

INTRODUCTION

As you gain skills as a cement mason, you'll move from finishing concrete to building formwork and eventually laying out building sites. As you have learned in other units, it is vitally important that building lines be laid out accurately, that screeds are set to the proper grade, and that driveways and slabs have the proper fall. All of these actions depend on the skill of the cement mason using the level or transit. In this unit you'll learn the proper way to set up an instrument, take readings, and record them accurately.

**FOCUS
ASSIGNMENTS**

FOCUS ASSIGNMENTS

1. Visit a job site where levels or transits are being used. Ask your instructor to explain the various situations that call for the use of a particular instrument.
2. Write a brief summary of your findings.



Writing



Employability

**UNIT
OBJECTIVE**

After completing this unit, you will show the following competencies by mastering the activities on the Assignment and Job Sheets and by scoring at least 85% on the Written Test.

**SPECIFIC
OBJECTIVES**

1. Select from a list uses of a level.
2. Identify types of levels.
3. Identify parts of a level.
4. Select from a list uses of a transit.
5. Identify types of transits.
6. Label major components of a transit.
7. Identify parts of a transit.
8. Identify different types of verniers.



9. Interpret readings on different styles of verniers.
10. List typical mistakes made in reading verniers.
11. Label vertical and horizontal cross hairs and line of sight on a leveling instrument.
12. State rules for proper care of leveling instruments.
13. Identify parts of a leveling rod.
14. Match parts of a leveling rod to their correct uses.
15. Describe commonly used direct-reading rods.
16. Identify markings on a direct-reading rod.
17. Read direct-reading rods. (Assignment Sheet 1)
18. Identify hand signals used by the instrument person to guide the rod person.
19. Accurately read various types of verniers on transits. (Assignment Sheet 2)
20. Set up and adjust a level. (Job Sheet 1)
21. Use a level to check elevations. (Job Sheet 2)
22. Use a level to perform differential leveling. (Job Sheet 3)
23. Tie a slip knot for adjusting a plumb bob. (Job Sheet 4)
24. Set up and adjust a transit. (Job Sheet 5)
25. Use a transit to locate building corners. (Job Sheet 6)
26. Measure and read angles in the field. (Job Sheet 7)



OBJECTIVE 1

Optional Activities/
Resources in Instructor's
Guide

Select from a list uses of a level.

WORDS YOU SHOULD KNOW	
elevation	given grade
differential leveling	leveling method by which the difference in elevation between two points is determined by plus and minus rod readings that are totaled and adjusted to bench mark
level	optical leveling instrument consisting of a telescope and leveling bubble; used with a tripod and leveling rod primarily for establishing grade levels

- Establish elevations and grades
- Establish differential elevations
- Transfer elevations from one point to another

OBJECTIVE 2

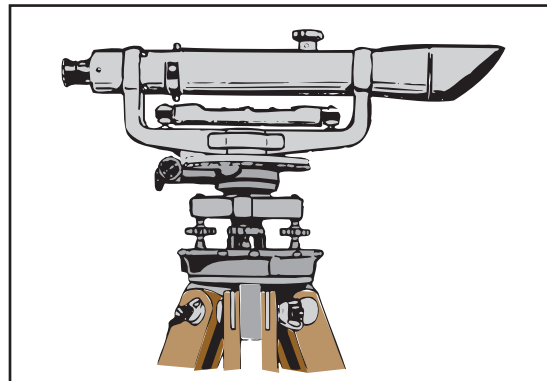
Optional Activities/
Resources in Instructor's
Guide

Identify types of levels.

WORDS YOU SHOULD KNOW	
laser-beam instrument	automatic level that uses a laser beam to establish elevation readings

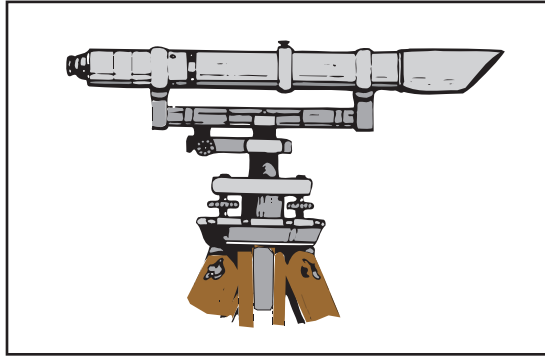
- Builder's level (Figure 1)

FIGURE 1



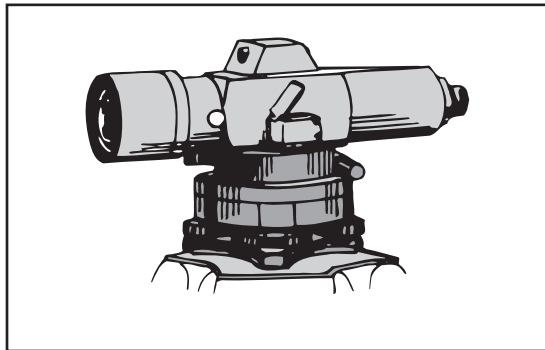
- Dumpy level (Figure 2)

FIGURE 2



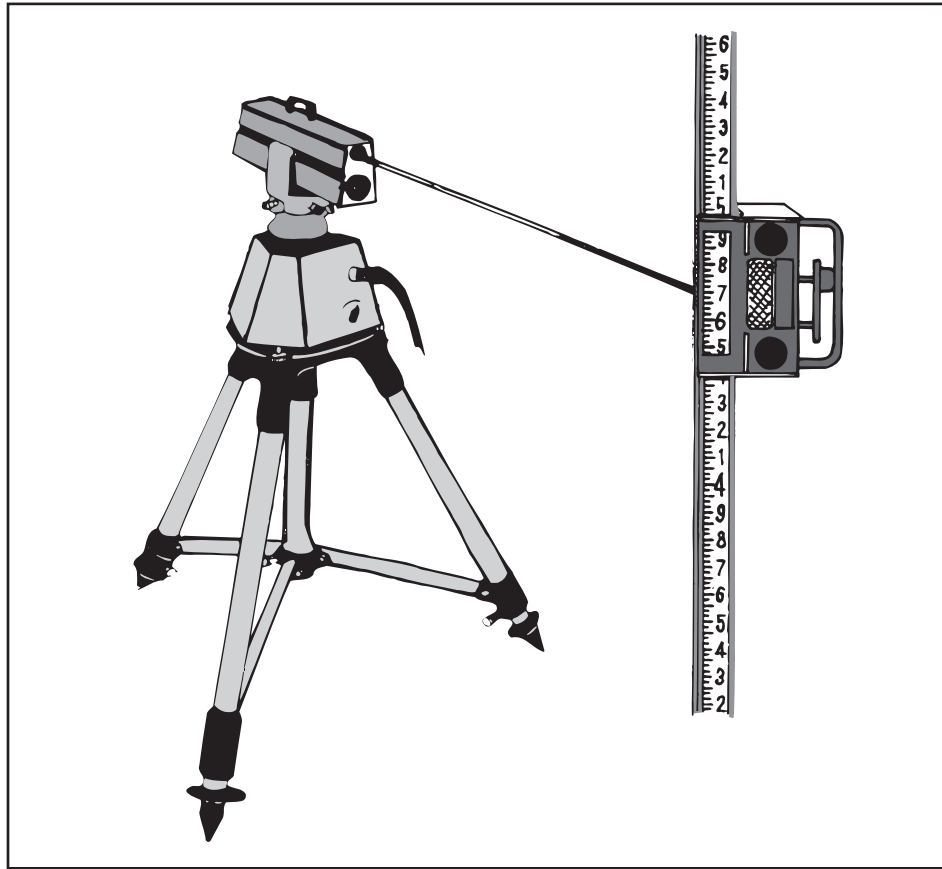
- Automatic level (Figure 3)

FIGURE 3



- Rotating laser-beam instrument (Figure 4)

FIGURE 4

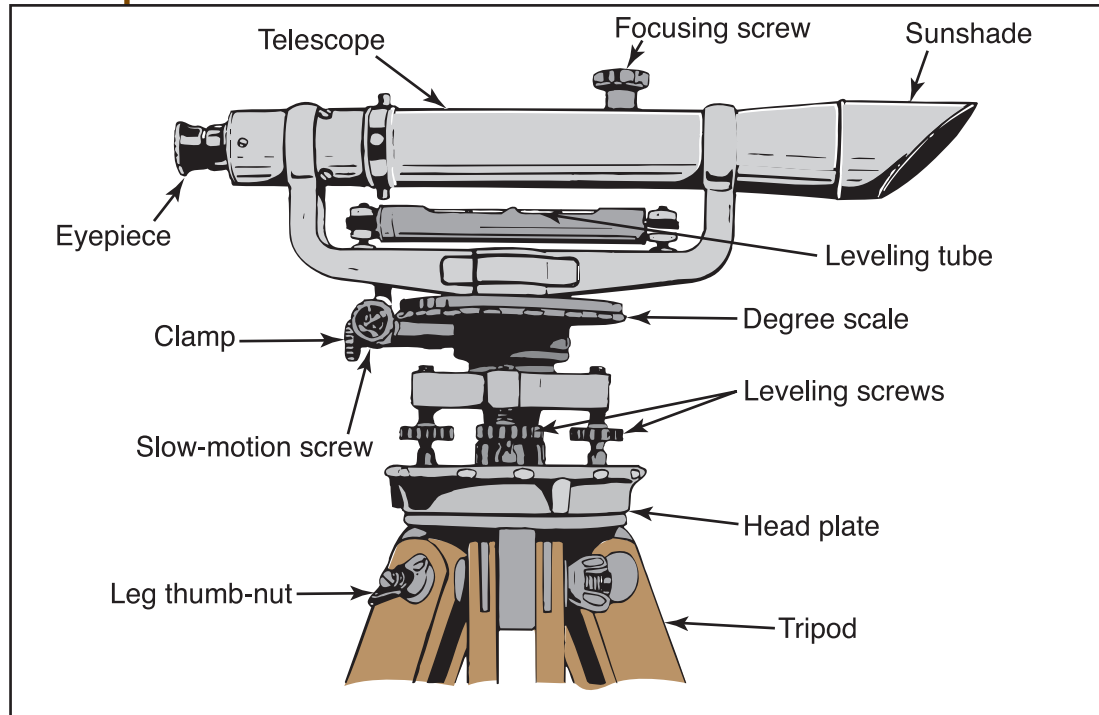


OBJECTIVE 3

Optional Activities/
Resources in Instructor's
Guide

Identify parts of a level.

FIGURE 5



OBJECTIVE 4

Optional Activities/
Resources in Instructor's
Guide

Select from a list uses of a transit.

WORDS YOU SHOULD KNOW

transit

very precise instrument used to establish straight lines and to measure horizontal and vertical angles

- Measure horizontal angles
- Measure vertical angles
- Measure elevations
- Lay out boundaries and building lines
- Establish elevations and grades

✓ **NOTE:** A leveling instrument is the preferred instrument for establishing grades, but a transit can be used if a level is not available.



OBJECTIVE 5

Optional Activities/
Resources in Instructor's
Guide

Identify types of transits.

- Engineer's transit
- Combination level transit

FIGURE 6

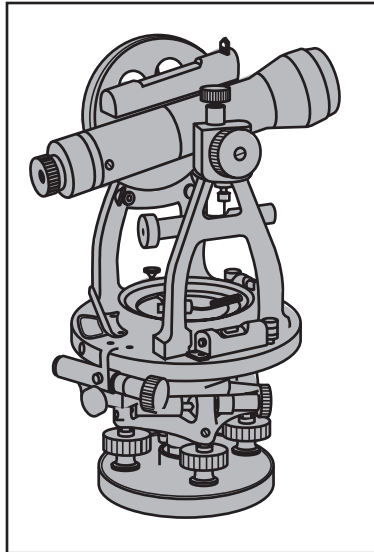
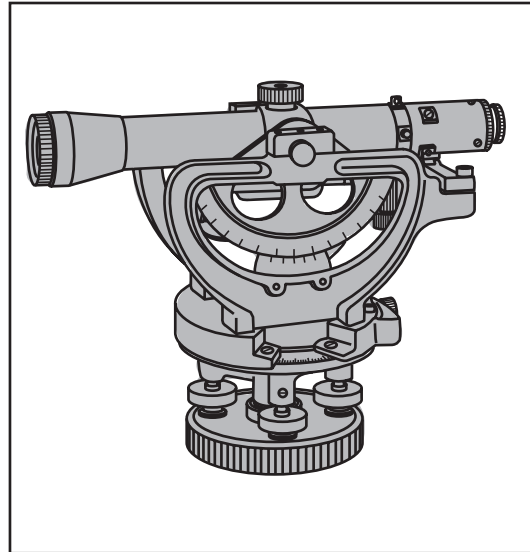
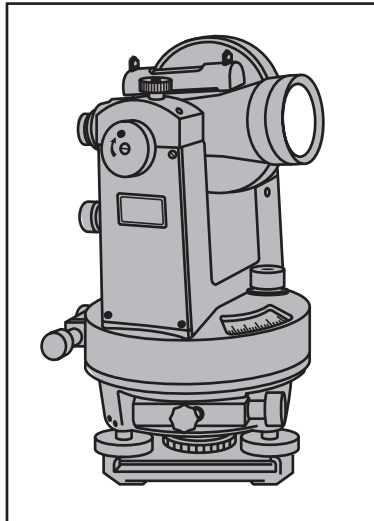


FIGURE 7



- Optical plummet transit

FIGURE 8



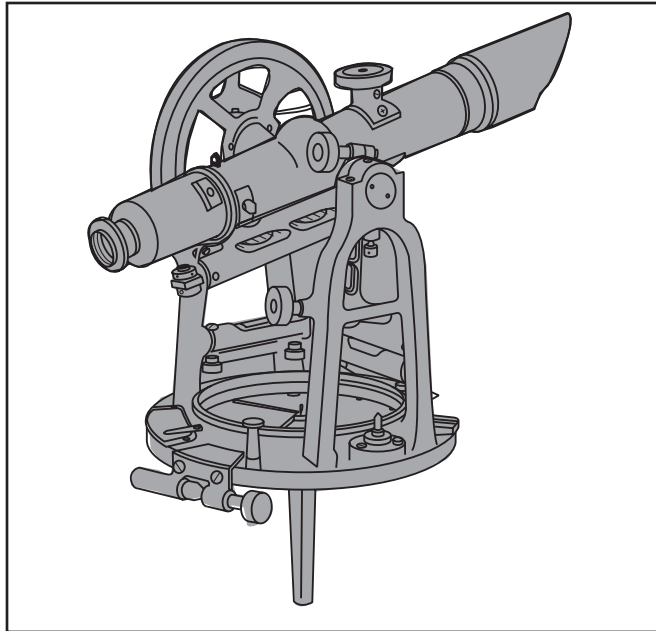
OBJECTIVE 6

Optional Activities/
Resources in Instructor's
Guide

Label major components of a transit.

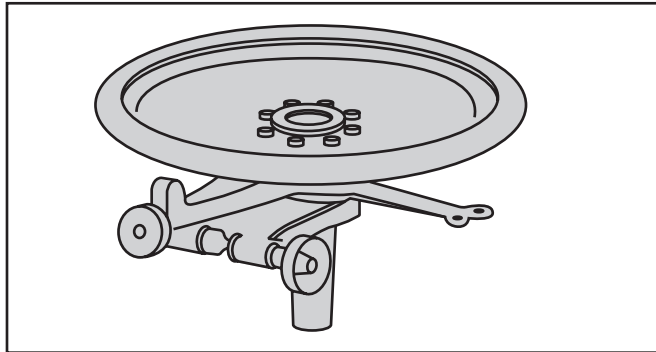
- Alidade (Figure 9)

FIGURE 9



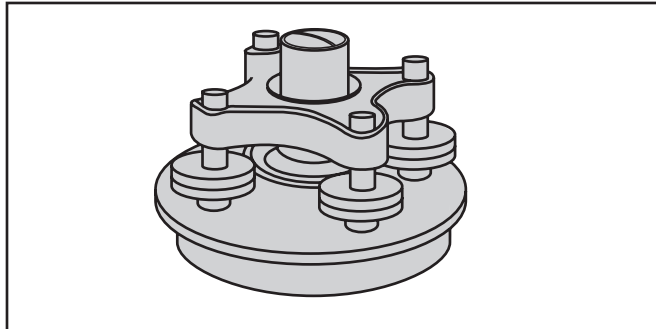
- Horizontal circle (Figure 10)

FIGURE 10



- Leveling head (Figure 11)

FIGURE 11



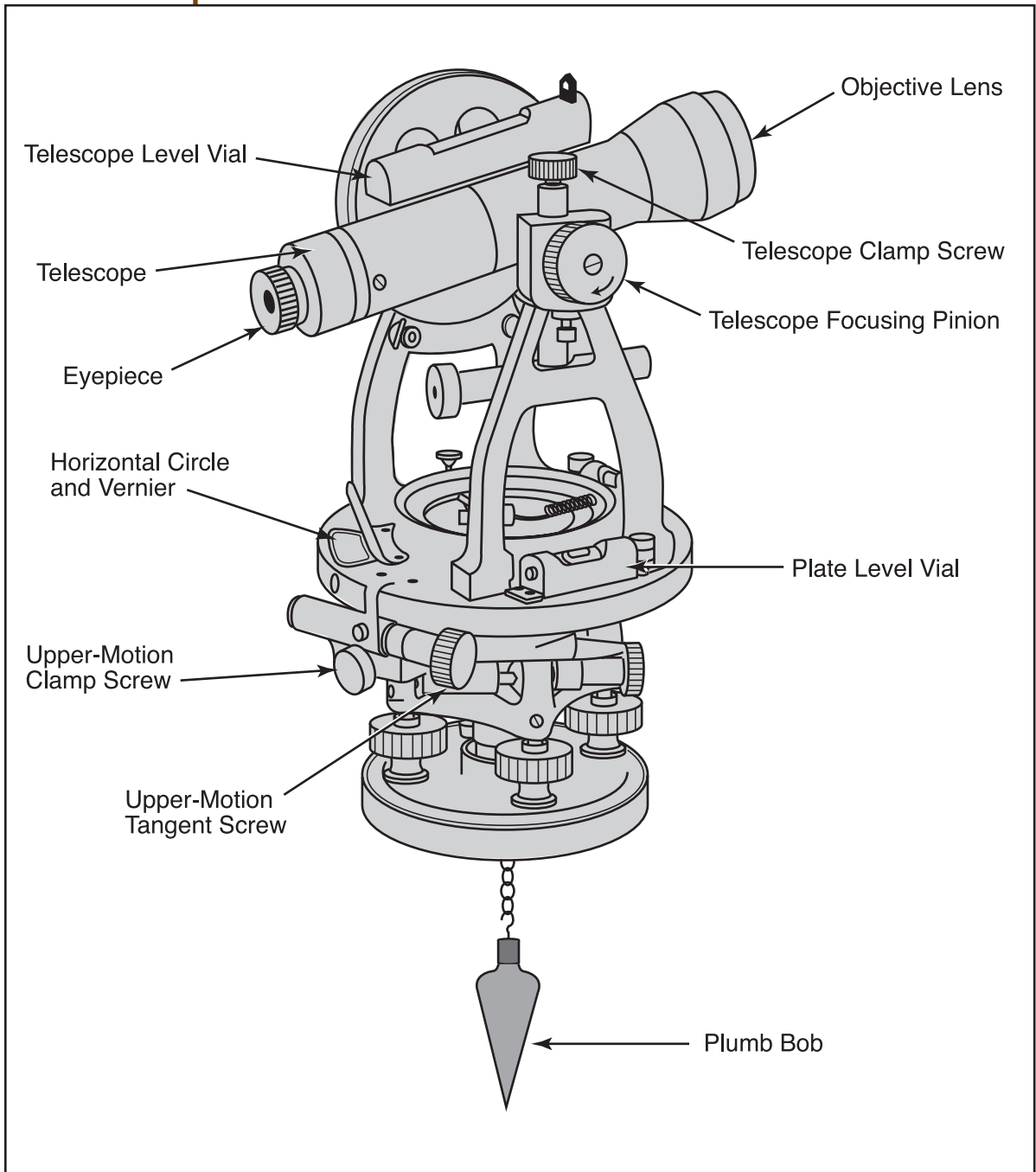
OBJECTIVE 7

Optional Activities/
Resources in Instructor's
Guide

Identify parts of a transit.

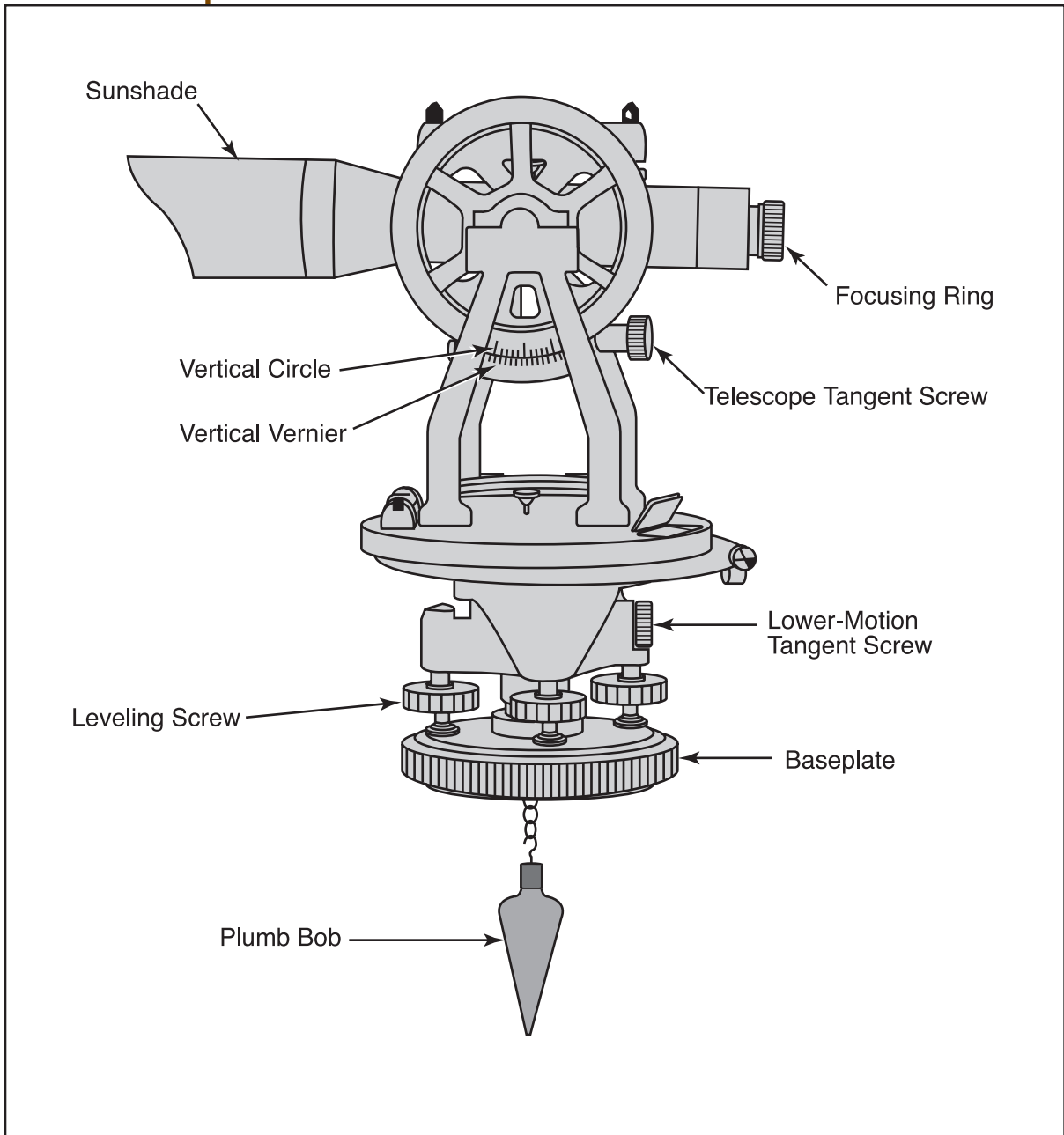
VIEW 1

FIGURE 12



VIEW 2

FIGURE 13



OBJECTIVE 8

Required Activities/
Resources
— Transparencies 1-3

Optional Activities/
Resources in Instructor's
Guide

Identify different types of verniers.



Your instructor will show you transparencies of different types of verniers.

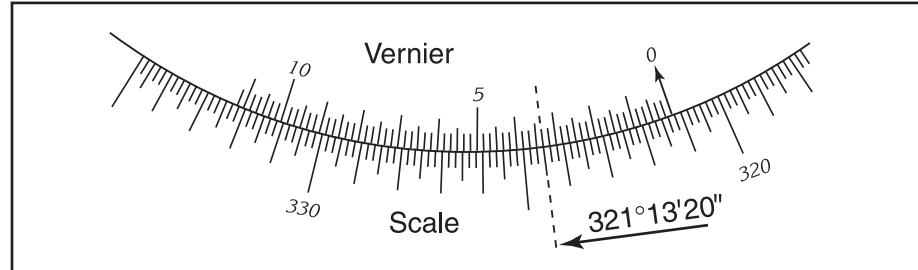
WORDS YOU SHOULD KNOW

least count	the smallest reading obtainable on a vernier without interpolating
vernier	short axillary scale set parallel to and beside a primary scale; provides fractional parts of the smallest mainscale divisions without interpolating
interpolate	to determine a value that occurs between two known values

- **Direct or single vernier** — Read in only one direction and must therefore be set with the graduations ahead of the zero (index) mark in the direction to be turned. (Figure 14)

Graduated 10 minutes reading to 10 seconds

FIGURE 14

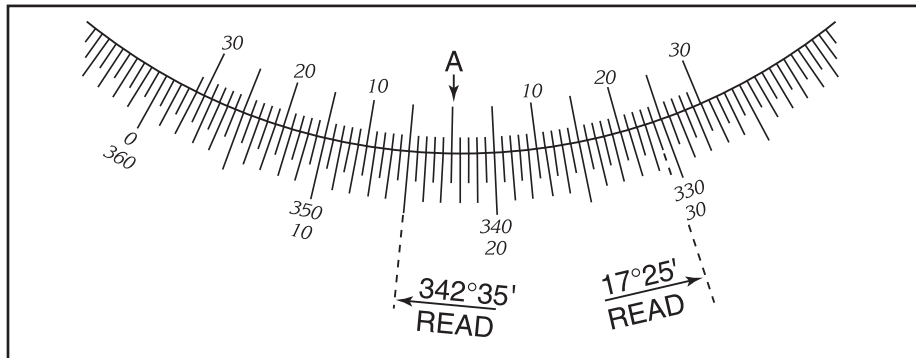


- **Double or double direct vernier** — Read either clockwise or counterclockwise, with only one-half being used at a time. Once the index mark is set coincident with $0^{\circ}00'$ on the circle, or at any known value, an observer is not limited to turning angles in one direction. (Figures 15-17)



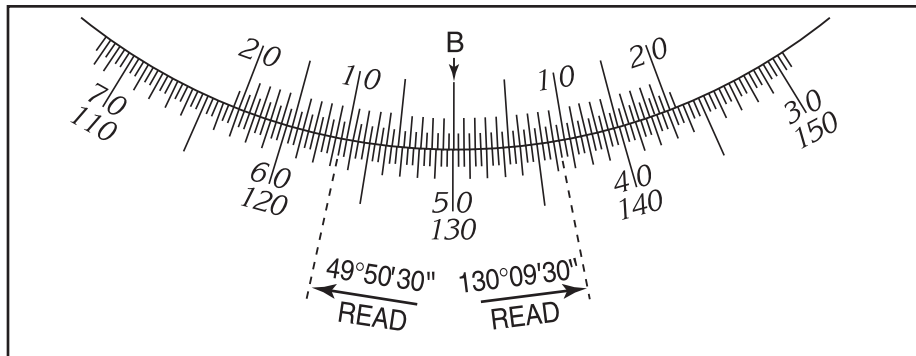
Graduated 30 minutes reading to one minute

FIGURE 15



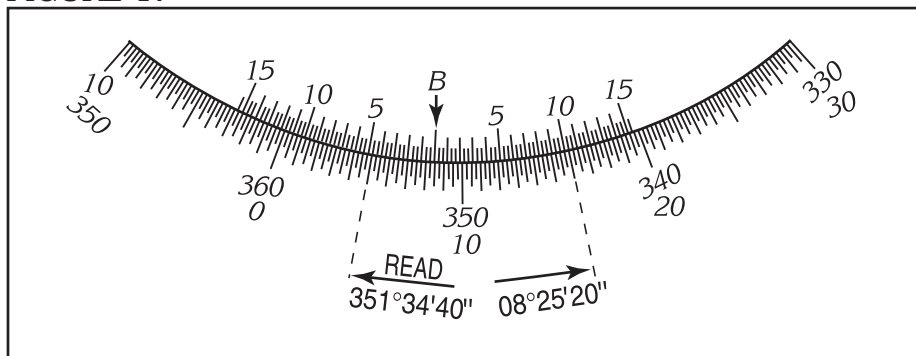
Graduated 20 minutes reading to 30 seconds

FIGURE 16



Graduated to 15 minutes reading to 20 seconds

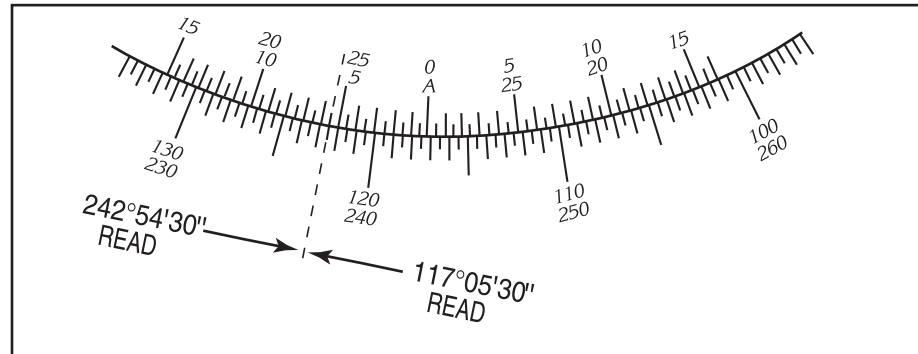
FIGURE 17



- **Folded vernier** — Avoids the long vernier plate required by the normal double vernier. Its length is the same as a direct vernier with half the graduations placed on each side of the index mark. (Figure 18)

Graduated 30 minutes reading to 30 seconds

FIGURE 18



✓ **NOTE:** The least count of any vernier can be found by the following relationship:

$$\text{Least Count} = \frac{\text{value of the smallest division on the scale}}{\text{number of divisions on the vernier}}$$

The combinations of scale graduations and vernier divisions generally used on transits are shown in Table 1.

TABLE 1 — TRANSIT SCALES AND VERNIERS

SCALE GRADUATIONS	VERNIER DIVISIONS	LEAST COUNT	FIG. NO.
30'	30	1'	4
20'	40	30"	5
30'	60	30"	7
15'	45	20"	6
10'	60	10"	3



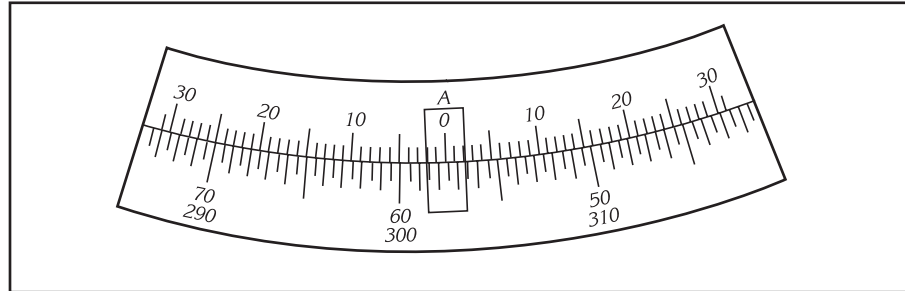
OBJECTIVE 9

Optional Activities/
Resources in Instructor's
Guide

Interpret readings on different styles of verniers.

- A vernier is read by finding a graduation on it that coincides with any division on the circle scale.
- ✓ **NOTE:** On a double vernier there should be two such matching lines, one for the clockwise angle and the other for the opposite counterclockwise angle.
- A vernier index shows the number of degrees (and sometimes the multiple of 10, 15, 20, or 30 minutes) passed over on the scale. (Figure 19)

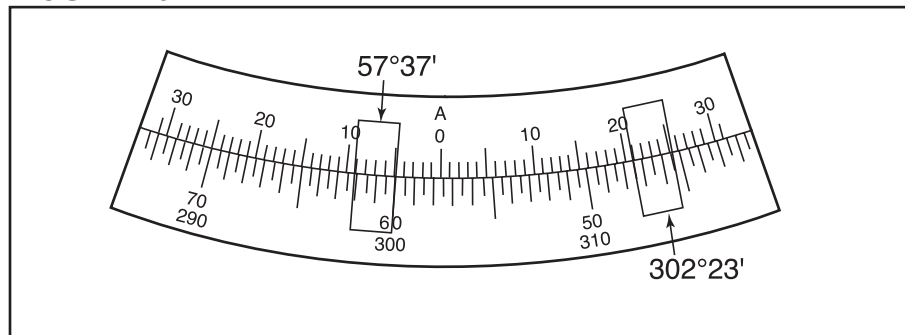
FIGURE 19



✓ **NOTE:** In Figure 19, the index would indicate on a clockwise angle that it has passed over $57^{\circ}30'$. The index would indicate on a counterclockwise angle that it has passed over 302° .

- The coincident vernier graduation gives directly the additional part of the degree. (This division on each side of the apparently matching lines should be checked for visual symmetry.) (Figure 20)

FIGURE 20



✓ **NOTE:** In Figure 20, the vernier graduation that apparently matches the circle graduation for a clockwise angle would be $57^{\circ}37'00''$. The vernier graduation that apparently matches the circle graduation for a counterclockwise angle would be $302^{\circ}23'00''$.



OBJECTIVE 10

Optional Activities/
Resources in Instructor's
Guide

List typical mistakes made in reading verniers.

- Not using a magnifying glass
- Reading the wrong direction from zero
- Failing to determine the least count correctly
- Omitting 10, 15, 20, or 30 minutes when the index is beyond those marks
- Failing to read directly on the line (parallax error)

OBJECTIVE 11

Optional Activities/
Resources in Instructor's
Guide

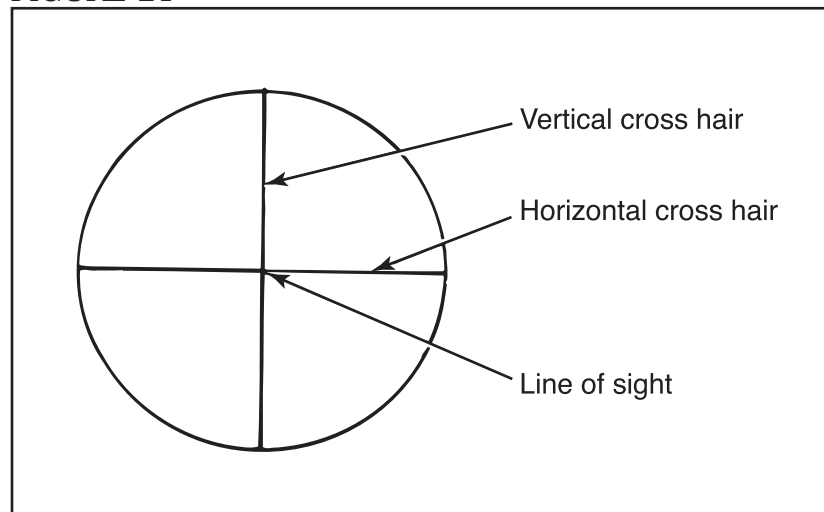
Label vertical and horizontal cross hairs and line of sight on a leveling instrument.

WORDS YOU SHOULD KNOW

cross hairs	fine horizontal and vertical lines in the telescope of leveling instrument; used as reference lines in the field or for marking instrumental axis
line of sight	line from an observer's eye to a distant point toward which he or she is directing a leveling instrument

✓ **NOTE:** Vertical cross hairs indicate direction. Horizontal cross hairs indicate the flat plane. The point where the vertical and horizontal cross hairs meet indicates line of sight. (Figure 21)

FIGURE 21



OBJECTIVE 12

Optional Activities/
Resources in Instructor's
Guide

State rules for proper care of leveling instruments.

✓ **NOTE:** Leveling instruments are sensitive instruments that require extremely careful treatment.

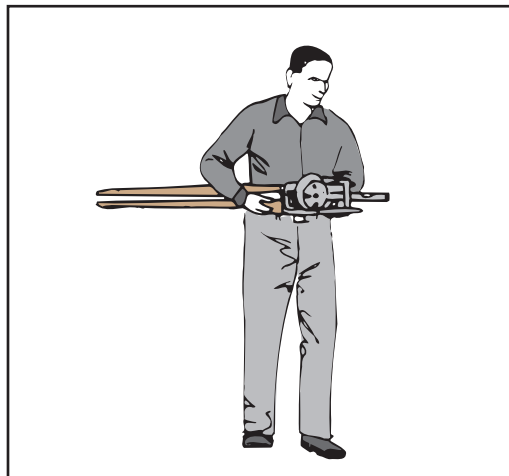
- Keep instrument in carrying case when not in use
- Protect instrument from shock and vibration when transporting
- Remove instrument from carrying case by lifting the level bar

✓ **NOTE:** Never grasp the telescope barrel while removing instrument from the carrying case.

- Never force screws or other moving parts of the instrument
- Place lens and tripod caps in carrying case after removing them from instrument
- Do not remove lenses
- Clean lenses with soft tissue only
- Always use sunshade regardless of weather
- Loosen leveling screws before returning instrument to carrying case
- Carry tripod under your arm with the instrument in front of you (Figure 22)

✓ **NOTE:** Never carry tripod over your shoulder when instrument is attached.

FIGURE 22



OBJECTIVE 13

Optional Activities/
Resources in Instructor's
Guide

Identify parts of a leveling rod.

WORDS YOU SHOULD KNOW

leveling rod rod with markings graduated upward from zero; used with leveling instruments to determine elevations

FIGURE 23

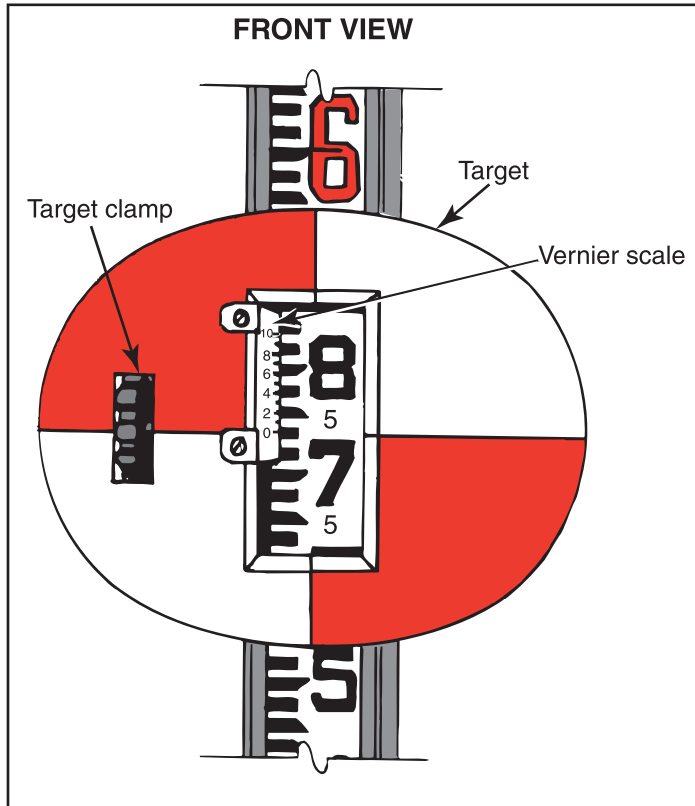
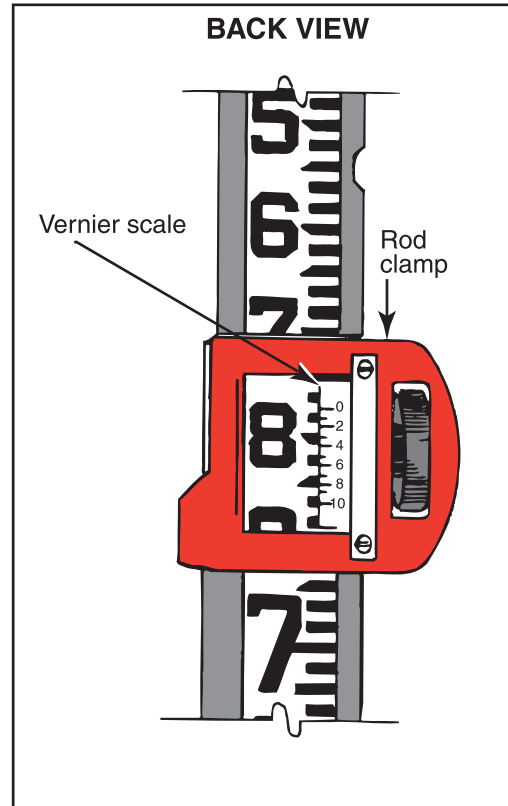


FIGURE 24



OBJECTIVE 14

Optional Activities/
Resources in Instructor's
Guide

Match parts of a leveling rod to their correct uses.

- **Target** — Helps make measurements within a certain range on leveling rod; holds vernier scale

✓ **NOTE:** The target is usually a red and white disk that slides up and down on the rod.

- **Target clamp** — Holds target in place
- **Rod clamp** — Holds rod open when extended
- **Vernier scale** — Enables reading to the nearest thousandth of a foot or nearest sixty-fourth of a foot



OBJECTIVE 15

Required Activities/
Resources
— Transparencies 4 and 5

Optional Activities/
Resources in Instructor's
Guide

Describe commonly used direct-reading rods.



Your instructor will show you transparencies of different types of direct-reading rods.

✓ **NOTE:** There are many types of leveling rods, but the two types of direct-reading rods described below are the ones most commonly used.

- Rod graduated in eighths of an inch — Marks indicate feet, inches, and eighths of an inch; each line and each space is one-eighth of an inch thick (Figure 25)
- Rod graduated in hundredths of a foot — Marks indicate feet, tenths of a foot, and hundredths of a foot; each line and each space is one hundredth of a foot thick (Figure 26)

FIGURE 25

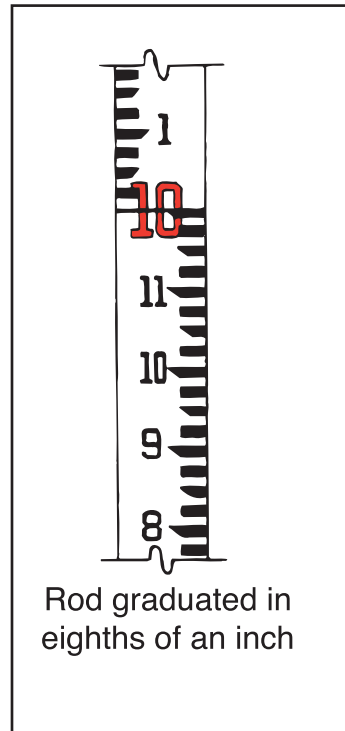
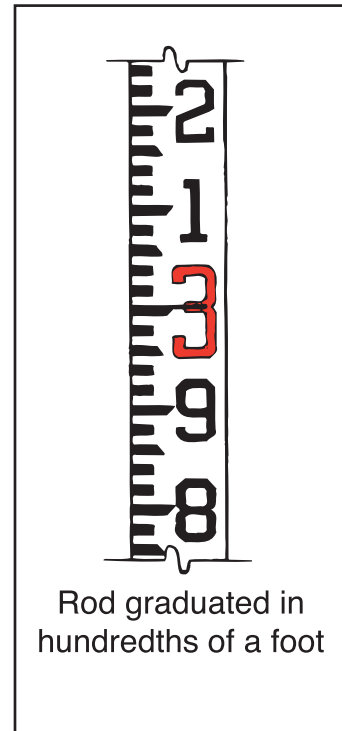


FIGURE 26



OBJECTIVE 16

Optional Activities/
Resources in Instructor's
Guide

Identify markings on a direct-reading rod.

- Marks at large red numbers indicate full feet
- ✓ **NOTE:** Some rods also have small running-foot numbers spaced at intervals between the large full-foot numbers; these are helpful in reading the rod when it is close to the instrument and the field of view through the telescope is limited
- Marks at small black numbers indicate full inches or tenths of a foot (0.1 foot), depending on rod used
- Black marks and spaces between full-inch or full-tenth-of-a-foot marks indicate eighths of an inch or hundredths of a foot (0.01 foot), depending on rod used (Figures 27 and 28)

FIGURE 27

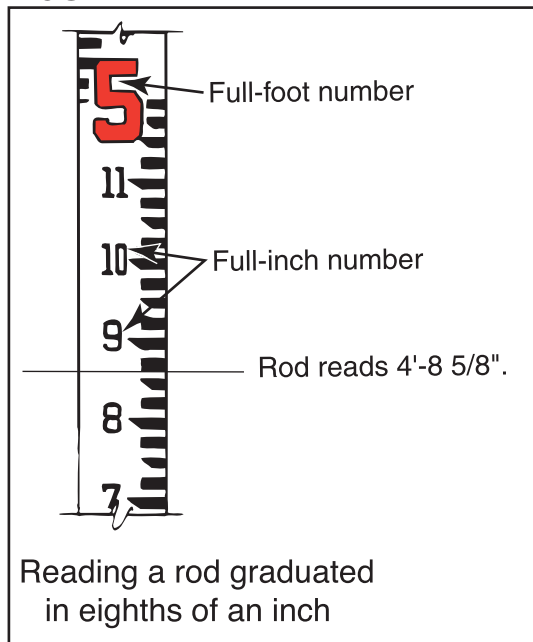
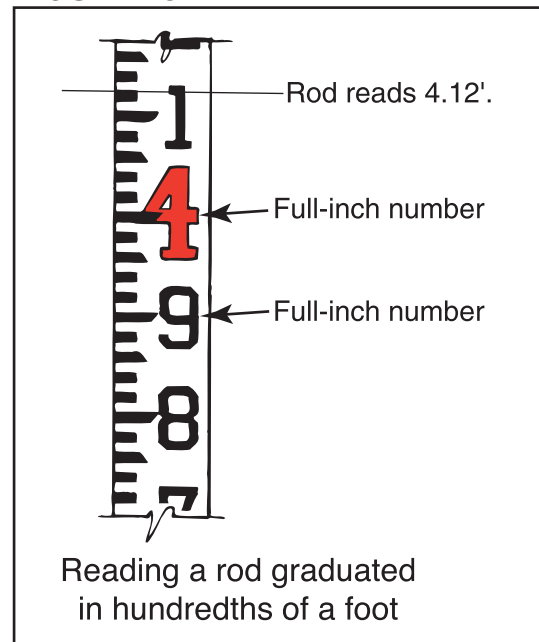


FIGURE 28



OBJECTIVE 17

Complete Assignment Sheet 1.



OBJECTIVE 18

Optional Activities/
Resources in Instructor's
Guide

Identify hand signals used by the instrument person to guide the rod person.

- Move in this direction

FIGURE 29

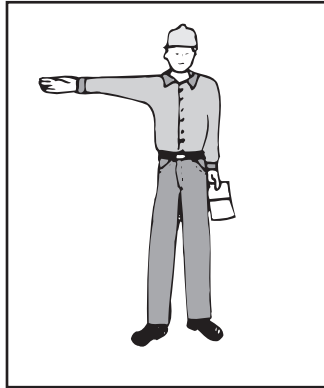
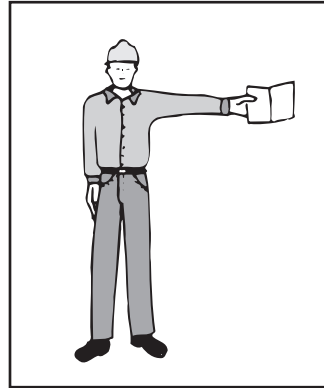
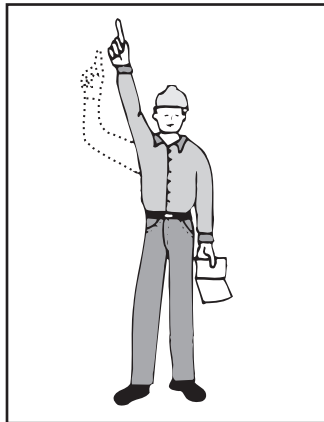


FIGURE 30



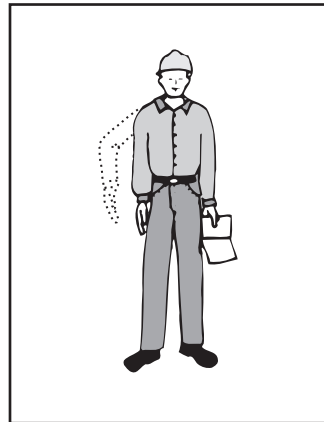
- Move up

FIGURE 31



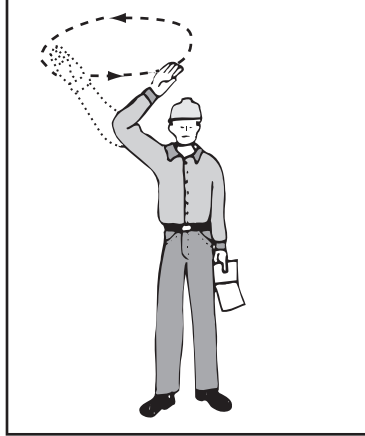
- Move down

FIGURE 32



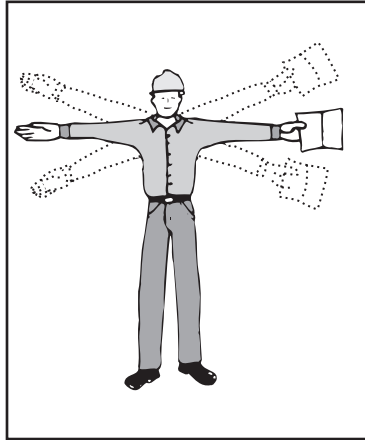
- Turning point

FIGURE 33



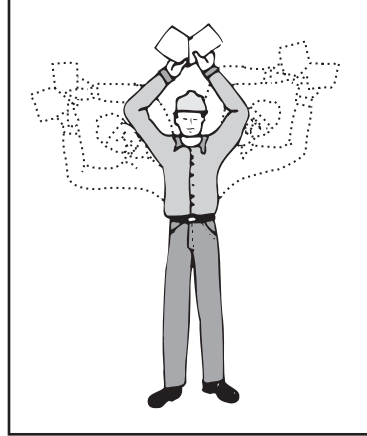
- Observation completed; move on; understand

FIGURE 35



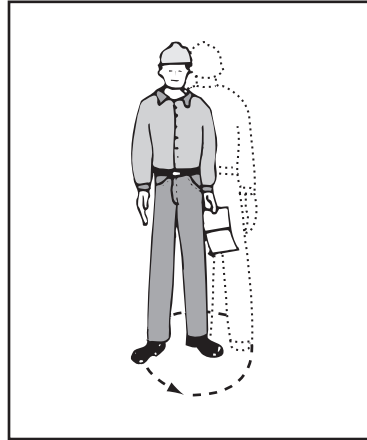
- Wave rod from side to side; rock rod back and forth

FIGURE 34



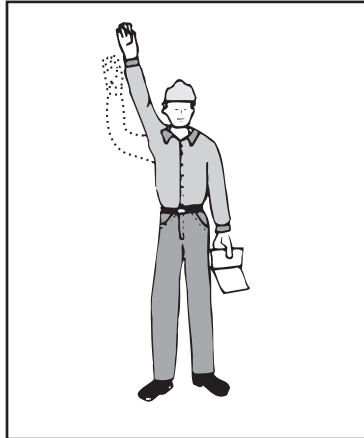
- Wrong face; check clamp; rod upside down

FIGURE 36



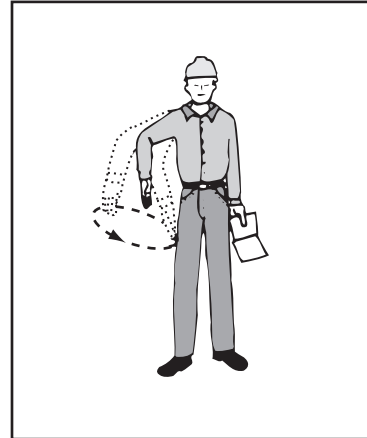
- Use long rod

FIGURE 37



- Come in

FIGURE 38



OBJECTIVE 19 Complete Assignment Sheet 2.

OBJECTIVE 20 Complete Job Sheet 1.

OBJECTIVE 21 Complete Job Sheet 2.

OBJECTIVE 22 Complete Job Sheet 3.

OBJECTIVE 23 Complete Job Sheet 4.

OBJECTIVE 24 Complete Job Sheet 5.

OBJECTIVE 25 Complete Job Sheet 6.

OBJECTIVE 26 Complete Job Sheet 7.



Name _____ Score _____

OBJECTIVE 17

Read direct-reading rods.

BASIC SKILLS



Mathematics



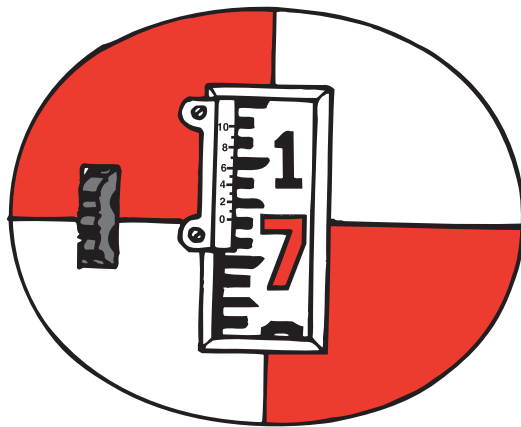
Employability

EQUIPMENT AND SUPPLIES

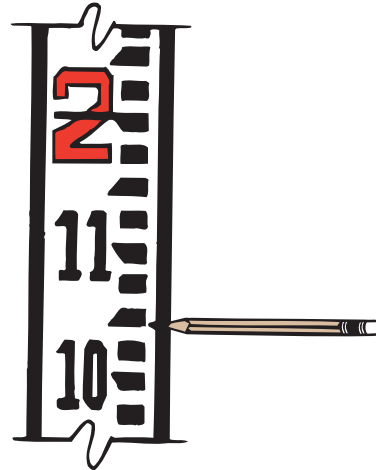
- Pen or pencil

INSTRUCTIONS

Read each of the following illustrations to the nearest eighth of an inch or hundredth of a foot, depending on the type of rod illustrated. Write the correct answers in the blanks.

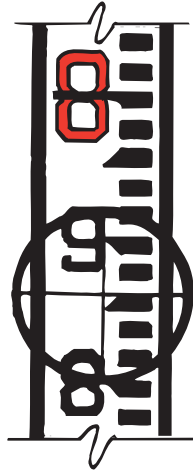


1. _____

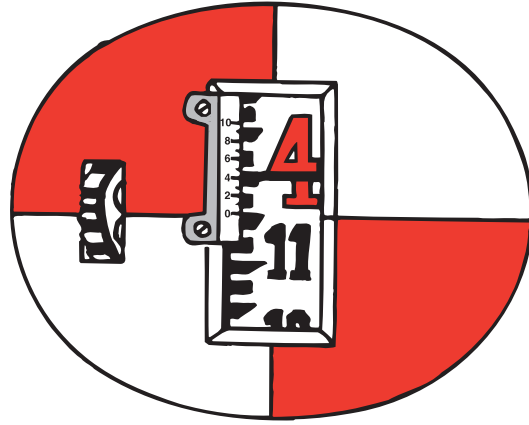


2. _____





3. _____



4. _____



Name _____ Score _____

OBJECTIVE 19

Accurately read various types of verniers on transit.

BASIC SKILLS



Mathematics



Employability

INTRODUCTION

Practice is the best means of understanding and accurately reading verniers. This assignment will provide you with good practice and will help you to become proficient in reading the different verniers.

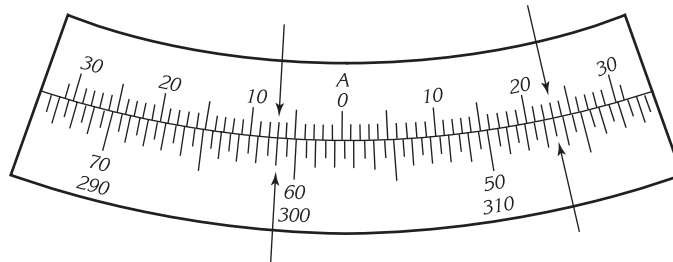
**EQUIPMENT
AND SUPPLIES**

- Pen or pencil

INSTRUCTIONS

As accurately as possible, interpolate the correct vernier reading for each problem and record your answer in the appropriate blank.

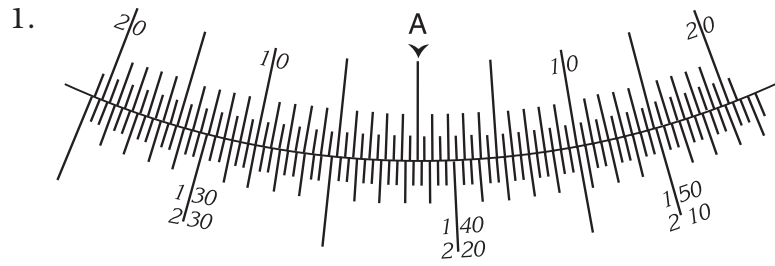
EXAMPLE:



Clockwise 57°37'00"

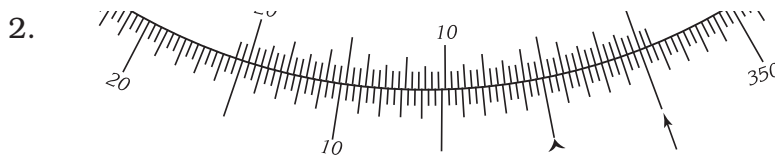
Counterclockwise 302°23'00"





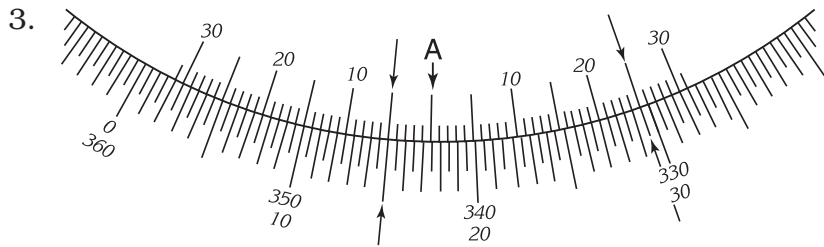
Clockwise _____

Counterclockwise _____



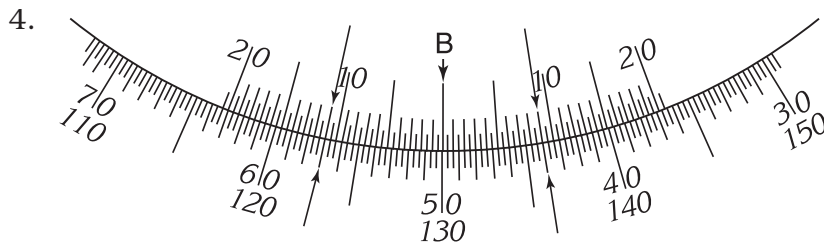
Clockwise _____

Counterclockwise _____



Clockwise _____

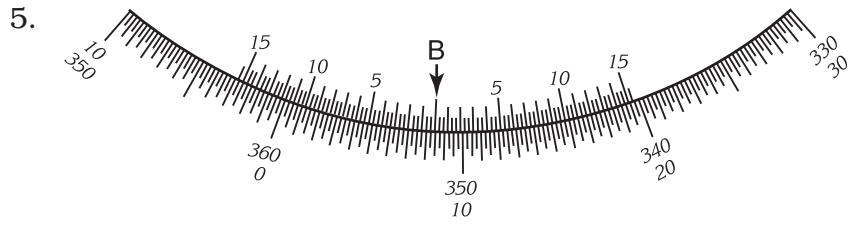
Counterclockwise _____



Clockwise _____

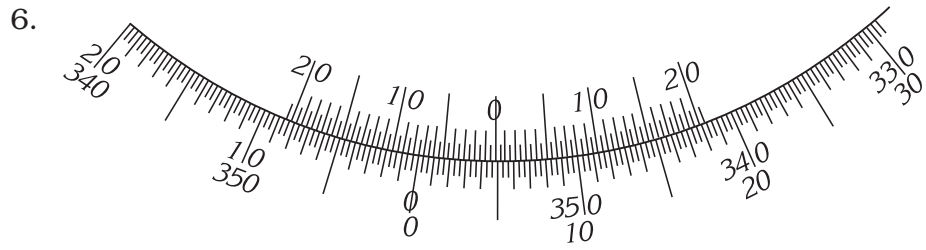
Counterclockwise _____





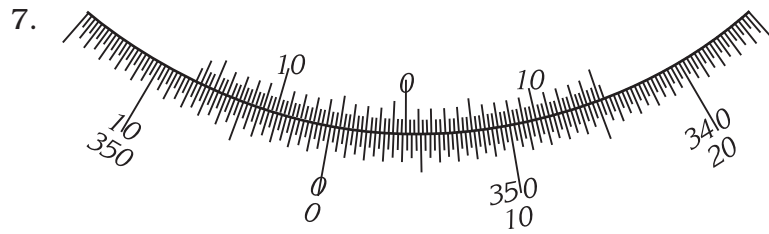
Clockwise _____

Counterclockwise _____



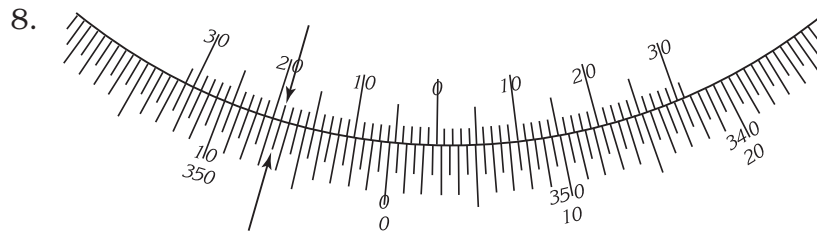
Clockwise _____

Counterclockwise _____



Clockwise _____

Counterclockwise _____



Clockwise _____

Counterclockwise _____





Name _____ Score _____

OBJECTIVE 20

Set up and adjust a level.

BASIC SKILLS



Employability

EQUIPMENT AND SUPPLIES

- Level in carrying case
- Tripod
- Personal protective equipment

✓ **NOTE:** Refer to C.F.R 1926.28 Sub Part C in regard to personal protective equipment.

PROCEDURE

Yes No

1. Set leg shoes of the two nearest tripod legs firmly in ground about 3 feet apart.

✓ **NOTE:** If the ground is not level, you may have to change position of tripod in order to keep head plate level. Always place two tripod legs on downhill or uneven side.

2. Tighten leg thumb-nuts if tripod is so equipped.

3. Remove head-plate cap and place cap in carrying case.



Yes No

4. Check head plate to assure that it is level. (Figure 1)

FIGURE 1



5. Remove instrument from carrying case by lifting level bar.

✓ **NOTE:** Never grasp the telescope barrel while removing instrument from carrying case.



Yes No

6. Attach instrument to tripod. (Figure 2)

✓ **NOTE:** Keep a firm grip on instrument until it is securely in position on tripod.

FIGURE 2



7. Remove dust cap from lens and place cap in carrying case.

✓ **NOTE:** Between uses, keep the dust cap in place to protect the lens from dust or scratches.

8. Attach sunshade to instrument if sunshade is not a permanent attachment.

9. Align telescope barrel directly over one pair of leveling screws.

✓ **NOTE:** The leveling screws will be used as the name indicates: to level the instrument, but do not overtighten.



Yes No

10. Rotate screws under leveling head by moving your thumbs in opposite directions until bubble is centered in leveling tube. (Figure 3)

FIGURE 3



Yes No

11. Turn instrument clockwise 90 degrees to align barrel over other pair of leveling screws.
12. Rotate screws under leveling head by moving your thumbs in opposite directions until bubble is centered in leveling tube.
13. Turn instrument clockwise 90 degrees to bring it parallel with first pair of leveling screws; center bubble again.



Yes No

14. Turn instrument clockwise 90 degrees to bring it parallel with second pair of leveling screws; center bubble again.

✓ **NOTE:** Bubble should stay in center regardless of direction the telescope is pointing. If bubble does not stay in center, instrument is out of level and should be adjusted by competent personnel.

15. Avoid touching tripod after instrument is level.

✓ **NOTE:** If instrument creeps off level or is bumped during use, stop and relevel instrument, and start again from last known good bench mark.

16. Turn eyepiece focusing ring until cross hairs appear clear and sharp.

✓ **NOTE:** The target may not be in focus.

17. Rotate focusing screw to bring target into sharp focus.

✓ **NOTE:** When cross hairs and target are in sharp focus, you should be able to read a rod accurately. Always tie level shots back to starting bench mark to check for error in rod shots or in field notes.

18. Replace lens dust-cap, disassemble instrument from tripod, loosen leveling screws and store instrument in carrying case; replace head-plate cap on tripod.

19. Store carrying case and tripod.

20. Have the instructor check your work.

21. Clean the work area and return tools and equipment to proper storage.



SKILL TEST RECORD

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of “3” or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

<u>Tripod thumb nuts tight</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
<u>Instrument is level and cross hairs are in focus</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
<u>Leveling screws are snug</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
<u>Standard time for a 4 rating is 5 minutes or less</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>

AVERAGE RATING

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

- 4 Skilled** — Can perform job with no additional training
- 3 Moderately Skilled** — Has performed job during training program; limited additional training may be required
- 2 Limited Skill** — Has performed job during training program; additional training is required to develop skill
- 1 Unskilled** — Is familiar with process, but is unable to perform job

EVALUATOR'S COMMENTS



Name _____ Score _____

OBJECTIVE 21

Use a level to check elevations.

WORDS YOU SHOULD KNOW

elevation	given grade
fall	difference between elevations of two points on a slope

BASIC SKILLS



Mathematics



Employability

EQUIPMENT AND SUPPLIES

- Level in carrying case
- Tripod
- Leveling rod
- Keel
- Personal protective equipment

✓ **NOTE:** Refer to C.F.R 1926.28 Sub Part C in regard to personal protective equipment.

- Specification furnished by instructor

✓ **NOTE:** The instructor will provide practice elevations on a shop floor or on a parking lot rather than on actual footings.

PROCEDURE

Yes No

1. Pick out and mark 10 locations on floor, parking lot or other location.

✓ **NOTE:** Be certain that the locations of all the elevations can be seen through the builder's level.

2. Set up and adjust level.

✓ **NOTE:** See Job Sheet 1.



Yes No

- 3. While assistant holds leveling rod at first checkpoint, sight through the level and take a reading on leveling rod. (Figure 1)

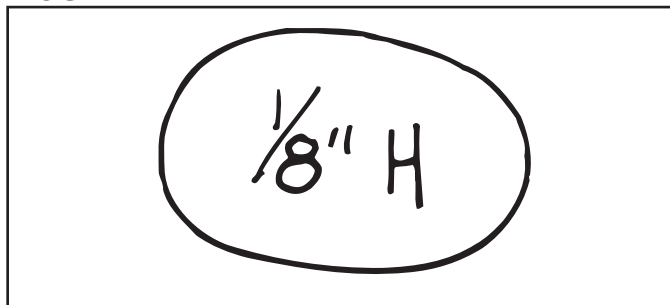
FIGURE 1



- 4. Have assistant use keel to record any difference between reading and correct elevation, marking H for high or L for low. (Figure 2)

EXAMPLE: If elevation is 5'-1½" and reading is 5'-1⅜". Footing elevation is ⅛ inch higher than correct elevation. Record ⅛" H on top of footing.

FIGURE 2



- 5. Have assistant move leveling rod to next checkpoint.
- 6. Adjust level to focus on next checkpoint.
- 7. Sight through the builder's level at the leveling rod and take a reading.



Yes No

- 8. Have assistant record any difference between reading and correct elevation, marking H for high or L for low.
- 9. Repeat steps 5 through 8 for each checkpoint.
- 10. Check with instructor to see whether elevations are all within the specifications.
- 11. Disassemble level from tripod, loosen leveling screws, and store in carrying case; put away other tools and equipment.
- 12. Have the instructor check your work.
- 13. Clean the work area and return tools and equipment to proper storage.



SKILL TEST RECORD

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Each reading within \pm specifications
($\frac{1}{8}$ " or 100th of a foot)

4 3 2 1

Standard time for a 4 rating
is 30 minutes or less

4 3 2 1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

- 4 Skilled** — Can perform job with no additional training
- 3 Moderately Skilled** — Has performed job during training program; limited additional training may be required
- 2 Limited Skill** — Has performed job during training program; additional training is required to develop skill
- 1 Unskilled** — Is familiar with process, but is unable to perform job

EVALUATOR'S COMMENTS



Name _____ Score _____

OBJECTIVE 22

Use a level to perform differential leveling.

WORDS YOU SHOULD KNOW

field book small book used to record instrument readings for layout and elevation of proposed structures

BASIC SKILLS



Mathematics



Employability

EQUIPMENT AND SUPPLIES

- Level in carrying case
- Tripod
- Leveling rod
- Field book
- Pencil
- Personal protective equipment

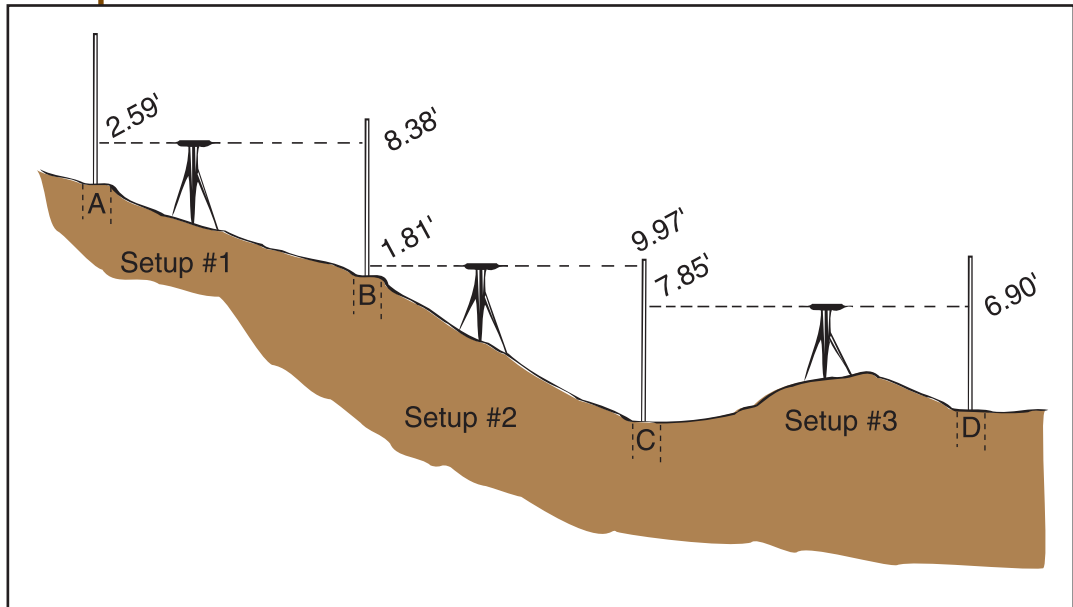
✓ **NOTE:** Refer to C.F.R 1926.28 Sub Part C in regard to personal protective equipment.

- Drawing

✓ **NOTE:** The procedure described in the Job Sheet is based on the elevations shown in the drawing on the following page. The instructor may prefer to assign other practice elevations. (Figure 1)



FIGURE 1



PROCEDURE

Yes No

1. Determine difference in elevation between points A and B.

A. Check drawing (Figure 1) to see which elevations are to be determined, and establish setup #1 for builder's level.

✓ **NOTE:** Do not set up more than 150 to 200 feet from each point, but be certain that points A and B can both be seen through the builder's level.

B. Set up and adjust builder's level at setup #1.

✓ **NOTE:** See Job Sheet 1.

C. While assistant holds leveling rod at point A, sight through the builder's level and take a reading on leveling rod.

D. Record reading in field book.

✓ **NOTE:** Line of sight at point A is 2.59 feet from setup #1.

E. Have assistant move leveling rod to point B.

F. Adjust builder's level to focus on point B.



Yes No

G. Sight through builder's level and take a reading on leveling rod.

H. Record reading in field book. (Figure 2)

✓ **NOTE:** Line of sight at point B is 8.38 feet from setup #1.

I. Record plus and minus readings in field book.

✓ **NOTE:** Plus sight is the rod reading from the point to the line of sight. Minus sight is the rod reading from the line of sight to the point.

FIGURE 2

Setup	+ Rod	H1	- Rod	Elevation
1	2.59			
			8.38	

2. Determine difference in elevation between points B and C.

A. Check drawing to see which elevations are to be determined, and establish setup #2 for builder's level.

✓ **NOTE:** Do not set up more than 150 to 200 feet from each point, but be certain that points B and C can both be seen through the builder's level.

B. Set up and adjust builder's level at setup #2.

✓ **NOTE:** See Job Sheet 1.

C. While assistant holds leveling rod at point B, sight through the builder's level and take a reading on leveling rod.

D. Record reading in field book.

✓ **NOTE:** Line of sight at point B is 1.81 feet from setup #2.



Yes No

- E. Have assistant move leveling rod to point C.
- F. Adjust builder's level to focus on point C.
- G. Sight through builder's level and take a reading on leveling rod.
- H. Record reading in field book. (Figure 3)

✓ **NOTE:** Line of sight at point C is 9.97 feet from setup #2.

- I. Record plus and minus readings in field book.

FIGURE 3

Setup	+ Rod	H1	- Rod	Elevation
1	2.59			
			8.38	
2	1.81			
			9.97	

- 3. Determine difference in elevation between points C and D.

- A. Check drawing to see which elevations are to be determined, and establish setup #3 for builder's level.

✓ **NOTE:** Do not set up more than 150 to 200 feet from each point, but be certain that points C and D can both be seen through the builder's level.

- B. Set up and adjust builder's level at setup #3.

✓ **NOTE:** See Job Sheet 1.

- C. While assistant holds leveling rod at point C, sight through builder's level and take a reading on leveling rod.

- D. Record reading in field book.

✓ **NOTE:** Line of sight at point C is 7.85 feet from setup #3.



Yes No

- E. Have assistant move leveling rod to point D.
- F. Adjust builder's level to focus on point D.
- G. Sight through builder's level and take a reading on leveling rod.
- H. Record reading in field book. (Figure 4)

✓ **NOTE:** Line of sight at point D is 6.90 feet from setup #3.

- I. Record plus and minus reading in field book.

FIGURE 4

Setup	+ Rod	H1	- Rod	Elevation
1	2.59			
			8.38	
2	1.81			
			9.97	
3	7.85			
			6.90	

- 4. Total plus sight column and minus sight column in field book. (Figure 5)

FIGURE 5

Setup	+ Rod	H1	- Rod	Elevation
1	2.59			
			8.38	
2	1.81			
			9.97	
3	7.85			
			6.90	
Sum	12.25		25.25	



Yes No

5. Subtract smaller number from larger to find the difference in elevations.

✓ **NOTE:** Subtracting 12.25 feet from 25.25 feet, leaves 13.00 feet. Point D is 13.00 feet lower than point A.

6. Disassemble builder's level from tripod, loosen leveling screws and store instrument in carrying case; put away carrying case, tripod, and other tools and equipment.

7. Have the instructor check your work.

8. Clean the work area and return tools and equipment to proper storage.



SKILL TEST RECORD

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of “3” or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

<u>Answers correct ($\frac{1}{8}$" or 100th of a foot)</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
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<u>Standard time for a 4 rating is 60 minutes or less</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
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AVERAGE RATING

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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- 3 Moderately Skilled** — Has performed job during training program; limited additional training may be required
- 2 Limited Skill** — Has performed job during training program; additional training is required to develop skill
- 1 Unskilled** — Is familiar with process, but is unable to perform job

EVALUATOR'S COMMENTS





Name _____ Score _____

OBJECTIVE 23

Tie a slip knot for adjusting a plumb bob.

WORDS YOU SHOULD KNOW

plumb bob a weighted, cone-shaped device fastened to a string or cord used to determine vertically

BASIC SKILLS



Employability

EQUIPMENT AND SUPPLIES

- Plumb bob with cord
 - ✓ **NOTE:** Cord can be attached to anything for this exercise
- Personal protective equipment
 - ✓ **NOTE:** Refer to C.F.R 1926.28 Sub Part C in regard to personal protective equipment.

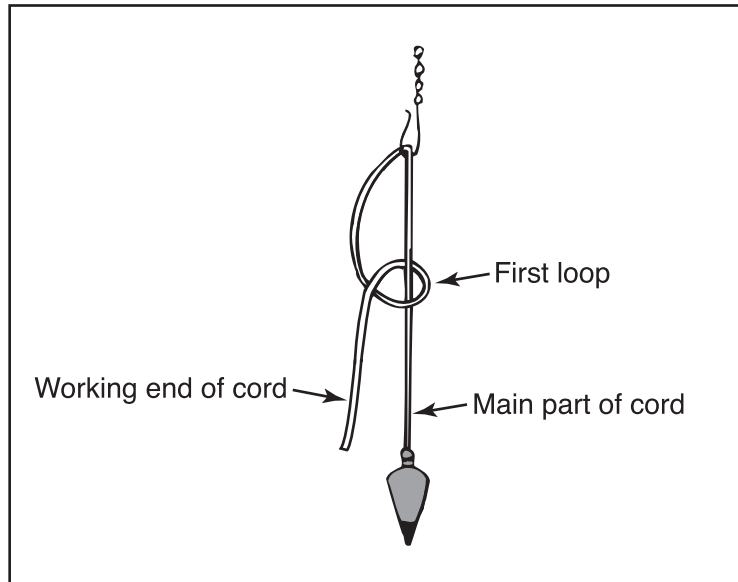
PROCEDURE

Yes No

1. Attach and knot cord. (Figure 1)
- A. Bring working end of cord in front of main part of cord.
 - B. Take working end behind main part of cord.
 - C. Draw working end through space between working end and main part of cord.



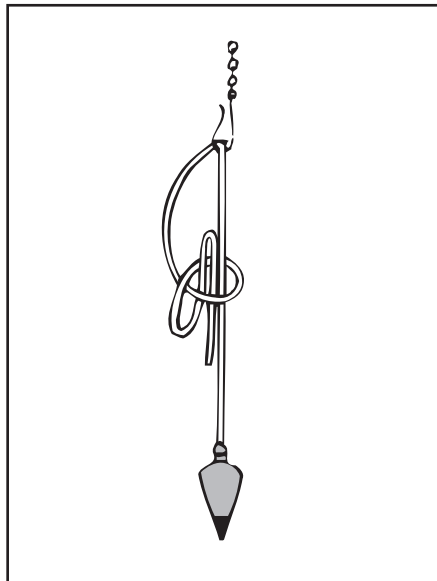
FIGURE 1



Yes No

- 2. Make a second loop in working end of cord.
- 3. Pass second loop up through bottom of first loop.
(Figure 2)

FIGURE 2

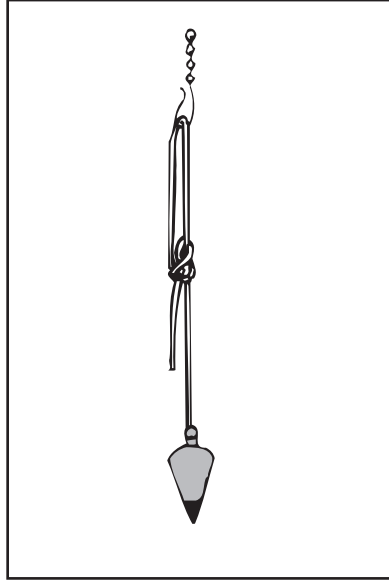


Yes No

4. Tighten knot. (Figure 3)

✓ **NOTE:** This knot secures the plumb bob without affecting the true perpendicular. The knot allows the plumb bob to be easily adjusted without untying the knot.

FIGURE 3



5. Have the instructor check your work.
6. Clean the work area and return tools and equipment to proper storage.



SKILL TEST RECORD

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of “3” or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

<u>Knot tied properly</u>	4	3	2	1
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<u>Know will slide without slipping</u>	4	3	2	1
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<u>Standard time for a 4 rating is 1 minute or less</u>	4	3	2	1
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AVERAGE RATING

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

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- 3 Moderately Skilled** — Has performed job during training program; limited additional training may be required
- 2 Limited Skill** — Has performed job during training program; additional training is required to develop skill
- 1 Unskilled** — Is familiar with process, but is unable to perform job

EVALUATOR'S COMMENTS



Name _____ Score _____

OBJECTIVE 24

Set up and adjust a transit.

BASIC SKILLS



Employability

EQUIPMENT AND SUPPLIES

- Transit in carrying case
- Tripod
- Plumb bob with cord
- Stake driven in ground and marked with established point (provided by instructor)
- Personal protective equipment

✓ **NOTE:** Refer to C.F.R 1926.28 Sub Part C in regard to personal protective equipment.

PROCEDURE

Yes No

1. Over stake at point established by instructor, set leg shoes of the two nearest tripod legs in ground about 3 feet apart; swing third leg out to form a triangle, placing legs on ground so that head plate is nearly level. (Figure 1)

✓ **NOTE:** If the ground is not level, you may have to change position of tripod in order to keep head plate level. Always place two tripod legs on downhill or uneven side.



FIGURE 1



Yes No

- 2. Check head plate to assure that it is level.
- 3. Tighten leg thumb-nuts.
- 4. Remove instrument from carrying case by lifting its baseplate.

✓ **NOTE:** Never grasp the telescope barrel while removing the instrument from carrying case.

- 5. Still holding instrument by its baseplate, attach instrument to tripod.
- 6. Remove dust cap from lens and place cap in carrying case.
- 7. Attach sunshade to instrument.
- 8. Attach plumb bob to instrument.

✓ **NOTE:** Follow procedure in Job Sheet 4.

- 9. Center instrument on footplate.



Yes No

- 10. Bring plumb bob to a position within 2 or 3 inches of established point on stake, moving tripod and instrument together.
- 11. Firmly set tripod legs into ground.
- 12. Raise or lower plumb bob until it hangs about 1 inch above established point on stake. (Figure 2)

FIGURE 2



- 13. Moving tripod legs from side to side, adjust legs as required to bring plumb bob within $\frac{1}{4}$ inch of established point on stake.
- 14. Loosen one pair of leveling screws.
- 15. Slide leveling head until plumb bob and the center of the small ellipse in which plumb bob swings are exactly over established point on stake. (Figure 3)



FIGURE 3



Yes No

16. Tighten leveling screws lightly.

✓ **NOTE:** Over tightening may warp the baseplate.

17. Level instrument.

✓ **NOTE:** Follow procedures as for level in steps 10 through 18 of Job Sheet 1.

18. Replace lens dust-cap, disassemble instrument from tripod, loosen leveling screws and store instrument in carrying case.

19. Store carrying case, tripod, and other tools and equipment.

20. Have the instructor check your work.

21. Clean the work area and return tools and equipment to proper storage.



SKILL TEST RECORD

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of “3” or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

<u>Tripod thumb nuts tight and leveling screws snug</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
<u>Instrument is level and in focus</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
<u>Plumb bob is on mark</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
<u>Standard time for a 4 rating is 15 minutes or less</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>

AVERAGE RATING

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

- 4 Skilled** — Can perform job with no additional training
- 3 Moderately Skilled** — Has performed job during training program; limited additional training may be required
- 2 Limited Skill** — Has performed job during training program; additional training is required to develop skill
- 1 Unskilled** — Is familiar with process, but is unable to perform job

EVALUATOR'S COMMENTS





Name _____ Score _____

OBJECTIVE 25

Use a transit to locate building corners.

BASIC SKILLS



Mathematics



Employability

EQUIPMENT AND SUPPLIES

- Transit in carrying case
- Tripod
- Plumb bob with cord
- 100 foot steel tape
- Claw hammer
- Sledge hammer
- Stakes
- Corner-stake layout

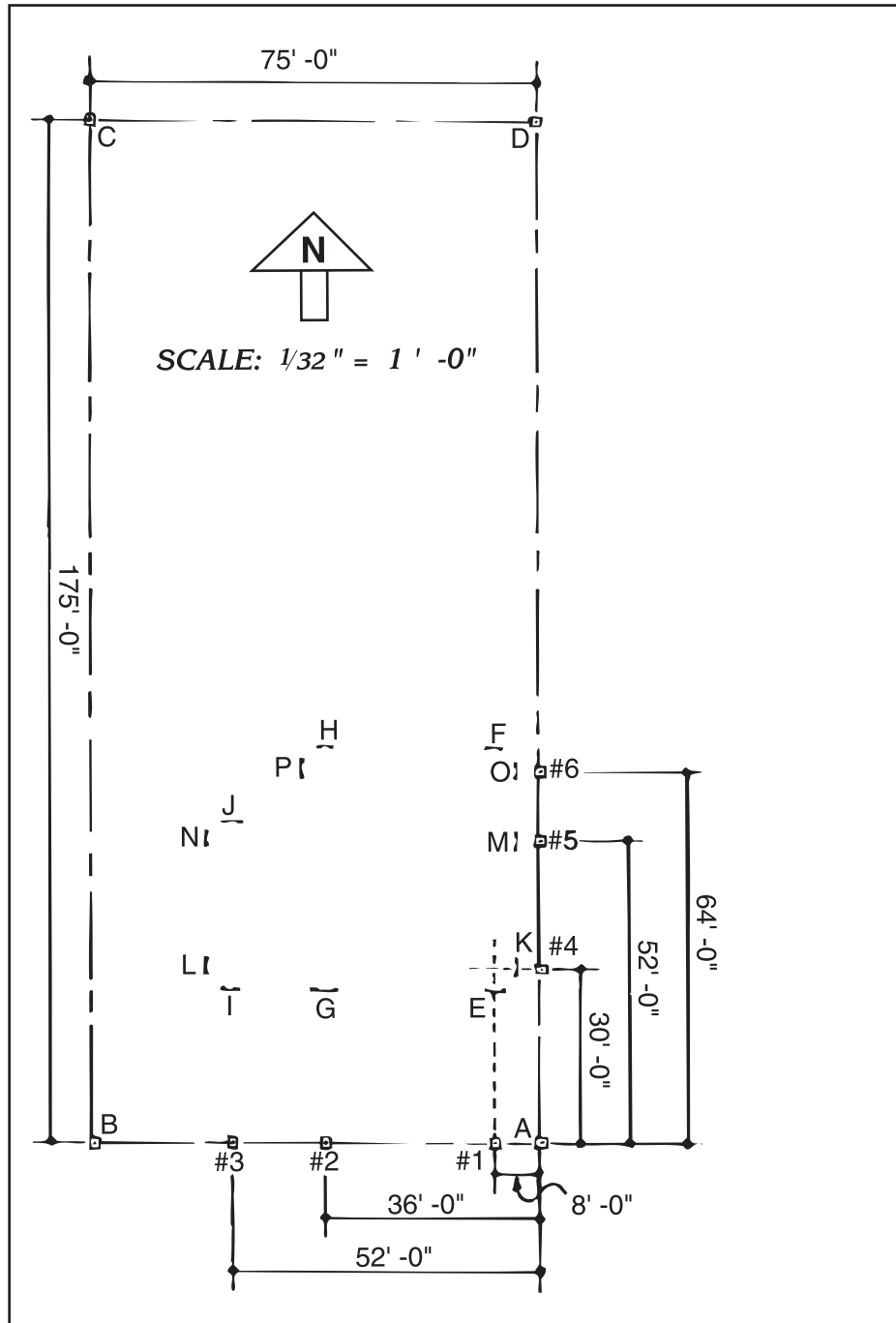
✓ **NOTE:** In Figure 1 the angle formed by lines AB and AD is a 90° angle.

- Personal protective equipment

✓ **NOTE:** Refer to C.F.R 1926.28 Sub Part C in regard to personal protective equipment.



FIGURE 1



PROCEDURE

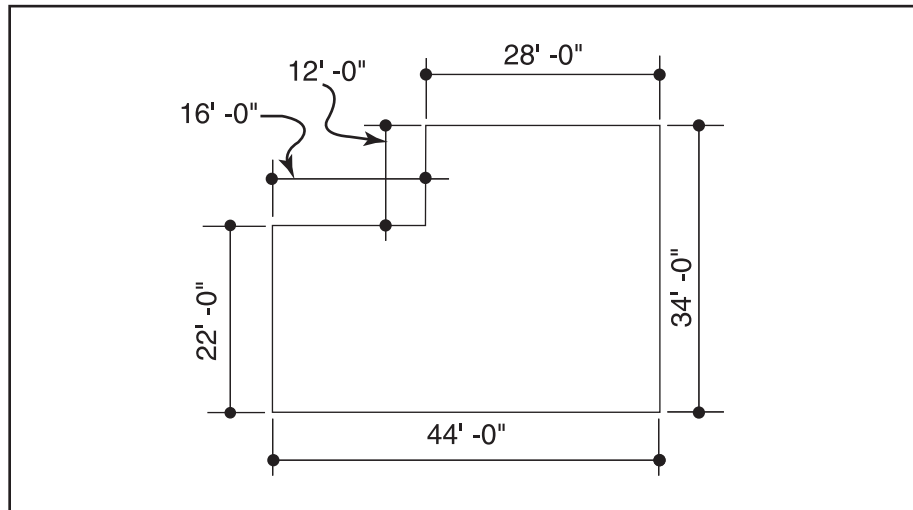
✓ **NOTE:** The procedure given in this Job Sheet is one of several acceptable methods.

Yes No

1. Study corner stake layout and building dimensions. (Figure 2)

✓ **NOTE:** The instructor has established property line points A, B, C, and D. The points have been marked on the lot with stakes and surveyors tacks. The instructor has determined that the angle formed by lines AB and AD is a 90 degree angle and the angle formed by lines AB and BC is a 90 degree angle. The building is set back 30 feet from the south boundary and 8 feet from the east boundary.

FIGURE 2



2. Check tacks on property line stakes to make certain that lines AB and AD form a 90 degree angle.
- A. Set up and adjust level-transit over point A.
 - B. Loosen vertical-motion clamp screws.
 - C. Tilt instrument downward and sight through telescope at point B.
 - D. Focus instrument on point B.
 - E. Set the 360 degree scale at zero.
 - F. Loosen horizontal-motion clamp screws and turn instrument clockwise until the scale indicates that a 90 degree arc has been completed.



Yes No

G. Tighten horizontal-motion clamp screws.

✓ **NOTE:** Do not over tighten screws.

H. Use tangent screw to make final 90 degree adjustment.

I. Loosen vertical-motion clamp screw and adjust tilt of instrument to sight at stake D.

J. Focus instrument on point D to determine whether line AD is 90 degrees from line AB.

✓ **NOTE:** If line AD is not 90 degrees from line AB, notify the instructor.

K. Tighten vertical-motion clamp screws.

3. Establish setup locations #1, #2, and #3 along line AD.

A. Beginning at point A, use a tape to measure along line AD to establish locations at distances of 30", 52", and 64".

B. With instrument still focused on point D, loosen vertical-motion clamp screw and adjust tilt of instrument to location of stake #1, 30 feet from point A.

C. Drive stake #1 at this location.

D. Set a tack in top of stake at exactly 30" from point A and straight with line AD.

E. Repeat Steps B-D to locate points #2 and #3, 52" and 64" from point A respectively.

F. Recheck alignment of tacks and adjust as necessary.

4. Check tacks on property line stakes to make certain that lines AB and BC form a 90 degree angle.

- Use same procedures outlined in section 2, steps A-K from point B.

5. Establish setup locations #4, #5, and #6, along line BC.

- Use same procedures outlined in Section 3, steps A-F from point B.



Yes No

6. Establish corner stakes #7 and #8.
- A. Set up and adjust level-transit over stake #1.
 - B. Loosen horizontal-motion screw.
 - C. Loosen vertical-motion screw and adjust tilt of instrument to locate point #4.
 - D. Tighten vertical-motion screw.
 - E. Tighten horizontal-motion screw.
 - F. Focus instrument and line up tack on point #4 with vertical cross hair.
 - G. Beginning at point #1, measure along line between point #1 and #4 to establish distances of 8" and 52".
 - H. Loosen vertical-motion clamp screw and adjust tilt of instrument to location of stake #7, 8" from point #1.
 - I. Drive stake #7 at this location.
 - J. Set a tack in top of stake at exactly 8" from point #1 and in line with vertical cross hair of instrument.
 - K. Repeat Steps G-J to locate point #8, 52" from point #1.
 - L. Recheck alignment of tacks and adjust as necessary.
7. Establish corner stakes #9 and #10.
- A. Use same procedures outlined in Section 6, steps A-L on line between points #2 and #5.
 - B. Establish points #9 and #10, 36" and 52" from point #2 respectively.



Yes No

- 8. Establish corner stakes #11 and #12.
 - A. Use same procedures outlined in Section 6, steps A-L on line between points #3 and #6.
 - B. Establish points #11 and #12, 8" and 36" from point #3 respectively.
- 9. Replace lens dust-cap, remove plumb bob from instrument, disassemble instrument from tripod, loosen leveling screws and store instrument in carrying case; store case and tripod.
- 10. Have the instructor check your work.
- 11. Clean the work area and return tools and equipment to proper storage.



SKILL TEST RECORD

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Each point properly located within specifications ($\pm \frac{1}{8}$ "	4	3	2	1
Standard time for a 4 rating is 2 hours or less	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

- 4 Skilled** — Can perform job with no additional training
- 3 Moderately Skilled** — Has performed job during training program; limited additional training may be required
- 2 Limited Skill** — Has performed job during training program; additional training is required to develop skill
- 1 Unskilled** — Is familiar with process, but is unable to perform job

EVALUATOR'S COMMENTS





Name _____ Score _____

OBJECTIVE 26

Measure and read angles in the field.

WORDS YOU SHOULD KNOW

range pole

a tall straight staff used to mark alignment while sighting a point; usually marked red and white alternately at 1 foot intervals

BASIC SKILLS



Mathematics



Employability

EQUIPMENT AND SUPPLIES

- Transit
- Tripod
- Range poles
- Field book
- Pencil
- Hammer
- Stakes
- Personal protective equipment

✓ **NOTE:** Refer to C.F.R 1926.28 Sub Part C in regard to personal protective equipment.

PROCEDURE

Yes No

1. Set three stakes in ground approximately 500 feet apart with an acute angle between them.
2. Set up the transit over Point A.

✓ **NOTE:** Refer to Job Sheet #1 for instruction. Assuming that the instrument is over the point and level, the following procedure is used to turn and “double” an angle. Turning an angle at least twice permits the elimination of mistakes and increases precision owing to the elimination of most instrument errors.



Yes No

3. Set the scales to zero.
- A. Loosen both the upper and lower motion clamps.
 - B. Hold the alidade stationary, and revolve the circle by pushing on the circle underside with the fingertips.
 - C. When zero is close to the index point of the vernier, tighten the upper clamp.
 - D. With a magnifying glass, slowly turn the upper tangent screw until the zeros are precisely in line. (Figure 1)

FIGURE 1



4. Sight the initial point (or backsight), in this case Point C.
- A. With the upper clamp tightened and the lower clamp loose, turn and point the telescope towards the initial point.
 - B. Once relatively close to the desired position, tighten the lower clamp.
 - C. While observing the point through the telescope, slowly turn the lower tangent screw until precisely in line with the initial point.
- ✓ **NOTE:** The vertical cross hair should be centered on the point being observed. Backsights should be equal to or longer than foresights.



Yes No

5. Turn the horizontal angle.
- A. Loosen the upper clamp and turn the telescope clockwise toward the final point (or foresight), in this case Point B.
 - B. When point is close to the vertical cross hair, tighten the upper clamp.
 - C. Slowly turn the upper tangent screw until the vertical cross hair is precisely in position.
6. Read the angle.
- A. Observe the vernier and determine the angle using a magnifying glass.
 - B. Record the value in the field book in the appropriate column.
7. Repeat the angle.
- A. After the initial angle has been recorded, “plunge” or “invert” the telescope.
 - B. Loosen the lower motion and sight the initial point or original backsight point.
 - C. Tighten the lower clamp.
 - D. Repeat steps 5 and 6, except that the telescope is not inverted and the initial horizontal angle setting is that of the initial angle.
 - E. Record the “doubled” angle in the appropriate column.
- ✓ NOTE:** This job skill can be performed again from Point B recording the angle of A-B-C. The instrument can also be set on Point C and that angle measured.
8. Have the instructor check your work.
9. Clean the work area and return tools and equipment to proper storage.



SKILL TEST RECORD

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Each point properly located within specifications ($\pm \frac{1}{8}$ "	4	3	2	1
Standard time for a 4 rating is 2 hours or less	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

- 4 Skilled** — Can perform job with no additional training
- 3 Moderately Skilled** — Has performed job during training program; limited additional training may be required
- 2 Limited Skill** — Has performed job during training program; additional training is required to develop skill
- 1 Unskilled** — Is familiar with process, but is unable to perform job

EVALUATOR'S COMMENTS

