibration checks?

Early morning before the sun comes up and the air temperature becomes hot.

4. Describe the step-by-step process used to calibrate a chain.

STEP 1 - Assign specific duties to the individuals assisting in the test: Two persons to hold the ends of the chains and apply the proper tension, one person to align the 0 ends, and one person to make the comparison at the 100- or 200-foot ends. Lay out the chains. Attach the tension handles to the chains. Assuming the chains will be lying on the ground fully supported, a tension of 10-12 pounds will be applied. (Check chain manufacturer for the exact tension required for the particular chain.) The persons doing the comparing should each have a magnifying glass for more precise alignment of the end marks.

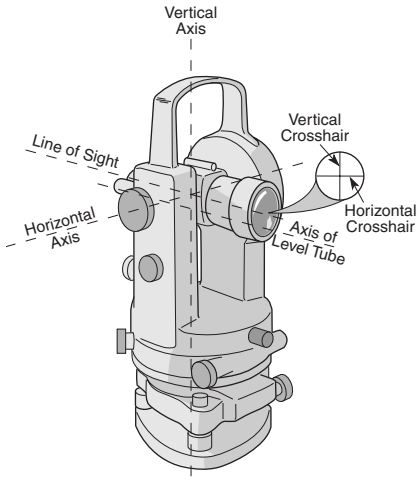
STEP 2 - With everyone in position, apply tension to the chains. Have the person at the 0 end communicate to the holders to align the 0's perfectly. When that is ready, communicate to the person measuring the difference between the calibrated chain and the chain being tested. Constant communication between the participants is the key to a successful comparison of the chains.

STEP 3 - The person doing the comparison should measure and record the difference (estimate to the thousandth of a foot) between the ends of the chains.

STEP 4 - Repeat the test at least three times to obtain an average of the difference in length. Apply any correction for expansion or contraction of the chain because of temperature. Compare the nominal (what length the chain should be) to the calibrated length.

5. Draw an instrument and show the principle lines and geometric relationships.

See text on page 10-11.



6. What out-of-calibration geometric relation is not eliminated by direct-and-reverse procedures?

Plate level not being perpendicular to the vertical axis.

7. When prolonging a centerline on a highway project, which geometric relationship is most important?

Line of sight should be perpendicular to the horizontal axis.

8. In high-rise construction, which of the geometric relationships within an instrument is most important for plumbing the structure?

The horizontal axis should be perpendicular to the vertical axis.

9. When using a transit as a level for setting grade on forms, establishing elevation, etc., which of the geometric relationships within an instrument is most important?

The line of sight should be perpendicular to the vertical axis.

10. What special procedure must be performed so that the quick peg can be performed by one person? Describe or illustrate.

STEP 1 - Locate two objects that are about 250 feet apart where it would be possible to glue onto or nail into a 2-foot or 1-meter section of an old rod. This could be old power poles, light poles, buildings, bridge piers, etc. Obtain permission to do this from the owner.

STEP 2 - Set up the leveling instrument exactly between these two objects, make sure it is level, and sight towards each object and mark the line of sight on the object. Because of the geometry of the instrument, these marks will be the same elevation.

STEP 3 - Glue or nail a section of rod on each object, making sure the foot or meter mark at the bottom of the rod is exactly on the marks placed on the object.

STEP 4 - Now, whenever a leveling instrument needs to be pegged, simply set up the instrument close to one of the objects. Sight onto the near rod face, and read the rod. Sight onto the far rod face, and read the rod.

STEP 5 - Compare the readings. Ignore the whole foot/meter parts of the reading as they may not be the same since a different part of the rod was glued to the object. However, the decimal part of the reading should be the same if the instrument is in proper adjustment. If the decimal parts are different, the instrument needs adjusted.

11. Describe how to check the calibration of a circular bubble.

STEP 1 - Screw the prism pole into the top assembly. Place prism pole tip in bottom shoe. Move the brackets as needed to center the bubble. Tighten the top and bottom.

STEP 2 - Now rotate or spin prism pole 360°. If the bubble is in adjustment, it will remain centered throughout this rotation. If the bubble drifts off of center, the bubble is not in adjustment.

STEP 3 - If the bubble needs adjustment, locate the vial adjustment screws on the bottom of the bubble housing, and turn them until the bubble is centered.

Repeat Step 2 until bubble remains centered in a full 360-degree rotation.