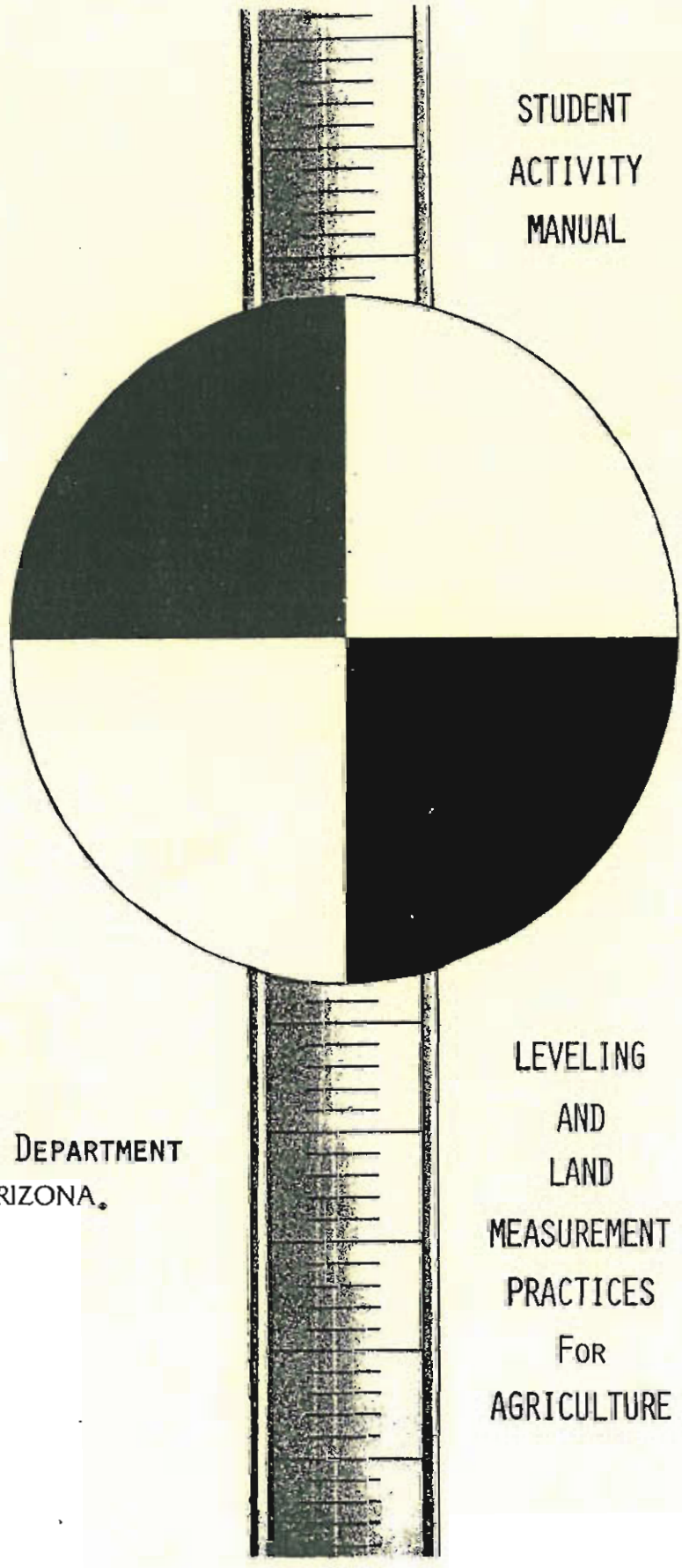
STUDENT ACTIVITY MANUAL



LEVELING AND LAND MEASUREMENT PRACTICES FOR AGRICULTURE

AGRICULTURAL EDUCATION DEPARTMENT
THE UNIVERSITY OF ARIZONA
TUCSON

Activity Manual

on

LEVELING AND LAND MEASUREMENT PRACTICES

for

AGRICULTURE

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Introduction

This Student Activity Manual is designed to provide student involvement through a series of learning activities and job operations concerning leveling and land measurement practices used in agriculture.

It is intended that the student carefully follow the written directions to each of the fourteen activities and perform the operations as outlined or as modified by your instructor. The companion reference presents the basic theory and subject matter information which is essential to the successful performance of specific operations.

TABLE OF CONTENTS

ACTIVITY NO. I - Legal Land Description

A. Objectives

1. To describe the rectangular system of public land survey.

2. To describe the location of a land area by legal description.

B. Introduction

The Rectangular System of land survey was implemented in the United States as a means of identifying the location of land boundaries. When agricultural land is sold the official deed contains a legal description of the land using the Rectangular System. In this activity you will use the information provided in the Reference Unit pp. 1-10 to assist in identifying legal descriptions of land parcels.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 1-10.

D. Questions for Study

1. What country is credited with originating the science of surveying and land measurement?

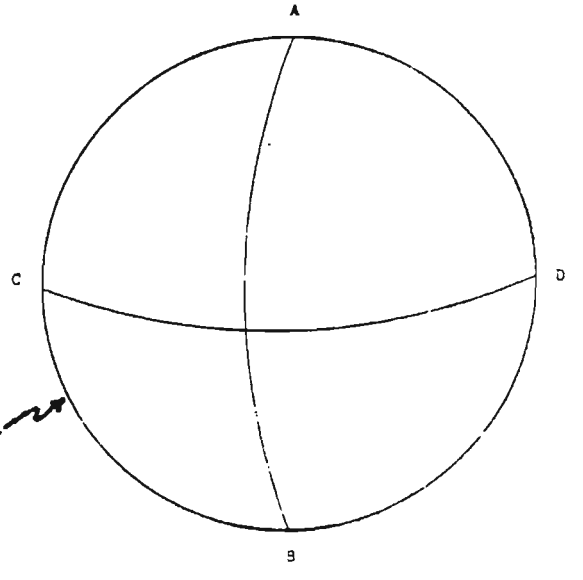
2. What is the purpose of the Rectangular System of land survey?

3. What is a principle meridian? A base line?

4. Using the space provided identify lines AB and CD with respect to the Rectangular System of land survey.

AB _____

CD _____



5. The position where the earth's principle meridian crosses the earth's base line is known as the _____ _____.

6. The United States is divided into _____ regions for survey purposes. Arizona is part of _____ regions.

7. Each region is named after its principle meridian. What are the names of the principle meridians for Arizona?

8. Lines of latitude located north and south of the base line are called _____ _____. The lines are located at _____ mile intervals.

9. Secondary meridian lines are established every _____ miles east and west of the primary meridian. These meridians are called _____ _____.

10. How large is a tract of land?

11. What is a township? How many townships are located in a tract of land?

12. What is a tier?

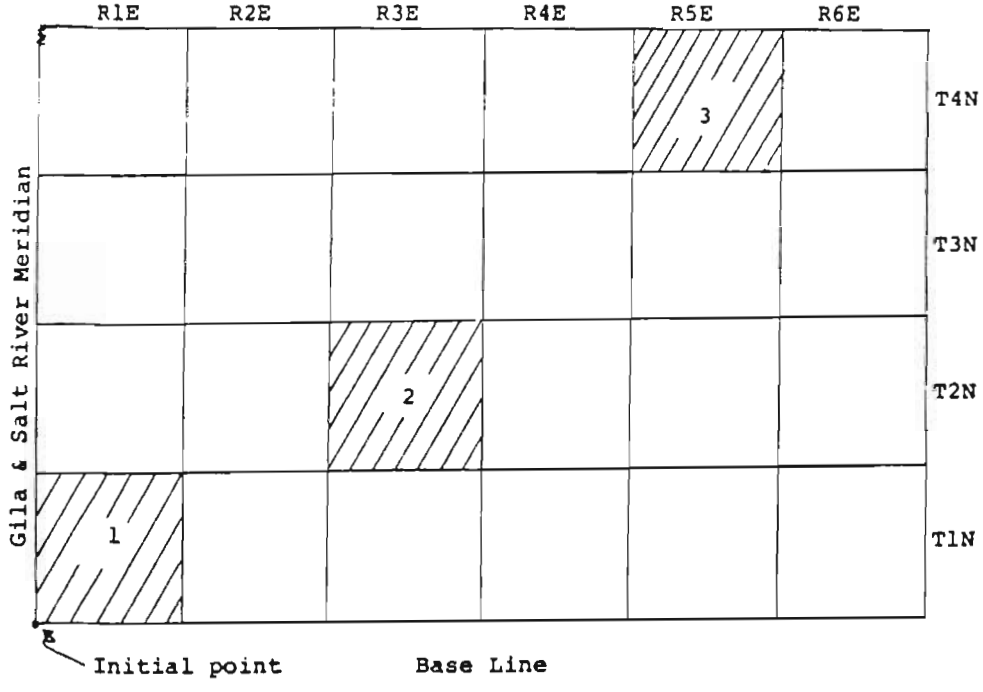
13. Townships are numbered consecutively _____ or _____ of the base line.

14. What is a range?

15. Ranges are numbered consecutively _____ or _____ of the principle meridian.

16. Identify the "range" and "tier" of the shaded townships.

1. = _____
2. = _____
3. = _____

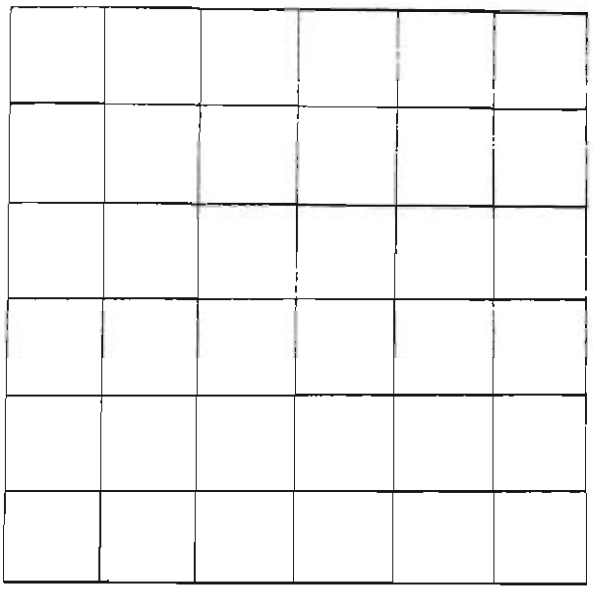


17. There are _____ sections to a township.

18. There are _____ acres in a section.

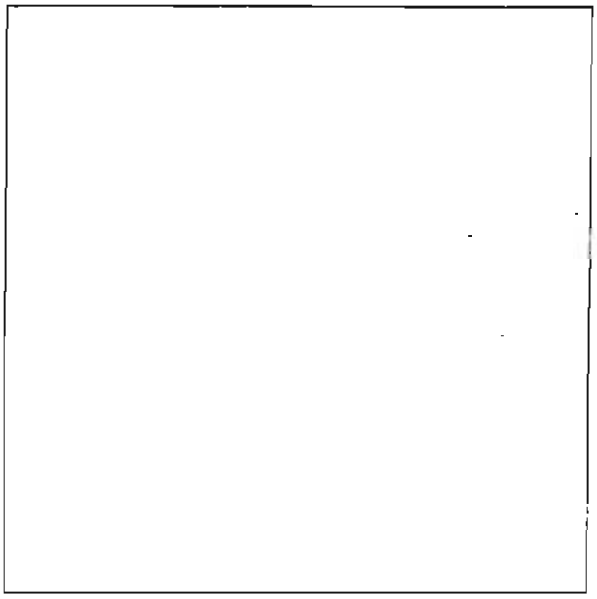
19. A section is usually _____ mile square.

20. Number the sections in the following township:



21. The standard practice of writing the legal description of a parcel of land is to start with the _____ area.

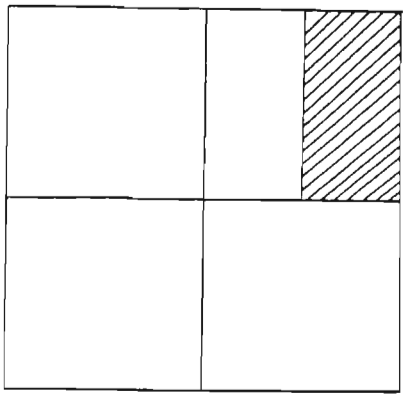
22. Draw in and label the exact area of this legal description: NW¼ of Section 1, Township 34 North, Range 3 East, Gila and Salt River Meridian.



Section 1

23. Write the legal description of the cross-sectioned area in each of the following sections and provide the number of acres in each.

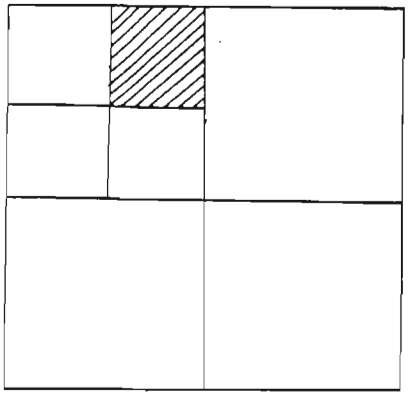
Section 16
Township 33 North
Range 10 West
Gila and Salt River Meridian



_____

_____

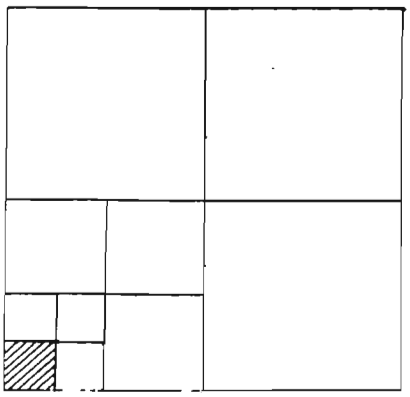
Acres_____



_____

_____

Acres_____



_____

_____

Acres_____

STUDENT INSTRUCTIONS

Write the legal description of your own property.

Legal description_____

_____

_____

Acreage_____

ACTIVITY NO. II - Leveling Equipment

A. Objectives

1. To describe the basic principle of operation of the tripod level.

2. To differentiate between a transit level and a dumpy level.

3. To identify operating parts of a dumpy level.

4. To list seven rules of proper care and use of the tripod level.

B. Introduction

The ability to identify and describe leveling equipment is basic to effective communication. This knowledge also enables an agriculturalist to select the appropriate instrument and equipment for a leveling operation. The purpose of this activity is to develop a knowledge of the leveling instrument and equipment used with it.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 11-20.

D. Questions for Study

1. What is the basic purpose of the tripod level?

2. Describe the basic principle of operation of the tripod level.

3. List five types of leveling instruments and their uses.

a.

b.

c.

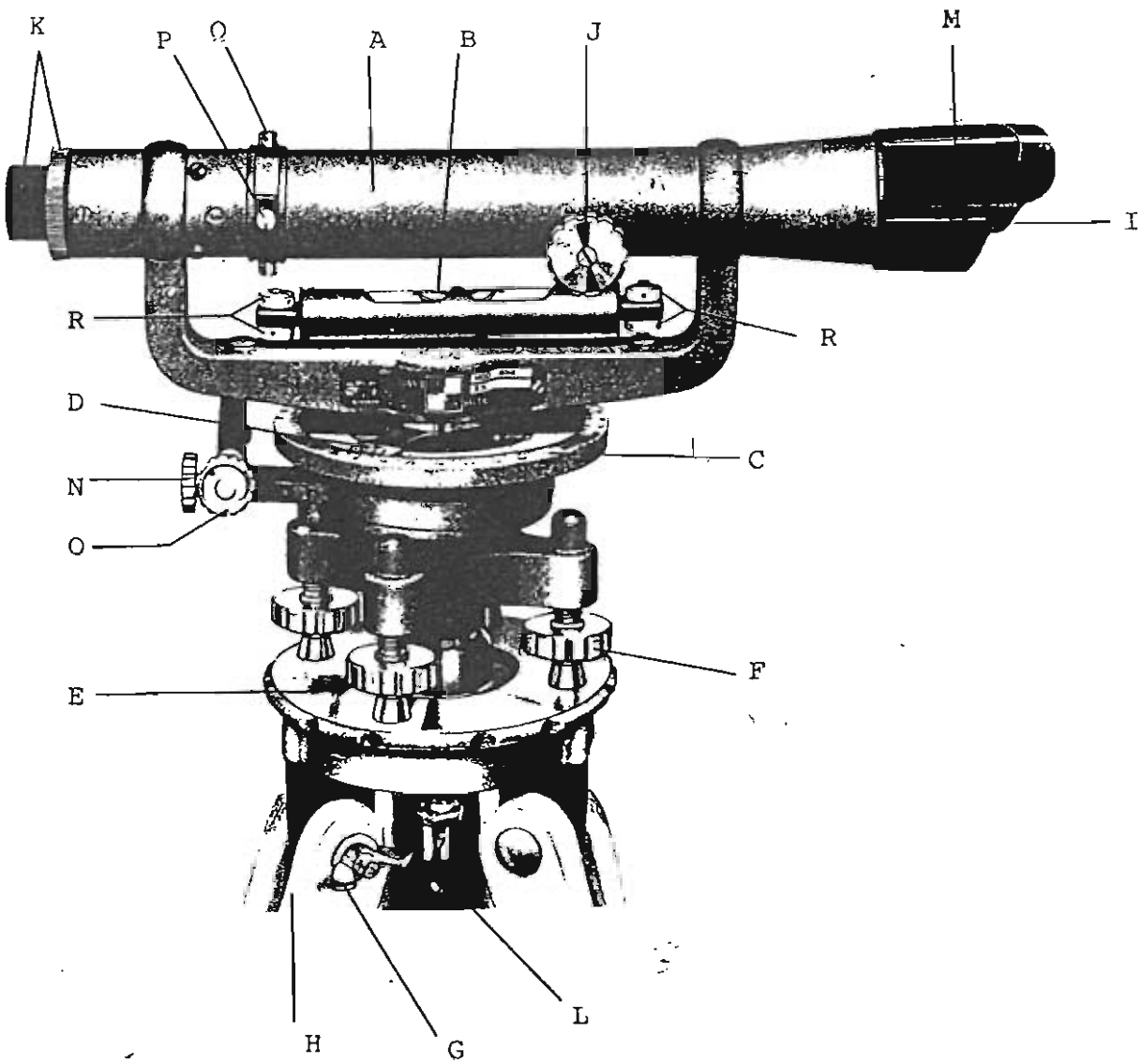
d.

e.

4. Differentiate between a transit and a dumpy level.

5. What is the difference between a utility and turrent type farm level?

6. Using the following picture, complete the table for each labeled part.


K
P
Q
A
B
J
M
I
R
R
D
C
N
O
F
E
H
G
L

Item No.	Name of Part	Function
A		
B		
C		
D		
E		
F		
G		
H		
I		
J		
K		
L		
M		
N		
O		
P		
Q		
R		

ACTIVITY NO. III - Land Measurement Equipment

A. Objectives

1. To list five methods used to measure horizontal distances.

2. To identify equipment used in agricultural land measurement.

3. To differentiate between the two types of steel tapes by method of graduation.

4. To list eight principle sources of error in measuring horizontal distances.

B. Introduction

Several methods and a variety of mechanical equipment are used to measure horizontal distances in agriculture. It is essential that the operator understand the methods and the equipment used for each if the equipment is to be properly applied. This activity is designed to develop a knowledge of land measurement methods and equipment commonly used.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 20-28.

D. Questions for Study

1. List five methods used to measure horizontal distances.

   a.

   b.

   c.

   d.

   e.

2. What is pacing?

3. Is the length of the human pace the same for all individuals? Why?

4. What is chaining?

5. How many feet are in a chain?

6. What equipment is used in chaining?

7. There are two commonly used methods of graduating steel tapes. How do they differ?

8. List the eight principle sources of error in measuring distances with a steel tape and explain how they can be avoided.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

9. A complete set of pins for chaining contains_____ pins.

10. What is a measuring wheel?

11. If after measuring a horizontal distance with a measuring wheel, the counter reads 72 revolutions and the wheel was 6.6 feet in circumference, what would be the distance covered? (Show calculations)

12. Mr. Jones measured the length and width of his cotton field with the above measuring wheel. The length of the field was determined to be 20 revolutions and the width 30 revolutions. How many acres of cotton does Mr. Jones have? (Show calculations)

13. What is a geodimeter? What is the principle of its operation?

STUDENT INSTRUCTIONS

Lay out a 100 foot steel tape and pace its length at least four times to determine the average length of your pace. Record the number of paces for each tape length below. (Show all work)

100' steel tape	# paces
1st tape length	
2nd tape length	
3rd tape length	
4th tape length	

1. Calculate the average length of your pace in the following space.

2. Pace off a field and determine the length of its boundaries. Draw a map of the field and label each boundary with the number of paces walked off and then convert the paces to feet and tenths of feet.

STUDENT INSTRUCTIONS

Remeasure the boundaries of the field which you paced with a measuring wheel and compare the results by answering the following questions.

1. What is the circumference of the measuring wheel you used?

2. Draw a map of the field measured and label each boundary with the wheel revolutions and convert each to feet and tenths of feet.

ACTIVITY NO. IV - Determining Land Acreage

A. Objectives

1. To calculate acreage of various shaped agricultural land parcels.

B. Introduction

Land measurement practices in agriculture are used to determine field boundaries and the exact acreage of land within the boundaries. Acreages for certain crops are limited by federal controls. Any acreage in excess of that set by the federal government is at a loss to the agriculturalist. It is therefore important that he calculate the quantity of land within a field to conform to legal limits. Knowing the amount of land acreage is necessary when purchasing fertilizer, pesticides, seed, etc.

This activity provides the student with the opportunity to calculate acreage of various shaped parcels of land.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 29-32.

D. Questions for Study

1. How many acres are there in a rectangular field 1326 feet long and 561 feet wide?

2. A farmer wishes to build a fence around a square field measuring a total distance of 640 rods. How many posts will he use, when he places them 16½ feet apart?

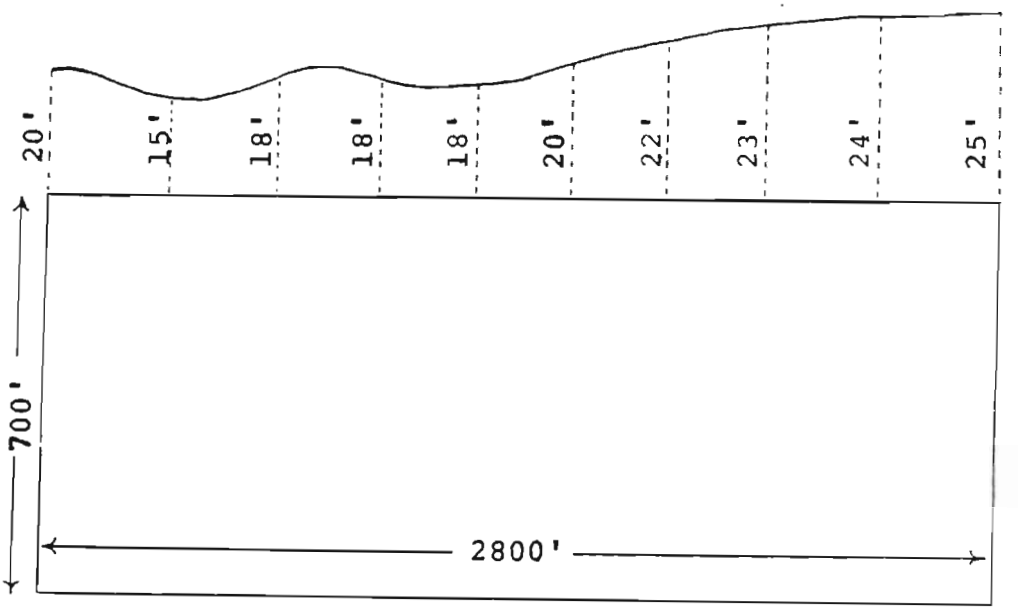
3. How much 3-wire fencing is needed to enclose a field that measures 190 feet, 212 feet, 190 feet and 212 feet on each of the four sides, respectively?

4. How many acres are there in a triangular field, if the base is 5000 feet and its altitude is 750 feet?

5. What is the cost of a pasture of rectangular shape purchased for $50.00 per acre, measuring 3 miles long and 2 miles wide?

6. You have determined by pacing a 100 foot distance several times that your pace is 36 paces per 100 feet. What is the area of a rectangular parcel of land when your pace count is 149 on the south side and 216 on the west side?

7. Determine the total area and acreage of the field shown below.



STUDENT INSTRUCTIONS

Using the measurements taken by the pacing and measuring wheel methods in Activity No. III, determine the acreage of the field. (Show Work)

1. Acres calculated by the pacing method_____.

2. Acres calculated by the measuring wheel method_____.

ACTIVITY NO. V - Chaining

A. Objectives

1. To measure horizontal distances using the steel tape and chaining pins.

2. To list eight errors in measuring with the steel tape.

B. Introduction

The steel tape is considered by many agriculturalists the most practical method of land measurement. Its success and accuracy is dependent upon a knowledge of the equipment and procedures used. In this activity you will be involved in measuring horizontal distances with the steel tape.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 46-51.

D. Questions for Study

1. A survey crew has completed measurement of a field for determining acreage. The tape used has an extra foot before zero numbered in a backward direction. (Figure 2-14b Reference Unit II) Answer the following questions concerning the measurements:

   a. After measuring line A the rear chainman held 9 pins and the 56 foot mark aligned with the last chaining pin. What is the distance measured?

   b. After measuring line B the rear chainman held 5 pins in his hand and the 75 foot mark aligned with the last chaining pin. The head chainman held the .7 on the chain. What is the distance measured?

   c. Round off the length of the sides A and B to the nearest foot, then determine the acreage of the field. The field is rectangular in shape.

   d. The rear chainman holds 4 pins in his hand, has one in the ground and is holding 68 feet on the chain, then the head chainman has gone_____ feet from the starting point.

2. List eight errors in measuring with the steel tape.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

3. When chaining on sloping ground, pins are used at each _____ of the chain.

4. What is a breaking point?

5. Why is the plumb bob used when taping on sloping ground?

6. When chaining on sloping ground, a correction factor is _____ to the surface distance to obtain a true horizontal distance.

7. What is the m thematical formula for the correction factor?

8. If the slope of a measured distance was 8 percent, and the measured distance was 600 feet, what would be the correct lineal distance measured?

JOB OPERATION NO. Va - Chaining on Level Ground

STUDENT INSTRUCTIONS

Using the chaining method for level ground, measure a predetermined distance using the following steps of procedure.

Equipment:	Materials:
-100' Steel tape	-Pencil
-Range poles	-Field notebook
-11 chaining pins with holder	

The steel tape (chain) you are using is _____feet long and the first foot is divided into _____parts per foot numbered in a _____direction.

Steps of Procedure	Illustrations/Key Points/ Safety Practices
A. Setting Range Poles	
1. The head chainman sets the range poles at the beginning and end of the line to be measured.	a. The range poles are used for "lining-in" purposes.
B. Throwing Tape	
2. While the head chainman is setting the range poles the rear chainman "throws" the tape by laying it out in the general direction of the line to be measured.	a. Be careful to avoid looping or twisting the tape.
C. Chaining Operation	
3. The head chainman takes the zero (0) end of the tape, and moves forward pulling the tape toward the end range pole.	

Steps of Procedure	Illustrations/Key Points/ Safety Practices
4. As the 100 foot mark of the tape nears the first pin, the rear chainman calls out "chain". The head chainman halts and places himself in a straight line with the range poles aided by signals from the rear chainman.	
D. Setting Pins	
5. After aligning the tape, the rear chainman holds the 100 foot mark exactly even with the pin. When the 100 foot mark is properly aligned the rear chainman calls out "right here". This is a signal for the head chainman to set his pin.	a. The head chainman kneels and applies approximately 10-12 pounds of tension to the tape with his left arm bearing against his leg.
6. The head chainman places a pin on line and next to the zero mark of the tape. Once the pin is set the head chainman also calls out "right here". This is a signal for the rear chainman to pull his pin.	
7. The rear chainman pulls his pin.	
8. After the head chainman sets his eleventh or last pin he calls out "tally".	
9. The rear chainman brings forward ten pins and gives them to the head chainman.	

Steps of Procedure	Illustrations/Key Points/ Safety Practices
E. Keeping Field Notes	
10. Record tallies on a field notebook page found on page 24.	a. The number of tallies recorded will be the number of thousands of feet which have been measured.
F. Continuing Chaining Operation	
11. Continue the chaining procedure as described above.	
G. Completing Chaining Operation	
12. When the end of the land distance to be measured is reached, the head chainman halts and the rear chainman moves to the last pin where he adjusts the tape so that an even foot mark is aligned with the pin. This is done so that the head chainman's end of the tape will fall within the section of the tape which is subdivided.	a. Proper tension is applied to the tape.
13. The head chainman reads the number of tenths and estimates hundredths. The rear chainman identifies the number of the foot mark which is opposite the pin.	a. The tenths and hundredths are added or subtracted from the foot mark depending on the type of tape graduation used. (See pages 48-49, Reference Unit III)
H. Determining Error	
14. Remeasure the distance above by measuring back to the starting point. Determine the difference in the two readings.	
15. If there is a difference in the two measurements what could have caused the difference?	

JOB OPERATION NO. Vb - Chaining on Sloping Ground

STUDENT INSTRUCTIONS

Measure a predetermined distance on sloping ground using the steps of procedure described below. Record your measurements on a field notebook page as illustrated in Reference Unit III, Page 51.

Equipment:

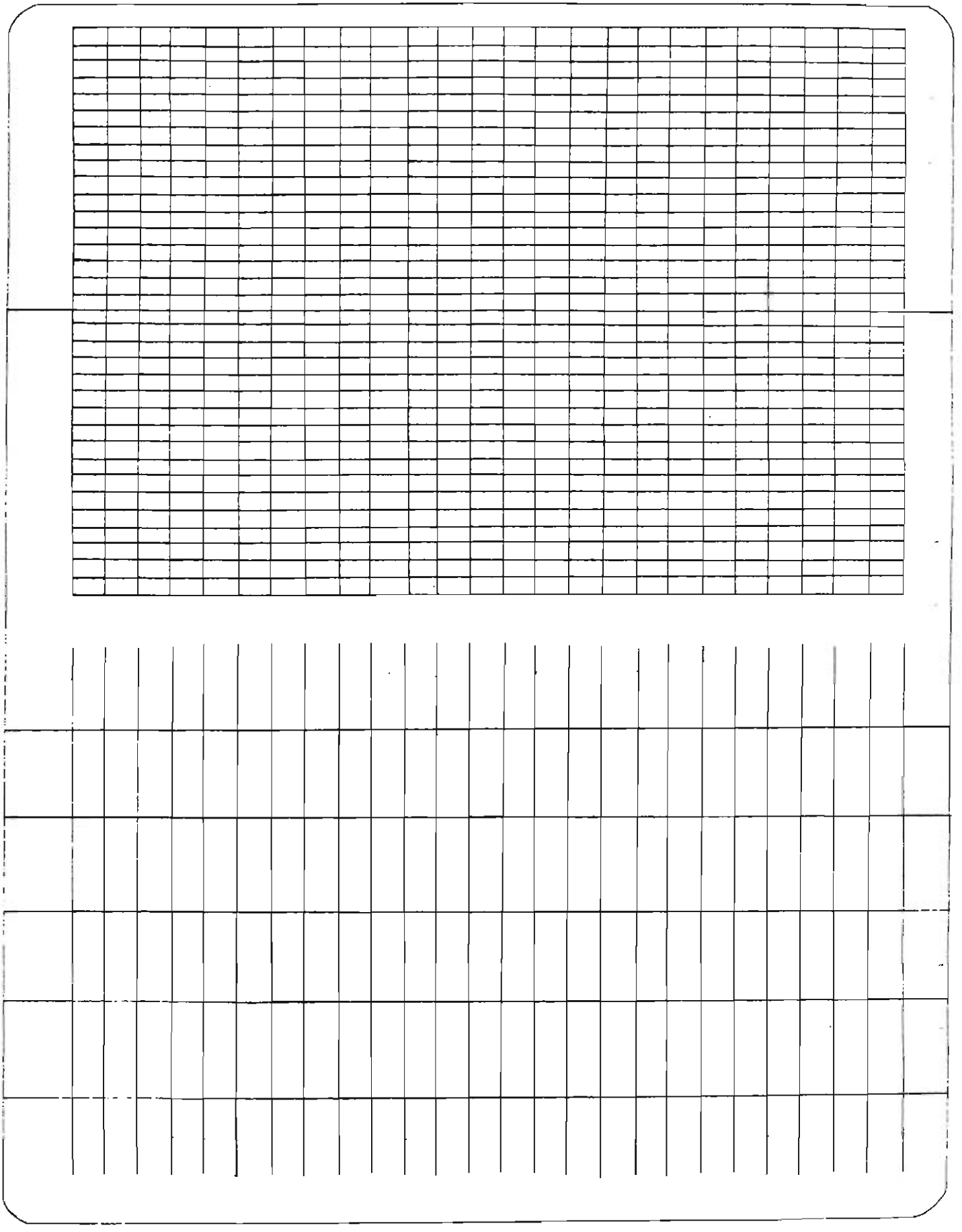
-100' Steel tape
-11 chaining pins with holder
-Plumb bob
-Hammer

Materials:

-Pencil
-Field notebook
-Wooden stakes

Steps of Procedure	Illustrations/Key Points/ Safety Practices
A. Throwing Tape	
1. The head chainman "throws" the tape by laying it out in the general direction of the line to be measured.	a. Avoid looping or twisting the tape.
B. Chaining Operation	
2. When moving up hill, the head chainman takes the zero (0) end of the tape and moves forward to a point selected by the rear chainman.	a. The rear chainman selects this point by estimation or with the use of a hand level while holding his end of the tape at chest height. The head chainman will hold the chain at this point on the ground. This point will be marked with a chaining pin.
3. The rear chainman holds his end of the tape at chest height. With the aid of a plumb bob, the rear chainman will hold an even foot mark directly over the starting point. This is done so that the head chainman's end of the tape will fall within the section of the tape which is subdivided into tenths.	

Steps of Procedure	Illustrations/Key Points/ Safety Practices
4. The head chainman "calls out" the tape reading in tenths and hundredths. The rear chainman "calls out" his tape reading in even feet.	a. Both chainman make the addition or subtraction depending on the type of tape used and check each other's results. The results are entered in the field notes found on page 25.
5. This process continues until the end of the distance measured is reached.	a. The total number of feet measured is obtained by summing the distance measured at each station.
C. Correction Factor	
6. Add correction factor to the surface distance obtained in Step 5.	a. $\frac{S^2}{200}$ per 100 ft. S = percent slope $\frac{\text{Distance measured}}{}$ + $\frac{\text{Correction factor}}{}$ = Correct lineal distance measured



CHAINING

STATION	FEET	TENTH

DATE _____

WEATHER _____ TEMP. ____

PAGE 1

EQUIPMENT

HC -

RC -

LOCATION

MAP OF MEASURED AREA

PROFILE OF MEASURED DISTANCE

CORRECTION FACTOR CALCULATIONS

ACTIVITY NO. VI - Aerial Mapping

A. Objectives

1. To measure land distances by the use of aerial maps.

2. To calculate land acreage by use of aerial maps.

B. Introduction

With the aid of aerial maps agriculturalists can determine land distance and acreage quickly and accurately. Aerial maps may also reveal low areas that may require minor land leveling. Upon completion of this activity you will be able to determine land distances and acreage using aerial maps of agricultural areas.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 54-56.

D. Questions for Study

1. With the use of aerial maps agriculturalists can measure land_____and determine_____.

2. What is a map measurer?

3. When using a sheet of paper to measure map distance how would you measure a curved line?

STUDENT INSTRUCTIONS

Using the aerial map on the following page measure field boundaries of the fields designated by your instructor and determine their acreage.

Field No.	Boundary Distances	Acres

ACTIVITY NO. VII - Tripod Level

A. Objectives

1. To set up the tripod level for a level line of sight.

2. To measure horizontal distances with a level.

B. Introduction

The success and accuracy of the sightings and measurements taken with the tripod level hinge greatly upon the procedure followed in setting up the instrument. In this activity you will use accepted techniques to properly set up and adjust the tripod level.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp.33-36.

D. Questions for Study

1. How should the leveling instrument be removed from its case?

2. How should the leveling screws be grasped?

3. The leveling screws should be rotated by bringing the thumbs of the hand_____ or_____ from one another.

4. Turning both leveling screws "in" moves the bubble to the _____.

5. When the bubble in the leveling tube moves to the left, both leveling screws are being turned_____ _____. (outward or inward)

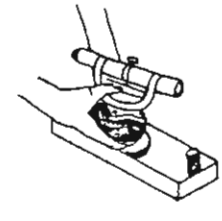
JOB OPERATION NO.VII - Setting up the Tripod Level

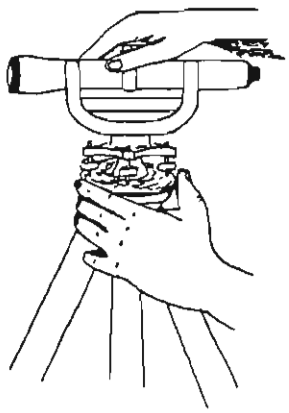
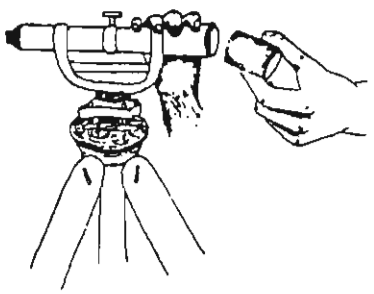
STUDENT INSTRUCTIONS

Set up the tripod level and bring it to an accurate setting following the steps of procedure shown below.

Equipment:

-Tripod
-Leveling Instrument
-Rod

Steps of Procedure	Illustrations/Key Points/ Safety Practices
A. Setting up the Tripod	
1. Loosen the tripod wing nuts to remove friction from the legs. 2. Spread the legs 3 to 4 feet apart and push them firmly into the ground. 3. Remove the thread protection cap and place it in the instrument case.	
B. Attaching Instrument to Tripod	
4. Remove instrument from case.	a. Pick up the instrument by the base to prevent damage to the telescope tube. 

Steps of Procedure	Illustrations/Key Points/ Safety Practices
5. Attach the instrument to the tripod by holding the instrument in one hand and turning the base with the other.	a. CAUTION: Tighten the base snugly with the hand - DO NOT FORCE. 
6. Remove the lens protection cap and place it in the instrument case. 7. Attach the sunshade.	

Steps of Procedure	Illustrations/Key Points/ Safety Practices

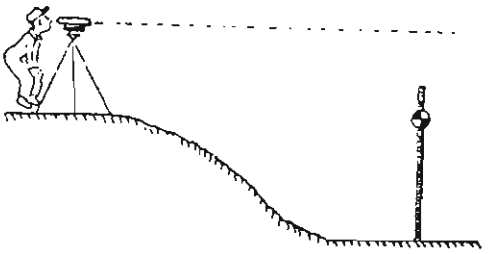
C. Leveling Instrument to Rough Setting

8. Set the telescope tube over two legs and push one leg into the ground until the bubble in the level tube is approximately centered.

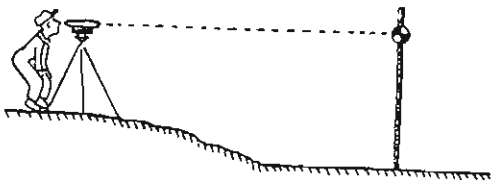
9. Rotate the telescope tube over the third leg and approximately center the bubble.

10. Sight through the instrument to determine whether the rod will come within the limits of the level.

11. If the rod is within the limits of the level, tighten the wing nuts, if not, move to a new location.



Rod not within limits of level



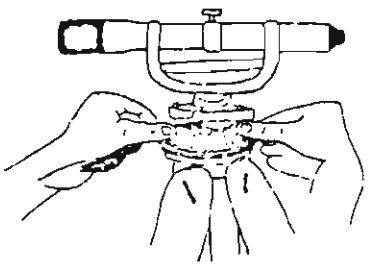
Rod within limits of level

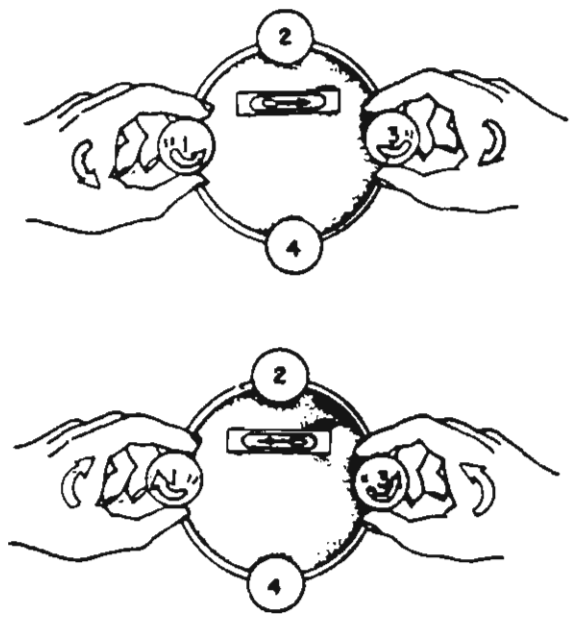
D. Leveling Instrument to Accurate Setting

12. Rotate the telescope tube in alignment with two leveling screws. Grasp the two screws between the thumb and forefinger of each hand. Rotate the screws by bringing the thumbs of the hand toward or away from one another.

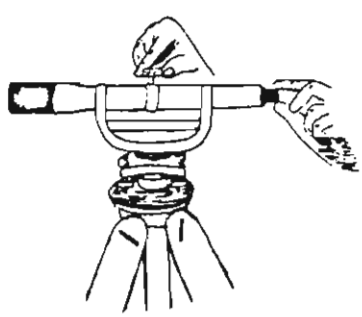
13. Keep the leveling screws working firmly against one another but avoid binding.

a. The bubble in the leveling tube will follow the movement direction of the left thumb.



Steps of Procedure	Illustrations/Key Points/ Safety Practices
14. Place the telescope tube over the second set of leveling screws and repeat the above operation. 15. Recheck and make changes as necessary through the 360° circle.	

E. Focusing Telescope

16. Aim the telescope tube at an unmarked object such as the sky and adjust the eye-piece until the cross-hairs are in sharp focus. 17. Aim the telescope tube at an object and adjust the objective focus until the object is clear.	

ACTIVITY NO. VIII - Checking the Tripod Level for Proper Adjustment

A. Objectives

1. To set up and test the tripod level for proper adjustment.

2. To set up and test the adjustment of the horizontal cross hair.

B. Introduction

Occasionally the leveling instrument is bumped or jolted out of adjustment. When this happens the line of sight and bubble of the level are not coordinated; therefore, the sightings taken will be incorrect. This activity is designed to teach you how to check the leveling instrument for proper adjustment.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 37-39.

D. Questions for Study

1. What effect would the following have on a leveling instrument?

   a. Thumb screws on the tripod are loose.

   b. Leveling screws are not firmly seated on the base plate.

   c. Leveling tube is not parallel with objective and eyepiece crosshairs.

2. Who should perform repairs on a leveling instrument?

JOB OPERATION NO.VIII - Testing the Tripod Level for Proper Adjustment

STUDENT INSTRUCTIONS

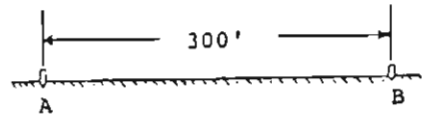
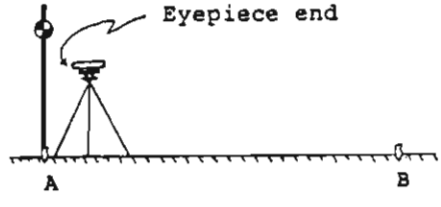
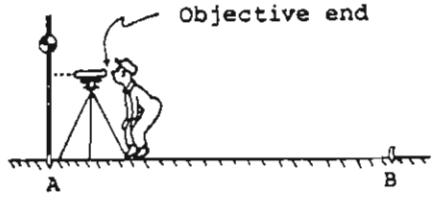
Carefully follow the steps of procedure listed below to determine if the leveling instrument is properly adjusted.

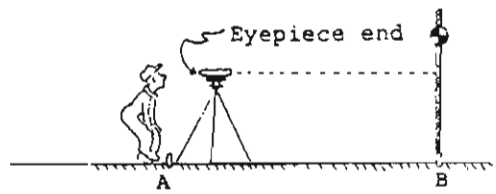
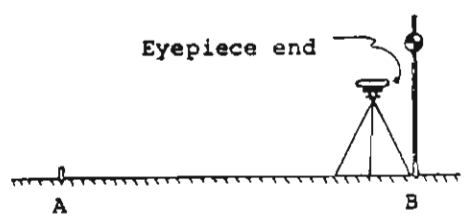
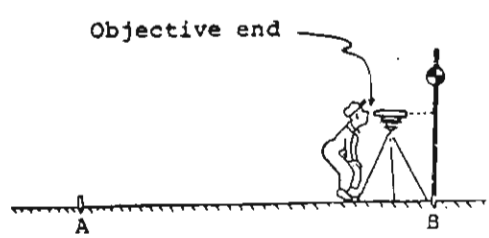
Equipment:

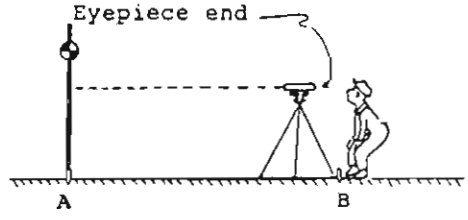
-Hammer
-Tripod
-Leveling instrument
-Rod

Materials:

-2 ea. wooden stakes

Steps of Procedure	Illustrations/Key Points/ Safety Practices
A. Placing Stakes in Ground	
1. Drive two stakes into the ground approximately 300 feet apart and label one "A" and the other "B".	
B. Setting up Instrument	
2. Set up the leveling instrument in such a position that the eyepiece is approximately one inch in front of the rod being held on top of stake "A". Level the instrument to an accurate setting.	
C. Checking Instrument for Proper Adjustment	
3. Take a rod reading on stake "A" sighting through the objective end of the telescope tube.	a. Rod reading on "A" with instrument at "A" = _____ 

Steps of Procedure	Illustrations/Key Points/ Safety Practices
4. Move the rod to stake "B". Set the rod on top of stake "B" and sighting through the eyepiece take a rod reading at stake "B".	a. Rod reading on "B" with instrument at "A" = _____ 
5. Determine the difference in elevation of stake "A" and "B" with instrument at "A". The difference between the two readings will be the difference in elevation plus or minus the error of adjustment.	a. Rod reading on "A" with instrument at "A" = _____ (Answer from Step 3a) b. Rod reading on "B" with instrument at "A" = _____ (Answer from Step 4a) c. Difference in elevation of "A" and "B" = _____ (5a - 5b = 5c)
6. Move the leveling instrument to stake "B". Set the level in such a position that the eyepiece is about one inch from the rod being held on top of stake "B". Level the instrument to an accurate setting.	
7. Take a rod reading on stake "B" sighting through the objective end of the telescope tube.	a. Rod reading on "B" with instrument at "B" = _____ 

Steps of Procedure	Illustrations/Key Points/ Safety Practices
8. Move the rod to stake "A". Set the rod on top of stake "A" and sighting through the eyepiece take a rod reading at stake "A".	a. Rod reading on "A" with instrument at "B" = _____ 
9. Calculate the difference in elevation of stake "A" and "B" with the instrument at "B". As before, the difference between the two sightings is the difference in elevation of stake "A" and "B" plus or minus the error of adjustment.	a. Rod reading on "B" with instrument at "B" = _____ (Answer from Step 7a) b. Rod reading on "A" with instrument at "B" = _____ (Answer from Step 7b) c. Difference in elevation of "B" and "A" = _____ (9a - 9b = 9c
10. The true difference in elevation of stake "A" and "B" is determined by adding the difference in elevation determined in steps 5 and 9 and dividing by two.	a. $\frac{A + B}{2}$ = true difference in elevation
11. Knowing the true difference in elevation between the two stakes and the height of instrument at stake "B", the correct rod reading at stake "A" can be computed by subtracting the true difference in elevation from the rod reading at stake "B".	a. Rod reading at stake "A" should be _____(Answer from Step 7a) minus _____ (Answer from Step 10a) equals _____(Correct rod reading at stake A) to give a level line of sight.

Steps of Procedure	Illustrations/Key Points/ Safety Practices
D. Calculating Adjustment	
12. Determine the amount of adjustment needed.	a. Rod reading at stake "A" from instrument at "B" equals_____(7b) minus _____(11a) reading to give a level line of sight. This requires _____(No. feet adjustment) to be made in the instrument's leveling tube.
E. Checking the Horizontal Cross Hair	
13. With the leveling instrument still set up and leveled at stake B and sighted at the target on the rod held on stake A, rotate the level back and forth slightly from side to side. If the ends of the cross hair cut the target in the same place as did the center of the cross hair, it is in adjustment. If the ends of the cross hair do not remain on the spot as did the center, the cross hair should be adjusted.	

ACTIVITY NO. IX - Reading the Leveling Rod

A. Objective

1. To explain the purpose of the leveling rod and target.
2. To identify the parts of a rod.
3. To read a leveling rod.
4. To extend and secure the leveling rod accurately.
5. To use and interpret field signals.
6. To perform as a rodman.

B. Introduction

A leveling rod is the "measuring stick" of surveying and leveling operations. Its accurate use depends greatly upon the surveying crews' ability to hold, extend, and read a leveling rod correctly. The ability to accurately read a leveling rod is necessary for most agricultural leveling operations. You will also use and interpret field signals.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 39-45.

D. Questions for Study

1. What is a leveling rod?

2. Most leveling rods consist of _____ or _____ sections of hardwood _____ to _____ feet in length.

3. Major divisions of the rod in feet are shown in large _____ (color) numbers.

4. Between each foot indicator are _____ numbers in _____ (color). Each of these numbers represent _____ of a foot measurement.

ACTIVITY NO. X - Leveling Field Notes

A. Objectives

1. To define bench mark, backsight, height of instrument, foresight, and turning point.

2. To explain the importance of field notes.

3. To prepare a page of field notes.

B. Introduction

One of the most important operations accomplished by the surveying crew is keeping accurate and complete field notes. It is obvious that no matter how carefully the leveling operation is done or how accurate the measurements, all is rendered valueless if the field notes are incomplete or unclear. This activity will teach you the proper and accepted procedure for taking field notes.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 44-47.

D. Questions for Study

1. What is a bench mark (BM)?

2. What points can be used as bench marks?

3. If the elevation of a bench mark is unknown, what should be done?

4. A rod reading taken on a point of known elevation is called a _____.

5. How is the height of instrument (HI) determined?

6. What is a foresight (FS)?

7. When is a turning point taken?

8. What are field notes?

9. Why are they kept?

10. What are four types of field notes?

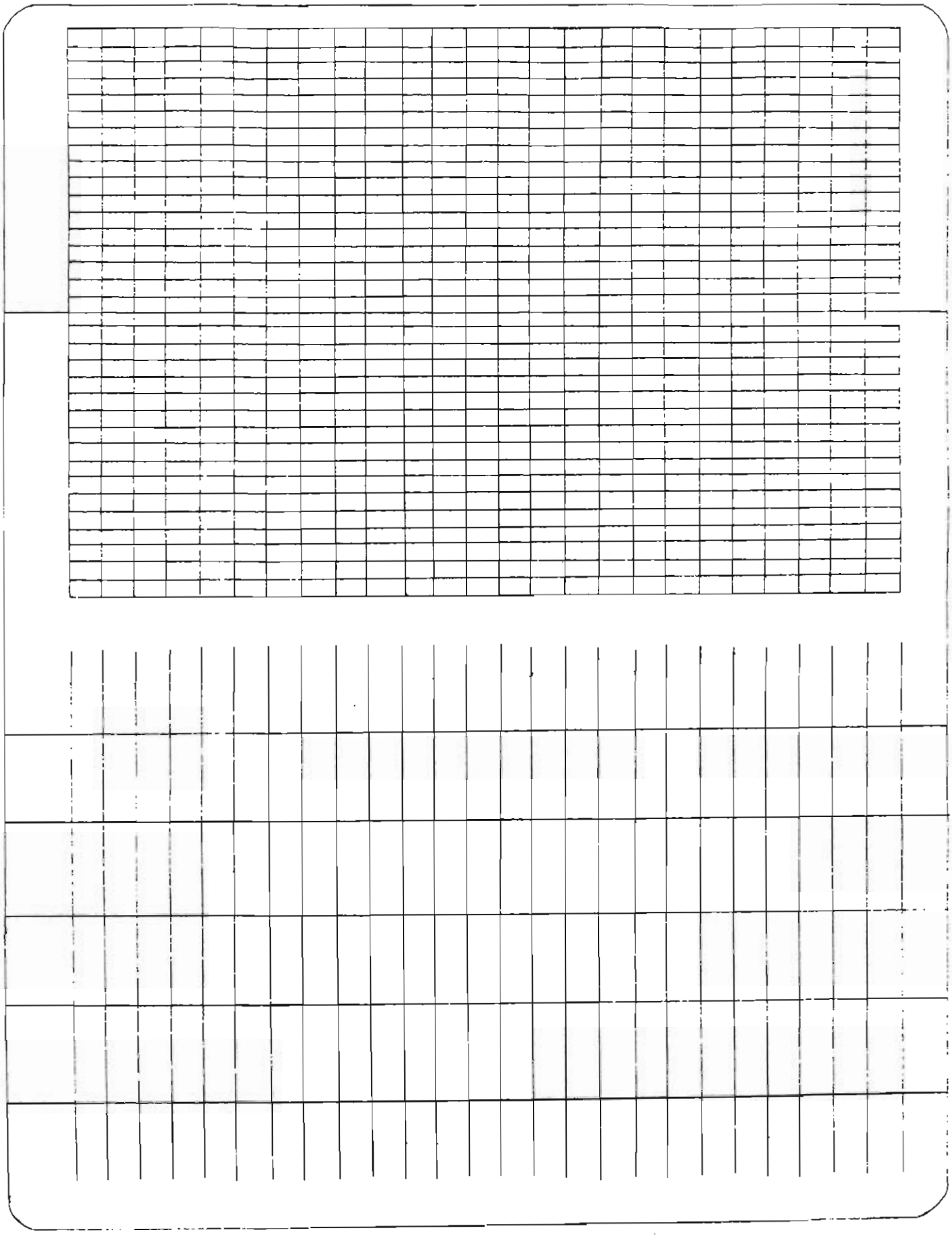
    a.

    b.

    c.

    d.

11. Complete a set of notes on the following field notebook page using the information obtained in Activity No. III on pacing.



ACTIVITY NO. XI - Differential Leveling

A. Objectives

1. To determine the difference in elevation of two points.

2. To develop skill in keeping accurate field notes on differential leveling.

B. Introduction

The basic function of the tripod level is determining differences in elevation between two points. A wide variety of agricultural jobs require that elevation or change in elevation be known. It is the purpose of this activity to describe the process and procedure of determining changes in elevation between points by differential leveling.

C. References

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 57-60.

D. Questions for Study

1. What is the most accurate way we have at our disposal to find the difference in elevation between two points which are not within sight of one another?

2. How many people are on a differential survey crew? What are they called?

3. How do we keep a running account or record of our progress in a differential survey?

4. Backsight is always_____ _to elevation to find

_____ _____ _____.

5. Foresight is always_____ from height of instrument to find_____.

6. Identify the following symbols used in differential leveling field notes.

TP_____ ⊼ _____

FS_____ BM_____

BS_____ HI_____

7. Complete the following page of field notes on differential leveling.

DIFFERENTIAL LEVELING

STATION	B.S. (+)	H.I.	F.S. (-)	ELEVATION
BM				
Π_1				
TP_1				
Π_2				
TP_2				
Π_3				
A				

MAY 19, 1974

CLEAR, 110°

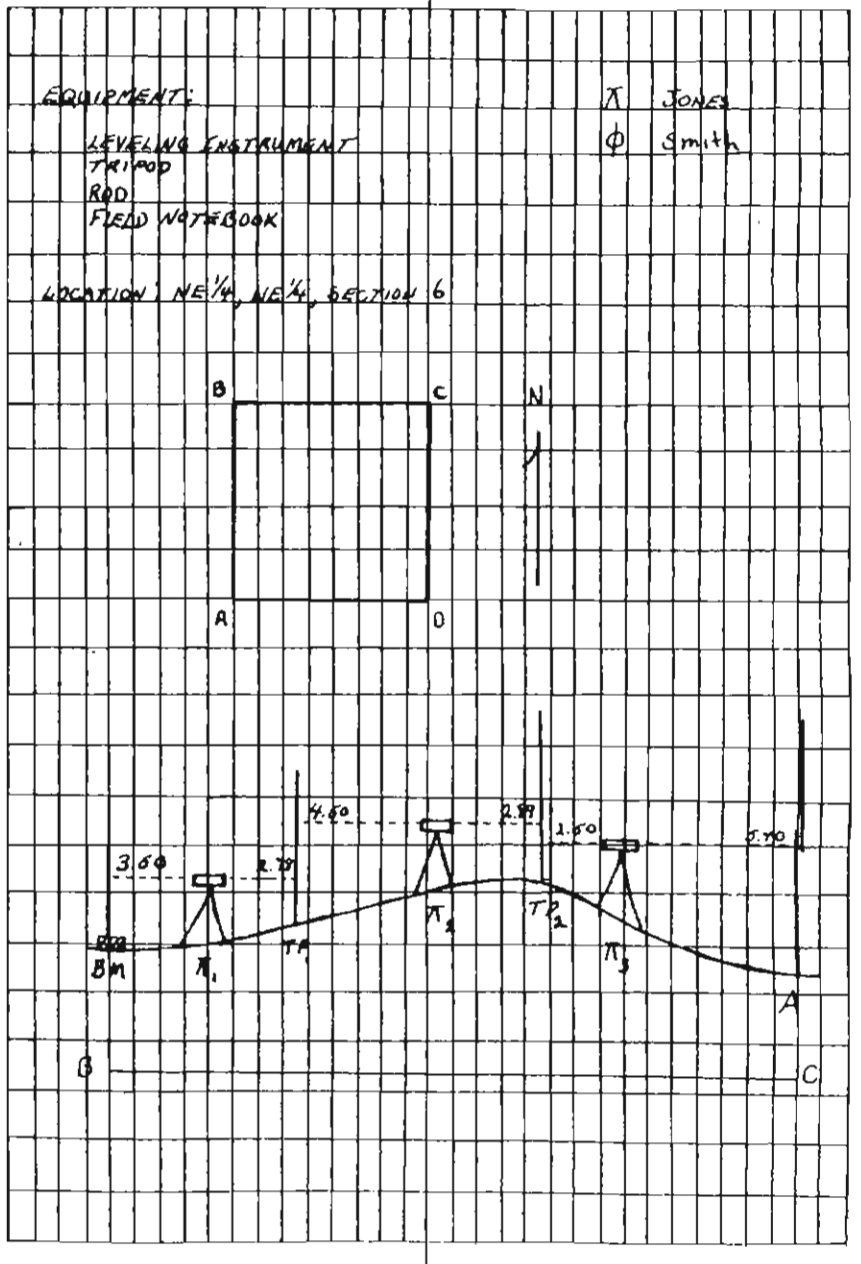
PAGE 1

EQUIPMENT:

LEVELING INSTRUMENT
TRIPOD
ROD
FIELD NOTEBOOK

Λ JONES
ϕ Smith

LOCATION: NE 1/4, NE 1/4, SECTION 6



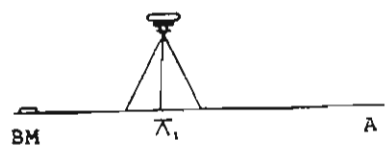
JOB OPERATION NO. XI - Differential Leveling

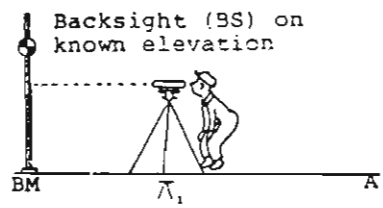
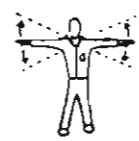
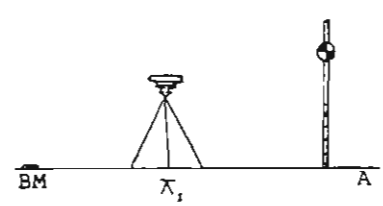
STUDENT INSTRUCTIONS

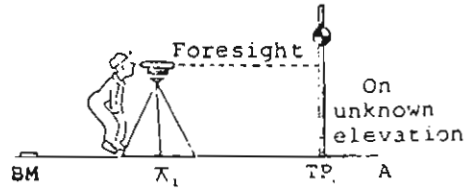
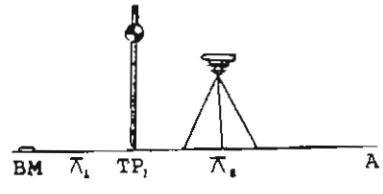
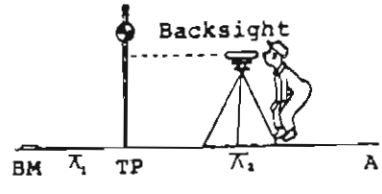
Carefully follow the steps of procedure listed below to determine the difference in elevation between two points. Record your findings on a field notebook page.

Equipment:
-Tripod
-Leveling instrument
-Rod

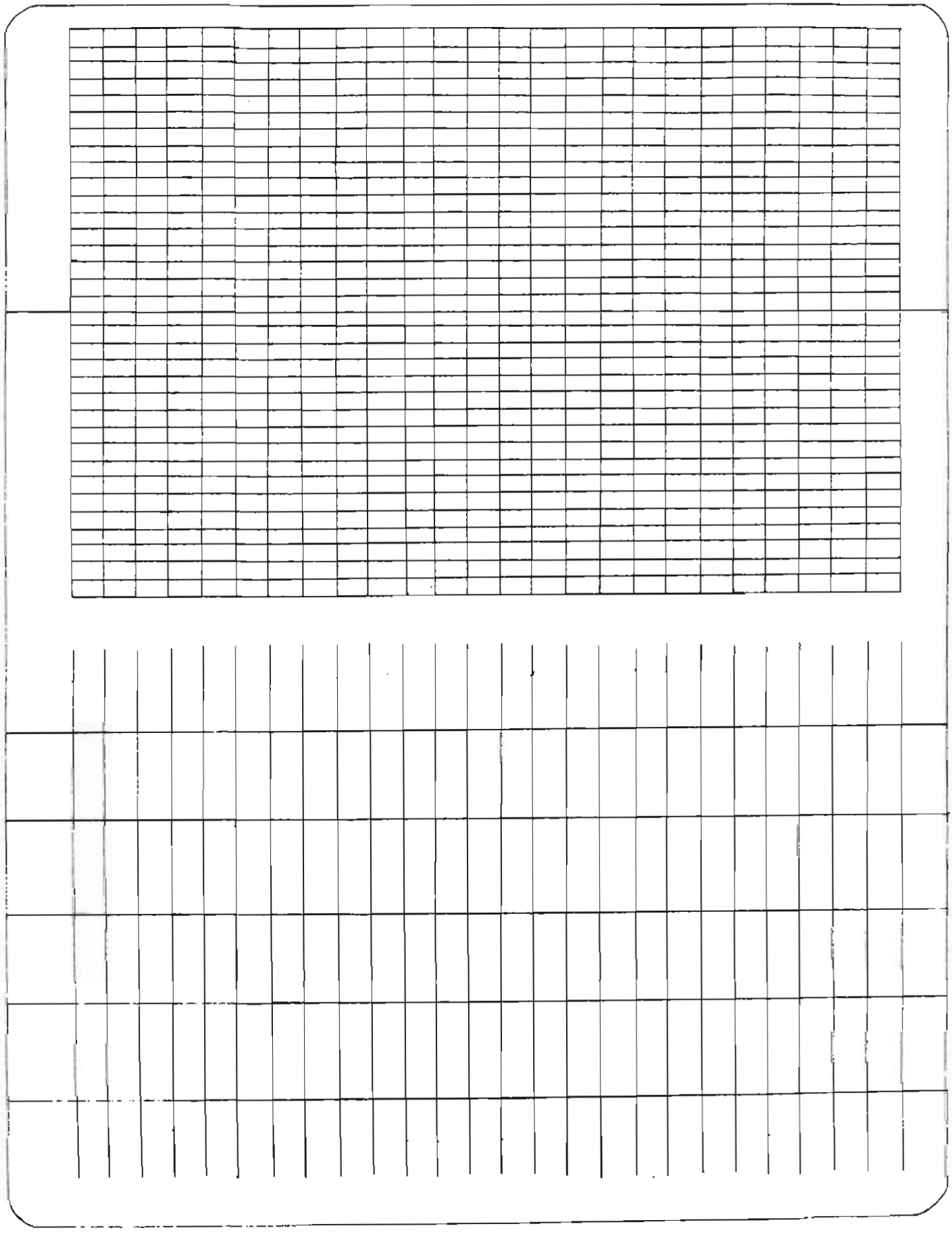
Materials:
-Pencil
-Field notebook

Steps of Procedure	Illustrations/Key Points/ Safety Practices
A. Establishing a Bench Mark	
1. Establish a Bench Mark.	a. Concrete well curb, corner of a road culvert, or any other permanent feature. If elevation is unknown, arbitrarily assign 100 ft. 
B. Setting up Leveling Instrument	
2. Set up and level the instrument to an accurate setting some distance away from the BM in the direction of survey. (Toward point A)	a. The distance from the instrument to the BM should not be so great as to make it impossible to read the rod accurately. Not more than 150 to 200 feet. 

Steps of Procedure	Illustrations/Key Points/ Safety Practices
C. Taking a Backsight	
3. Take a Backsight reading on the rod held on the Bench Mark by the rodman. Record the reading in the BS column of BM in the field notebook page on page 53 to record your sightings.	a. After taking the reading check the bubble in the level tube to insure the instrument is level. 
4. Determine the Height of Instrument. Record the Height of Instrument in HI column of π_1 in the field notes.	a. To obtain Height of Instrument, the BS is added to the Bench Mark elevation. BS + BM = HI
D. Moving Rod to New Location (TP)	
5. Give the "all right" signal to the rodman. At this signal the rodman will move to a new point along the route of survey.	a. DO NOT MOVE OR ADJUST THE INSTRUMENT AT THIS TIME. 
6. The rodman moves toward point A, limited by distance and changes in elevation.	a. The rodman sets the rod on solid ground with the front face of the rod plainly visible to the instrument man. 

Steps of Procedure	Illustrations/Key Points/ Safety Practices
E. Taking a Foresight	
7. Take a Foresight reading on the new rod location. Record the reading in the FS column of TP_1 in the field notes.	a. The new rod location is known as Turning Point 1. 
8. Determine the elevation of Turning Point 1. Record the elevation in the ELEV. column of TP_1 in the field notes.	a. To obtain the elevation of TP_1, subtract the Foresight from the Height of Instrument. HI - FS = ELEVATION.
F. Moving Tripod Level to New Location	
9. Move the tripod level to a new location in the direction of point A. The rodman remains at TP_1. Set the instrument to an accurate setting.	a. The rodman turns the rod around so that the front face of the rod is plainly visible to the instrument man. 
10. Take a Backsight reading on the rod held at turning point 1 (TP_1). Record the Backsight reading in the BS column of TP in the field notes.	a. Recheck the bubble in the level tube. 
11. A new Height of Instrument is determined. Record the Height of Instrument in the field notes.	a. The new Height of Instrument is determined by adding the Backsight to the elevation of the TP. BS + ELEVATION = HI

Steps of Procedure	Illustrations/Key Points/ Safety Practices
G. Counting Differential Leveling Procedure	
12. Repeat Steps 1 through 11 until Point A is reached and its elevation relative to the Bench Mark is obtained.	a. Record all sightings in the field notes.



ACTIVITY NO. XII - Profile Leveling

A. Objectives

1. To determine the difference in elevation of a series of points along a given line.

2. To develop skill in keeping accurate field notes on profile leveling.

B. Introduction

A variety of agricultural applications require the elevations of a series of points along a given line be known. Profile leveling is essential to lay out sewer lines, drains, ditches, or similar structures. This activity provides the student with the opportunity to perform profile leveling.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 61-64.

D. Questions for Study

1. What is the principle difference between differential leveling and profile leveling.

2. What is a station?

3. How are stations identified or recorded?

4. Write the elevations of the following stations used in profile leveling.

6 + 01 _____

3 + 00 _____

2 + 25 _____

5. Write the normal station marking for the following elevations.

150 feet _____

100 feet _____

226 feet _____

JOB OPERATION NO.XII - Profile Leveling

STUDENT INSTRUCTIONS

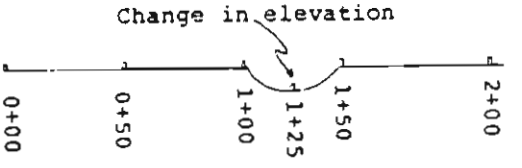
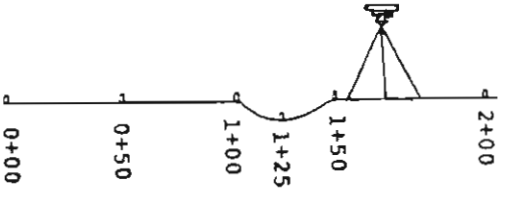
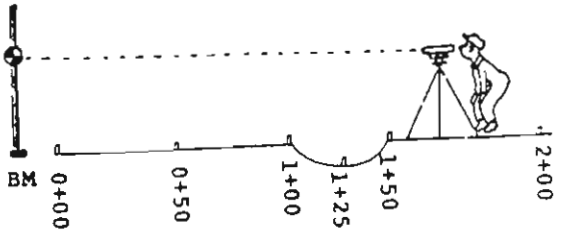
Carefully follow the steps of procedure listed below to perform profile leveling. Record your findings on a field notebook page.

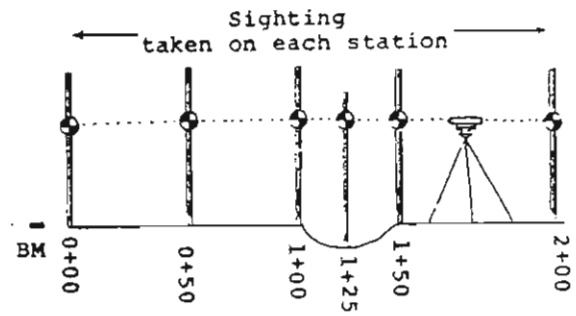
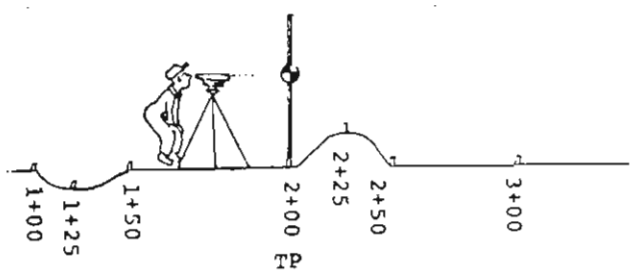
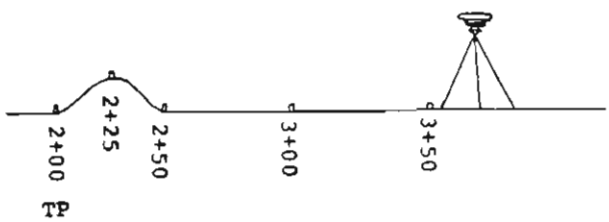
Equipment:

-Tripod
-Leveling instrument
-Rod
-Hammer

Materials:

-Wooden stakes
-Field notebook
-Pencil

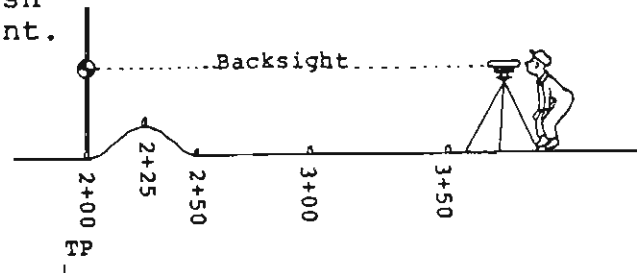
Steps of Procedure	Illustrations/Key Points/ Safety Practices
A. Marking the Stations	
1. The line to be profile leveled must be marked off ("stationed") at intervals of 50 ft. or at each sharp change in land surface.	a. Stakes should be set at each station. 
B. Setting up Tripod Level	
2. Set up the tripod level and bring it to an accurate setting. Set the level approximately 150 to 200 feet from station 0+00 in the direction of survey.	
C. Taking a Backsight	
3. Take a Backsight on a Bench Mark to establish the Height of Instrument. Set up a field notebook page for profile leveling similar to the one shown on page 63 in the Reference Unit. Record the BS reading in the BS column of BM. Use the field notebook page on page 58 to record your sightings.	

Steps of Procedure	Illustrations/Key Points/ Safety Practices
4. Determine Height of Instrument by adding the BS to the known elevation of the BM.	BS + ELEVATION OF BM = HI
D. Taking Foresight on Each Station	
5. Take as many FS readings on as many stations on the line convenient to the position of the instrument. Record the rod reading on each station in the field notes.	a. The rodman moves to each station. The instrument remains in place.  b. To determine the elevation of each station subtract the FS from the HI. HI - FS = ELEVATION
E. Moving Instrument to New Location	
6. When it is necessary to move the instrument to a new position, use the rod reading on the last station as a TP. Record the TP in the field notes under the FS column of TP.	
7. Move the instrument to a new location same distance down the line to be surveyed.	a. New location should be approximately 150 to 200 feet from TP in the direction of survey. 

Steps of Procedure	Illustrations/Key Points/ Safety Practices

F. Taking Backsight on TP

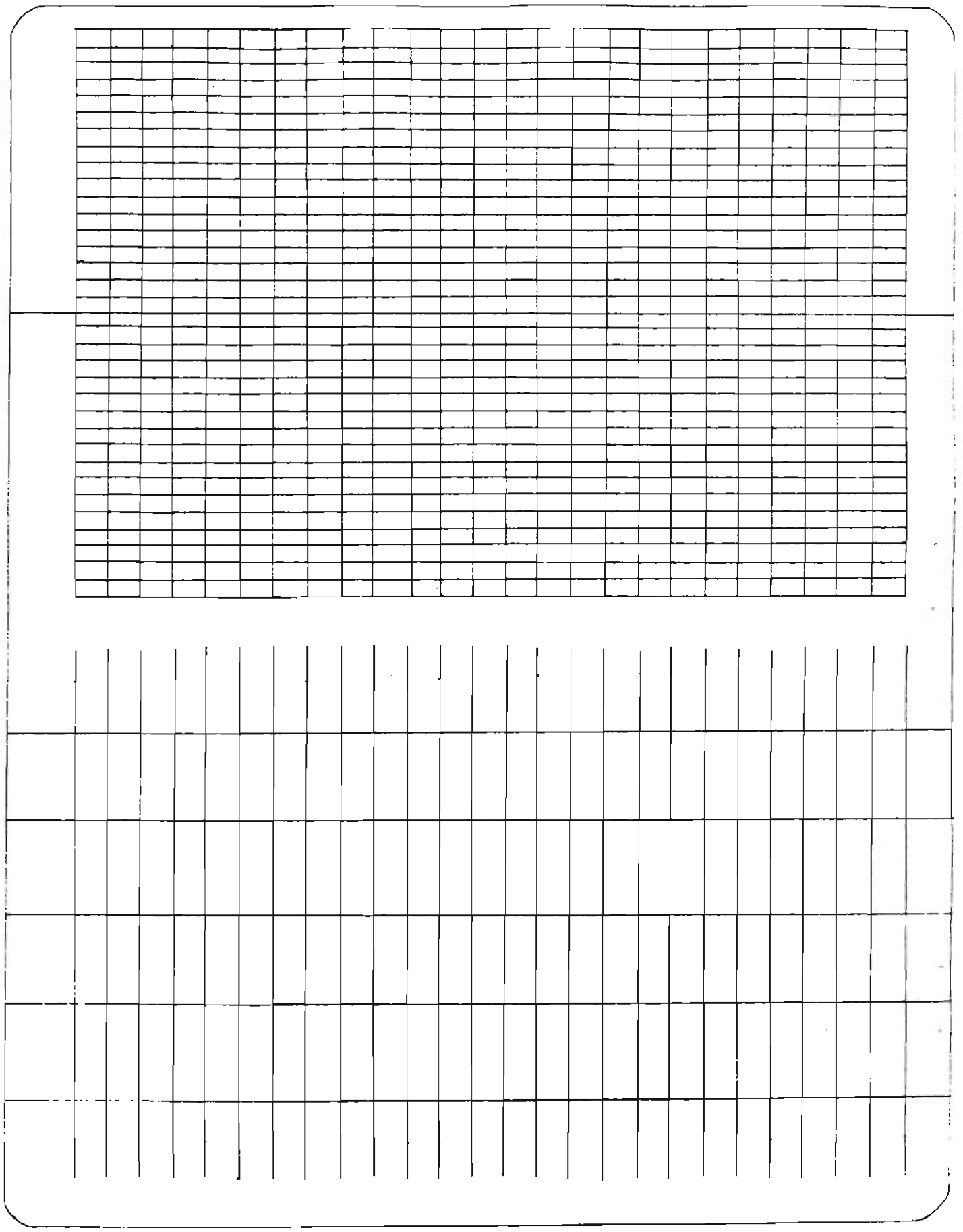
8. Take a BS on TP to establish the new Height of Instrument. Record the BS under the BS column of TP



9. Determine the new Height of Instrument by adding the BS to the elevation of the previous station.

BS + ELEVATION = HI

10. Repeat steps 1 through 9 until the end of the line to be surveyed is reached.



ACTIVITY NO. XIII - Laying Out Contours

A. Objectives

1. To develop a contour map using the grid system.

2. To develop skill in keeping accurate notes on leveling for contour mapping.

B. Introduction

Contour mapping assist agriculturalists in planning drainage patterns, cropping systems, and controlling soil erosion. These maps show surface elevation at various points throughout a parcel of land. Contour maps are also used by horticulturalists in planning and laying out landscapes. In this activity you will make a contour map of a land parcel.

C. Reference

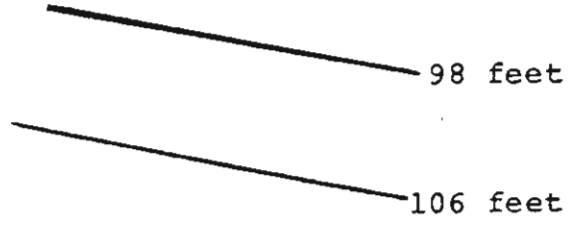
1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 64-70.

D. Questions for Study

1. What is a contour?

2. What is a contour interval?

3. What is the contour interval of the following two adjacent contour lines?

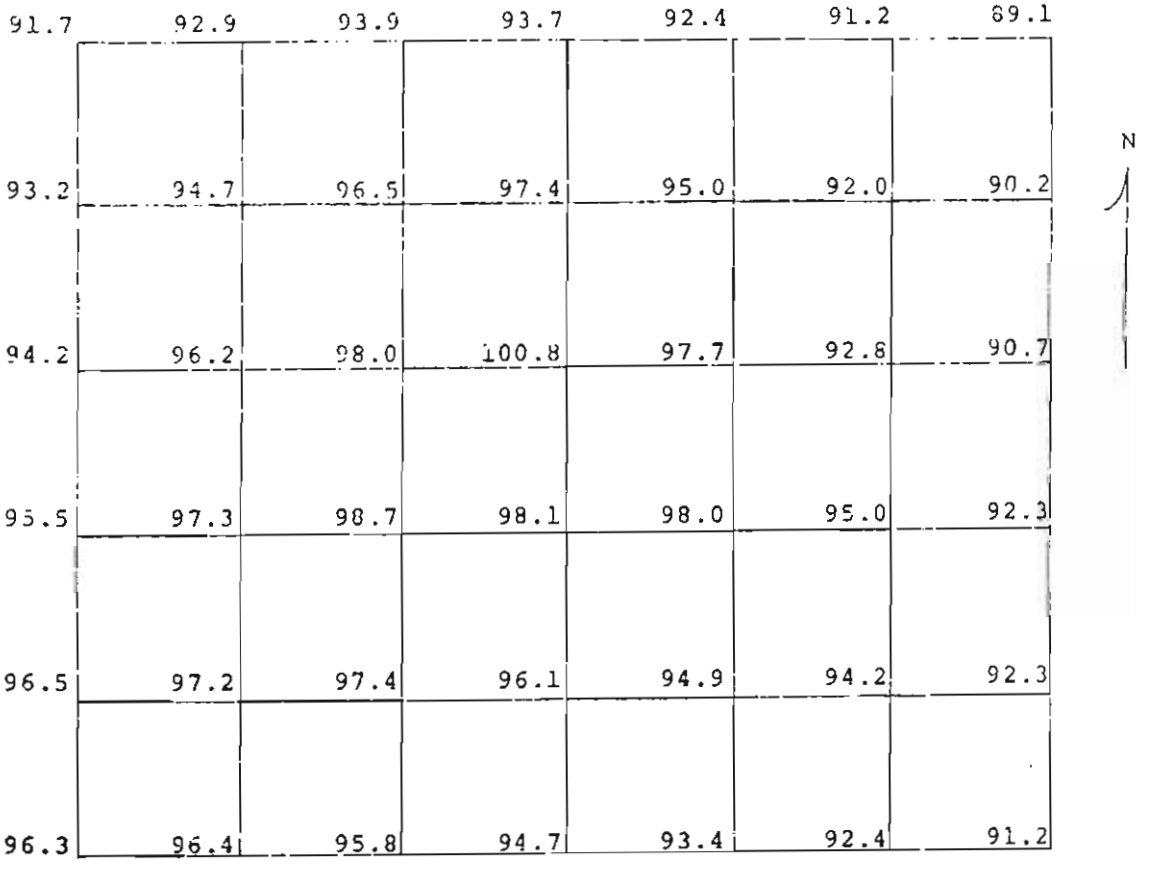


4. Contour lines on a map which are spaced closely together represent a surface having a _____ slope.

5. Contour lines on a map which are spaced far apart represent a surface having a _____ slope.

6. Draw a contour map of the area shown below and identify the following:

   a. Gully
   b. Levelest part of field
   c. Lowest point of field
   d. Highest point of field
   e. Ridge of field
   f. Area where slope is greatest
   g. Percent slope of the area where the slope is greatest.



Scale: 1 inch = 100 ft.

JOB OPERATION NO.XIII - Laying Out Contours

STUDENT INSTRUCTIONS

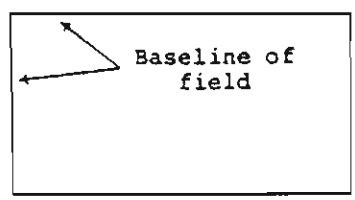
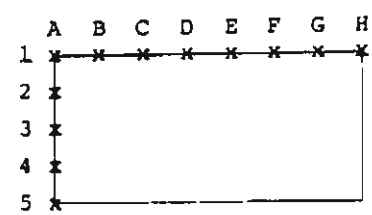
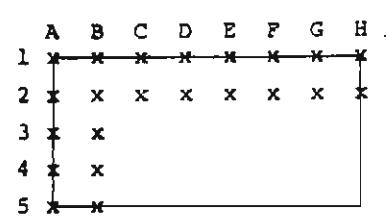
Follow the steps of procedure listed below to perform the contour mapping procedure.

Equipment:

-Tripod
-Leveling instrument
-Rod
-Hammer

Materials:

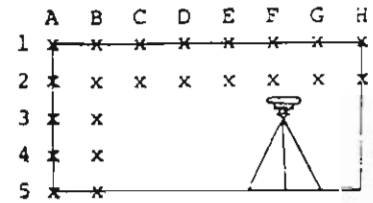
-Tall stakes (quantity varies with field size)

Steps of Procedure	Illustrations/Key Points/ Safety Practices
A. Establishing the Baseline	
1. Establish an east-west line and a north-south baseline as near as possible to two boundaries of the field to be contour mapped.	
B. Measuring Baseline Intervals	
2. Starting from the corner where the two baselines meet, measure with a steel tape at 100 foot intervals along each baseline.	
C. Placing Guide Stakes	
3. Drive tall stakes into the ground at each 100 foot interval. Each interval should be marked as shown in the illustration to the right.	
4. Drive a second line of stakes one grid interval distance (100 feet) in from the baseline.	

Steps of Procedure	Illustrations/Key Points Safety Practices

D. Setting Up Tripod Level

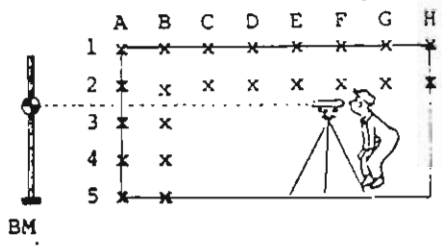
5. Set up the tripod level somewhere in the field where the entire field can be seen through the telescope tube.



E. Taking a Backsight

6. Take a Backsight on a Bench Mark or some other point of known elevation. If there is not a Bench Mark or other point of known elevation take a sighting on a permanent object and arbitrarily give it an elevation of 100 feet.

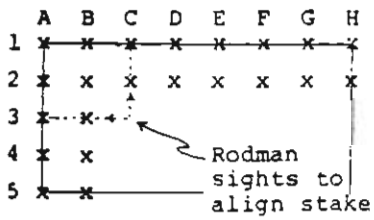
a. Rodman holds rod on Bench Mark with the rod face clearly visible to the instrument man.

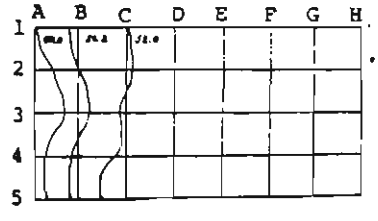


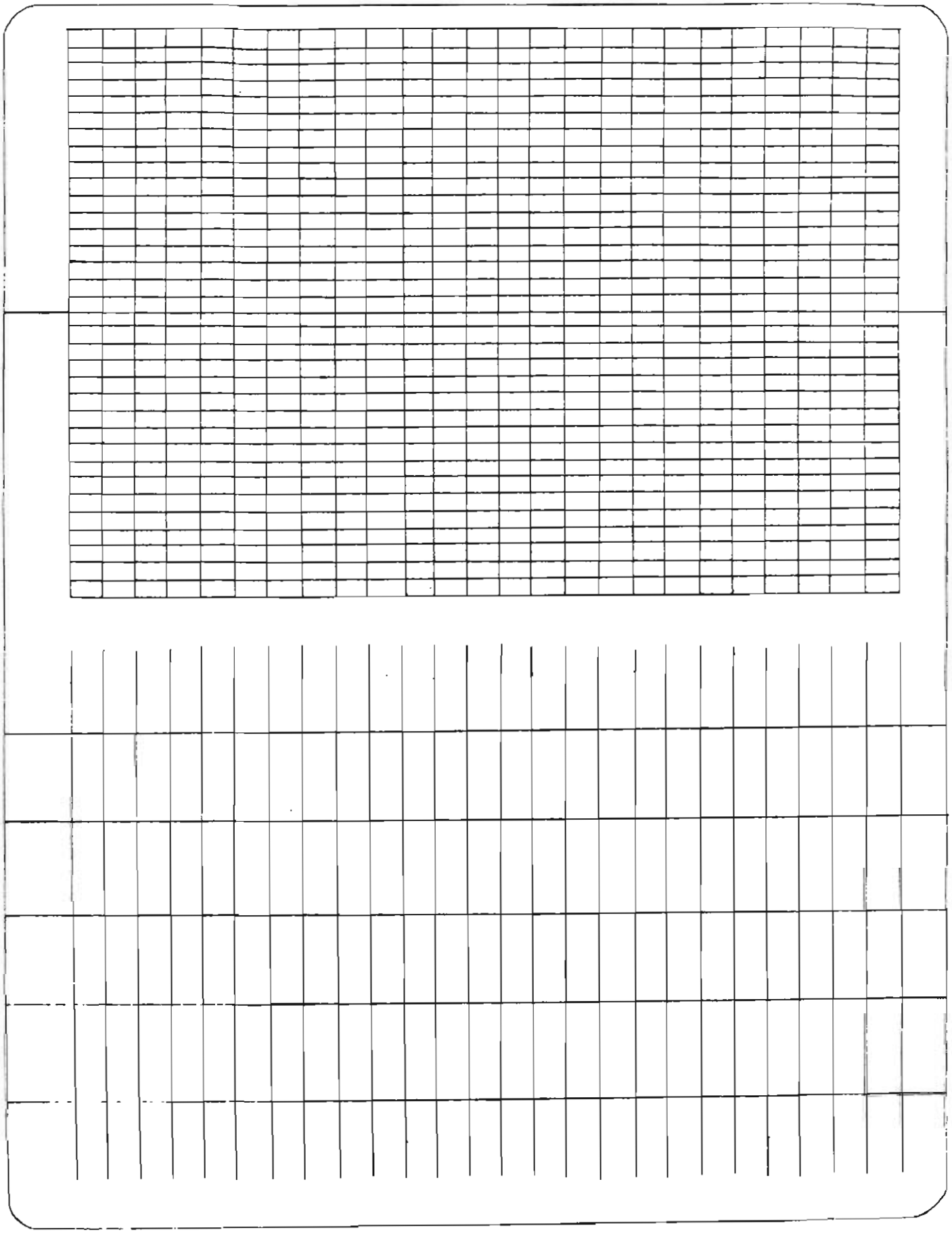
F. Taking a Foresight on Each Station

7. The rodman then moves to each stake or station where a rod reading is taken. Each station is identified by a combination of one letter and one number that corresponds to its location on the map. The elevations of the various stations are determined by profile leveling. Each rod reading taken is a Foresight and is entered under the FS column of each station. Complete a set of field notes on contour mapping. Use the field notebook page found on page 65.

a. The stations not identified by stakes can be located by the rod man "sighting in" his position by aligning appropriate pairs of stakes.



Steps of Procedure	Illustrations/Key Points/ Safety Practices
G. Drawing the Contour Map	
8. Draw a contour map of the field surveyed. (Example- Reference Unit, page 70)	a. Reproduce the grids on ten square graph paper. The scale should conform to one of those found on an engineer's scale. Show the elevation of each grid point on the map. Draw the elevation of each grid point on the map. Draw in contour lines, given in even values, with a contour interval of 1 foot. 



ACTIVITY NO. XIV - Determining Grades, Cuts & Fills

A. Objectives

1. To perform the grading operation.

2. To calculate cuts and fills on a land parcel for a given slope.

B. Introduction

A field that is not uniform in grade or slope will have an uneven distribution of water when irrigated. Water will accumulate in the low areas and result in decreased crop production. The agriculturalist in order to maintain maximum production must construct his fields to a specific degree of slope for drainage or movement of water across the field at a desired rate. It is the purpose of this activity to provide you the opportunity to determine cut and fills on a field of a given slope.

C. Reference

1. Student Reference, Leveling & Land Measurement Practices for Agriculture, February 1974, pp. 70-78.

D. Questions for Study

1. What is a grade or slope?

2. What is the percent slope of a field that falls 5 feet in 200 feet of grade?

3. What is the difference between a cut and a fill?

4. If the elevation of a field is 8 feet at a certain location and the land grading plan calls for an elevation of 8.5 feet at the point, a_____ of .5 feet is required.

JOB OPERATION NO. XIV - Grading Procedure

STUDENT INSTRUCTIONS

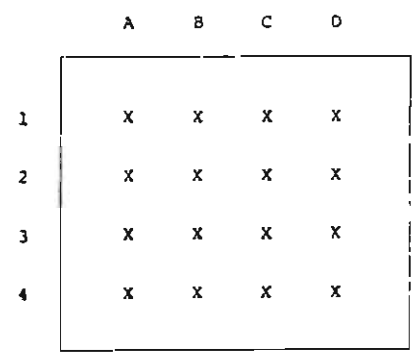
Carefully follow the steps of procedure listed below to perform the grading operation.

Equipment:

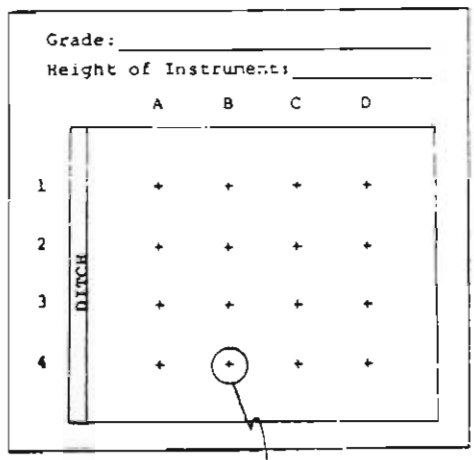
-Tripod
-Leveling instrument
-Rod
-Hammer

Materials:

-Wooden stakes
-Pencil
-Field notebook

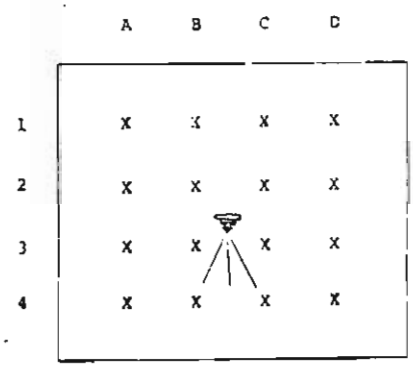
Steps of Procedure	Illustrations/Key Points/ Safety Practices
A. Laying Out Contour Grid on A Field	
1. Lay out a contour development grid on the field to be graded. Refer to Activity No. XIII for Steps of Procedure. A field notebook page is provided on page 73 to record your findings.	a. Stakes are placed at each station. Distance or interval between stakes is equal to 100 feet. 
2. Make a field map similar to the one shown in Reference Unit IV, Figure 4-23, page 76.	a. The number of stations depends upon the field size. If the field is larger than the one in the illustration below there will be more stations. (con't)

Steps of Procedure	Illustrations/Key Points/ Safety Practices
	a. (Con't)



B. Setting up Tripod Level

3. Set up the leveling instrument where the entire field can be seen through the telescope tube.

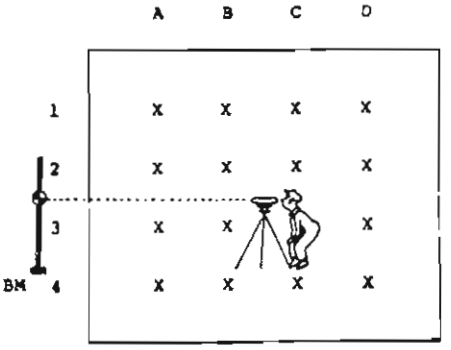


Steps of Procedure	Illustrations/Key Points/ Safety Practices

C. Taking Backsight

4. Take a Backsight on a Bench Mark or some other point of known elevation. Enter the Height of Instrument on the map. BM + BS = Height of Instrument.

a. If there is no Bench Mark or other point of known elevation take a sighting on a permanent object and arbitrarily give it an elevation of 100 feet.



D. Taking Foresight on Each Station

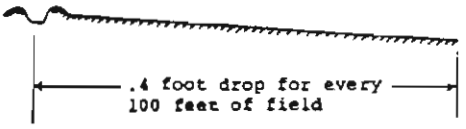
5. Take a Foresight on each station to determine its elevation. Enter the elevation of each station on the map on a field notebook. page found on page 73.

a. To determine the elevation of each station subtract the rod reading (Foresight) from the Height of Instrument.

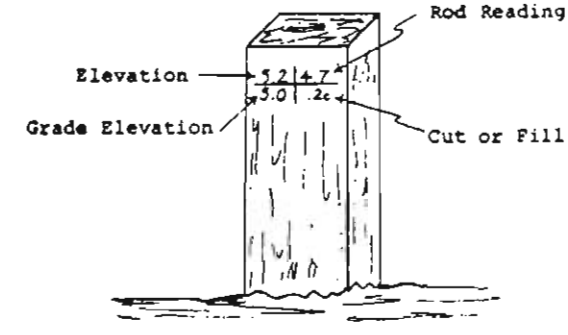
HI - FS = ELEVATION

b. A slope of .4% will be used. .4% is a drop of .4 feet for every 100 ft. of field starting from the ditch end.

Ditch



Steps of Procedure	Illustrations/Key Points/ Safety Practices
E. Calculating Average Elevation	
6. Calculate the average elevation of the field. Place the average elevation in the center of the map.	a. This is done by summing all the station elevations and dividing by the number of stations. $\frac{\text{Sum of all elevations}}{\text{Number of Stations}} = \text{Average Elevation}$
F. Calculating Grade Elevation	
7. Determine the grade elevation of each station starting from the center of the field. Record on map.	a. Grade elevations for stations 50 feet from the center of the field are determined by adding or subtracting a .2 ft. to the average elevation. The slope is .4 feet per 100 feet but since we are concerned with a distance of 50 feet to the nearest station the slope will be half that for 100 feet or .2 feet. Average Elevation + .2 = Grade elevation of stations 50 ft. west of center. (In the direction of the ditch) Average Elevation - .2 = Grade elevation 50 ft. east of center. (In the direction of the tail end of the field) b. For stations west of the center, the slope per 100 feet will be added to the elevation, and subtract for those east of the center Grade Elevation $\pm$ or .4 = Grade Elevation

Steps of Procedure	Illustrations/Key Points/ Safety Practices
G. Calculating Cuts and Fills	
8. Determine cuts and fills at each station. Record on map.	a. This is done by subtracting the grade elevation at each station. If the elevation is larger than the grade, it will be a cut. If the elevation is smaller than the grade, it will be a fill. Grade Elevation - Elevation = Cut or Fill
H. Marking Stakes at Each Station	
9. Mark the rod reading elevation, grade elevation, and cut or fill taken at each station on the upper part of each stake.	
I. Checking Cut/Fill Balance	
10. Check the balance between cuts and fills.	a. An excess of cut over fill in a ratio of approximately 1.2 to 1.6 is necessary to allow for compaction and equipment operator errors. To check this ratio, the cuts and fills are summed. The cut-fill ratio is determined by the following formula: $\frac{\text{Sum or Cuts}}{\text{Sum of Fills}} = \text{cut/fill ratio}$

Steps of Procedure	Illustrations/Key Points Safety Practices
I. Checking Cut/Fill Balance (Con't)	
	b. If the cut/fill ratio calculated is between 1.2 and 1.6 there will be enough earth from the cuts to fill the lower area of the field. If a satisfactory ratio was not calculated, all grade elevations would have to be lowered by .1 and cut and fills recalculated.
J. Calculating Earth Moved	
11. Calculate the total number of cubic yards of earth to be moved in order to level the field.	
a. $\frac{\text{Cut/fill ratio(ft) x 100 ft. x 100 ft.}}{27\ \text{yds/ft}^3} =$ cubic yds. to be moved.