

## Lesson A2–4

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# Applying Differential Leveling Techniques

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**Unit A.** Mechanical Systems and Technology

**Problem Area 2.** Soil and Environmental Technology Systems

**Lesson 4.** Applying Differential Leveling Techniques

### **New Mexico Content Standard:**

**Pathway Strand:** Natural Resources and Environmental Systems

**Standard: I:** Recognize importance of resource and human interrelations to conduct management activities in natural habitats.

**Benchmark: I-B:** Apply cartographic skills to natural resources.

**Performance Standard: 5.** Use land survey and coordinate system.

**Student Learning Objectives.** Instruction in this lesson should result in students achieving the following objectives:

1. Explain the important aspects of keeping survey notes for a differential survey.
2. Explain the steps involved in completing a differential survey exercise.
3. Explain how to calculate allowable error in a survey exercise.

**List of Resources.** The following resources may be useful in teaching this lesson:

**Recommended Resources.** One of the following resources should be selected to accompany the lesson:

U3010b. *Surveying in Agriculture*. Urbana, Illinois: Vocational Agriculture Service, University of Illinois at Urbana-Champaign.

**Other Resources.** The following resources will be useful to students and teachers:

Benton, Arthur R., Jr., and Philip J. Taetz. *Elements of Plane Surveying*. New York, New York: McGraw-Hill, Inc., 1991. (Chapter 3)

## List of Equipment, Tools, Supplies, and Facilities

Writing surface  
Overhead projector  
Transparencies from attached masters

**Terms.** The following terms are presented in this lesson (shown in bold italics):

Backsight  
Benchmarks  
Differential leveling  
Elevation  
Foresight  
Height of instrument  
Station  
Traverse  
Turning point

**Interest Approach.** Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

*Discuss with the students everything that must be done before a building can be built. Lead the discussion to the preparation of the land. Surveying is a major component of preparing a site for a building.*

# Summary of Content and Teaching Strategies

**Objective I:** Explain the important aspects of keeping survey notes for a differential survey.

**Anticipated Problem:** What are the important aspects of keeping survey notes for a differential survey?

- I. No aspect of surveying work is more important than keeping accurate records of field notes. Surveying notes must be recorded legibly and accurately in a field book as the work is done. Notes should not be recorded on scratch paper first and later transferred to a book. Doing this introduces an opportunity for error. The field notes reflect the quality of the work done. Professional looking notes indicate professional quality work in measurement and readings. Other surveyors completing later surveys often refer to survey notes. When making entries in the field book, a 3-H or 4-H pencil should be used. Pen or soft lead pencil marking may become smeared and unreadable over time. Avoid erasures of data since this also makes the validity of the data questionable. Make corrections by drawing a single thin line through the incorrect data and writing the correct entry above. Misspelled words, however, may be erased. There are several important sections included in a field notebook. Each part plays a specific role in the accurate completion of the leveling exercise. The different sections are:
  - A. Table of Contents—Leave a few pages blank at the beginning of the book for a table of contents. On this page, the recorder should make a brief description and a page reference for each activity completed. Include enough information so that someone examining the table of contents can identify the work done, the place and the date it was completed.
  - B. Paging—A survey activity may require one or more sets of facing pages. Each set is considered one page when pages are numbered. Begin a new day's work on a new page.
  - C. Form of Entries—Printed entries are generally more legible than written entries. Field notes should be arranged according to the standard form that has been developed. This form outlines specific information, which should be found on each of the facing pages.
  - D. Left-hand page—This page includes a legal description of the land and the type of survey at the top of the page. The recorder should place column headings between the first two horizontal lines at the top of the page. Readings should be recorded and tabulated in these columns as well. It is important to record figures with the decimal point and digits in line vertically. Show precision of readings by recording significant zeros (i.e. 4.7 compared to 4.70). The column heading which should be found in the survey notes are:
    1. **Station (Sta.)**—location of the leveling rod when the reading is being taken.
    2. **Backsight (BS)**—A level reading taken on a point of known or assumed elevation.
    3. **Foresight (FS)**—A level reading taken on a point of unknown elevation.
    4. **Height of Instrument (HI)**—The elevation of the level line of sight with respect to the benchmark, as indicated by the cross hairs in the telescope. Height of instrument

is calculated by adding the backsight to the elevation of the benchmark or turning point whichever is being used.

5. **Elevation (Elev.)**—The height of a point relative to the benchmark location of the survey. Elevation is calculated by subtracting the foresight from the height of instrument.
- E. Right-hand page—The date, time of day, and weather conditions should be recorded on the top left of this page. The names and duties of the survey party should be recorded at the top right of the right-hand page. The type and number of the surveying instrument may also be recorded there. Also included on this page should be a sketch of the survey. Sketches should be to general proportions. Indicate north on all sketches using conventional signs and symbols. The recorder should sign the lower right corner of the right-hand page.

*A variety of techniques may be used to assist students in mastering this objective. Students should use text materials to understand the important aspects of keeping survey notes for a differential survey. Surveying in Agriculture is recommended. Use TM: A2–4A to assist in the discussion on this topic. It provides a good example of a field notebook's table of contents.*

**Objective 2:** Explain the steps involved in completing a differential survey exercise.

**Anticipated Problem:** What are the steps involved in completing a differential survey exercise?

- II. **Differential leveling** is a way to determine the difference in elevation between two or more points. The establishment on the relative elevation of a number of permanent points in an area is especially useful if drainage or soil conservation work is to be done. Permanent points of known or assumed elevation from which leveling surveys are started are called **benchmarks**. The elevation of a benchmark may be its height above sea level if this information is known. It is customary, however, in agricultural and construction surveys to assume that the elevation of this first benchmark is 100.00 feet, and to determine the elevations of all other points in relation to this first benchmark. The process of completing a differential survey is simple. When trying to determine the elevation of a point in relation to a benchmark, this new point will be called benchmark two.
  - A. Make the first setup of the instrument at some convenient distance away from the benchmark. This distance depends upon the accuracy of the instrument but in most cases should not exceed 300 or 400 feet. Normal practice in the field is to determine this distance by pacing.
  - B. The leveling rod is placed on the benchmark and a reading is taken. This reading is a backsight. Once this backsight is recorded, the rod person then moves to a point between the instrument and benchmark two.
  - C. The rod's new location is called a turning point. A **turning point** is a solid location, usually marked by a temporary stake, on which a foresight is taken, to which the instrument is moved, and from which a backsight is taken to determine a new height of instrument.

- D. A reading is taken on the turning point. This reading is a foresight. Once this reading is recorded, the instrument is moved and the process is repeated until benchmark two is reached. It is a good practice to make the line-of-sight distances to the foresights and backsights approximately equal to balance out any errors in the accuracy or adjustment of the instrument. In all cases, the survey should continue until a circuit is completed.
- E. The total distance covered in a leveling circuit is called a **traverse**. The last foresight is taken on the original benchmark one as a check on the degree of accuracy. The difference between the original and final reading on benchmark one is the error of the survey and should not exceed a reasonable allowance.

*A variety of techniques may be used to assist students in mastering this objective. Students should use text materials to understand the steps involved in completing a differential survey exercise. Surveying in Agriculture is recommended. Use TM: A2–4B and TM: A2–4C to assist in the discussion on this topic.*

**Objective 3:** Explain how to calculate allowable error in a survey exercise.

**Anticipated Problem:** How is allowable error calculated for a survey exercise?

- III. In leveling, errors can and will occur. These are most often done accidentally. The final error of closure in a leveling circuit is proportional to the square root of the number of rod readings. The formula assumes a distance of 100 feet for each rod reading. Therefore, we divide the total length of the traverse by 100, determine the square root of that dividend, and multiply by the factor of .014. For experienced surveyors, a less tolerant factor of .007 may be used. If the error of the survey is greater than the allowable amount calculated, the survey should be repeated.

*A variety of techniques may be used to assist students in mastering this objective. Students should use text materials to understand how to calculate allowable error in a survey exercise. Surveying in Agriculture is recommended. Use TM: A2–4D to assist in the discussion on this topic.*

**Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the end of each chapter in the recommended textbooks may also be used in the review/summary.

**Application.** Students should complete one or more differential leveling exercises in a familiar area.

**Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activity. A sample written test is attached

## **Answers to Sample Test:**

### **Part One: Matching**

1 = h, 2 = c, 3 = g, 4 = e, 5 = b, 6 = f, 7 = a, 8 = d

### **Part Two: Completion**

1. 3-H; 4-H
2. professional

### **Part Three: Short Answer**

See Objective 1 in the lesson to score this item.

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# Test

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## Lesson A2–4: Applying Differential Leveling Techniques

### Part One: Matching

*Instructions.* Match the term with the correct response. Write the letter of the term by the definition.

- |              |                         |                          |
|--------------|-------------------------|--------------------------|
| a. backsight | b. benchmark            | c. elevation             |
| d. foresight | e. height of instrument | f. differential leveling |
| g. station   | h. turning point        |                          |

- \_\_\_\_\_ 1. A solid location, usually marked by a temporary stake, on which a foresight is taken, to which the instrument is moved, and from which a backsight is taken to determine a new height of instrument.
- \_\_\_\_\_ 2. The height of a point relative to the benchmark location of the survey.
- \_\_\_\_\_ 3. Location of the leveling rod when the reading is being taken.
- \_\_\_\_\_ 4. The elevation of the level line of sight with respect to the benchmark, as indicated by the cross hairs in the telescope.
- \_\_\_\_\_ 5. A permanent point of known or assumed elevation from which leveling surveys are started.
- \_\_\_\_\_ 6. Process of determining the difference in elevation between two or more points.
- \_\_\_\_\_ 7. A level reading taken on a point of known or assumed elevation.
- \_\_\_\_\_ 8. A level reading taken on a point of unknown elevation.

### Part Two: Completion

*Instructions.* Provide the word or words to complete the following statements.

1. When making entries in the field book, a \_\_\_\_\_ or \_\_\_\_\_ pencil should be used.
2. Professional looking notes indicate \_\_\_\_\_ quality work in measurement and readings.

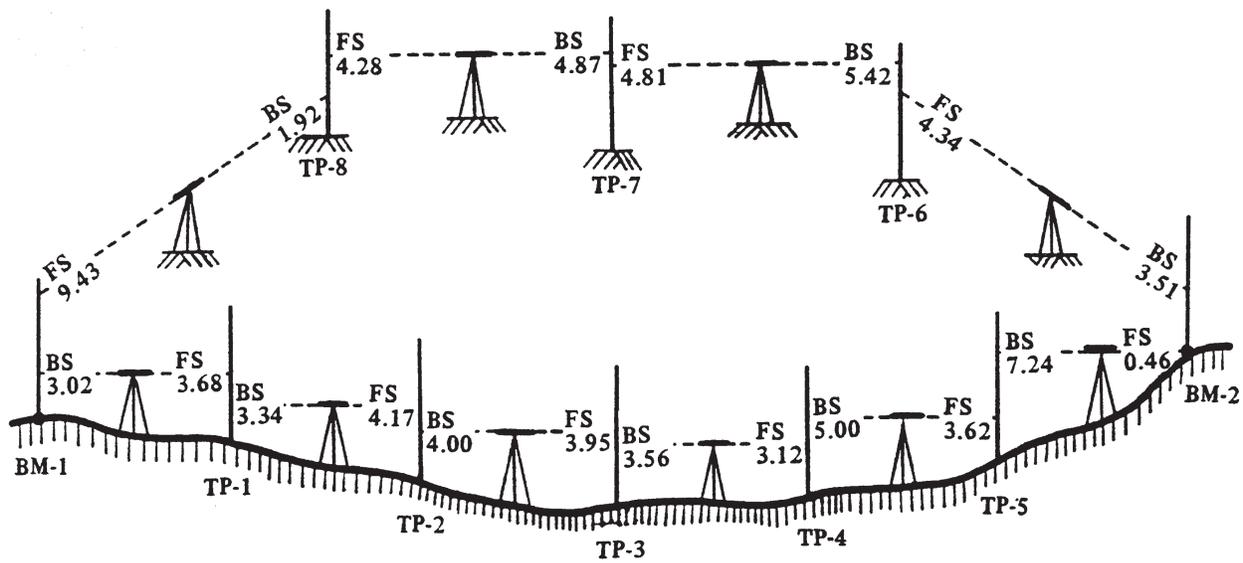
### Part Three: Short Answer

*Instructions.* Provide information to answer the following question.

What items should be found on the right-hand page of field notes?



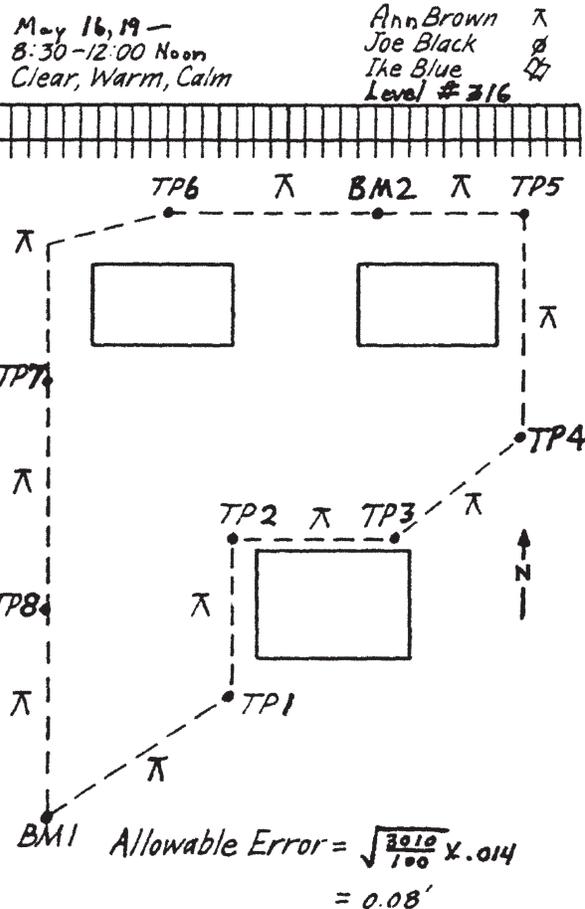
# EXAMPLE OF A TRAVERSE USING DIFFERENTIAL LEVELING



# FIELD NOTEBOOK DATA FOR DIFFERENTIAL LEVELING

Michael Aiken Farm  
NE ¼ NW ¼ Sec 4, T4N R6W  
Differential Leveling

Sta.	BS	HI	FS	Elev.	Dist.
BM-1	3.02			100.00	
		103.02			310
TP-1	3.34		3.68	99.34	
		102.68			270
TP-2	4.00		4.17	98.51	
		102.51			270
TP-3	3.56		3.95	98.56	
		102.12			270
TP-4	5.00		3.12	99.00	
		104.00			370
TP-5	7.24		3.62	100.38	
		107.62			250
BM-2	3.51		0.46	107.16	
		110.67			280
TP-6	5.42		4.34	106.33	
		111.75			320
TP-7	4.87		4.81	106.94	
		111.81			350
TP-8	1.92		4.28	107.53	
		109.45			320
BM-1			9.43	100.02	
					3010
	Error = 0.02'				



# CALCULATING ALLOWABLE ERROR

**Allowable error (E) = the square root of the dividend of the length of the traverse in feet divided by 100, times a factor of .014.**

**Example:**

**In a survey that traverse was 3010 feet. What is the allowable error? \_\_\_\_\_**

$$E = \sqrt{3010/100} \times .014$$

$$= 5.486 \times .014 = 0.08 \text{ feet}$$

**Allowable error = 0.08 feet**