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

1. Explain the operating principles of irrigation systems.
2. Compare and contrast the irrigation methods used in agriculture.
3. Demonstrate how to calibrate and maintain irrigation systems.
4. Explain and perform the maintenance procedures of irrigation systems.

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

- E-unit(s) corresponding to this lesson plan. CAERT, Inc. [http://www.mycaert.com](http://www.mycaert.com).
Equipment, Tools, Supplies, and Facilities

- Overhead or PowerPoint projector
- Visual(s) from accompanying master(s)
- Copies of sample test, lab sheet(s), and/or other items designed for duplication
- Materials listed on duplicated items
- Computers with printers and Internet access
- Classroom resource and reference materials

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

- available water
- border-strip irrigation
- center-pivot irrigation
- chemigation
- evapotranspiration
- field capacity
- furrow irrigation
- permanent wilting point
- sprinkler irrigation
- subsurface irrigation
- surface irrigation
- water efficiency
- water-application efficiency
- water-conveyance efficiency
- water-use efficiency
- wheel-move irrigation

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.

Bring in two house plants. One should have dry soil, and the other should have wet soil. Hold up each, and have students say what they notice about the soil. As they figure out that one is very dry, ask: What happens if I do not water the soil that is dry? Will the plant die? What happens to field crops when they do not receive enough water? Will they die? What can we do about this?

Show a picture of an irrigation system in action. Ask them how it works. Finally, ask them to share what they know about large irrigation systems. Perhaps they have a family member or friend who has an irrigation system.
Objective 1: Explain the operating principles of irrigation systems.

Anticipated Problem: What are the operating principles of irrigation systems?

I. Irrigation water has been used for centuries. Human dependence on water increases as time passes. Agriculture is one area where this is true. Plants need water to grow, but the soil holds a limited amount at one time. Too much water can be as harmful as too little water.

A. Modern power sources, with the use of deep well pumps and underground water reservoirs, have provided a major contribution to irrigation water.

B. As a natural resource, water is precious and limited. Therefore, it is imperative to use water as efficiently as possible.

C. Irrigation water is a major source of water for many field crops and vegetables, especially those grown on sandy soils. Therefore, it is necessary to ensure that irrigation systems are designed to use just the proper amount of water at various times.

D. As crops grow, they are continuously using water. The water use varies with crops as they grow throughout the growing season.

E. Evapotranspiration is moisture lost from the plant due to evaporation and transpiration. Water loss is huge when evapotranspiration occurs.

1. To make maximum use of available water sources, the irrigator must fully understand how much water (on average) falls in the form of rain. Knowing this will assist in determining whether irrigation water is needed.

2. Rainfall needs to be considered when determining how much moisture crops need. However, not all rainfall is effective—just the portion that contributes to evapotranspiration.

F. In addition to rainfall, the soil types being irrigated or wetted from rain are just as important. How much water soils can hold and drain is considered extremely important for optimal plant uptake.

1. If too much water is distributed at one time, leaching of leachates, minerals, and nutrients may occur. Too little water can cause severe wilting in plants. There must be some amount of water retained in the soil water reservoir so it is available for plant uptake at all times.

2. Irrigation water should be scheduled so the water in the reservoir does not become too low. Therefore, the water-holding capacity of the soil water reservoir must be known and carefully monitored.
3. There are ways to understand and monitor what the soil reservoir is able to retain. For instance, **field capacity** is a situation in which the soil is wetted and allowed to drain for a couple days. The moisture adhering to the soil left after natural soil drainage is said to be at field capacity.

4. The **permanent wilting point** is a situation in which the lower limit of water is available to plants. Therefore, water molecules are very tightly held to the soil particles and are virtually unavailable to plants.

5. The difference between field capacity water and permanent wilting point is the **available water**—water that plants may consume.

G. Irrigation systems include three basic scheduling methods. Each varies in terms of its output of water and actual operations.

1. Soil water can be measured by using a soil probe, screw auger, and/or a shovel and by estimating how much water is available to plant roots. Digging up a small area of soil randomly throughout a field will help determine this.

2. Instruments (e.g., tensiometers and electrical resistance blocks) may be used by inserting them in the soil to be checked and then taking readings at various intervals.

3. Plants should be observed to determine if they are under stress from lack of moisture.

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**Teaching Strategy:** Prior to beginning this lesson, have students (in groups of three) plant two or three corn seeds in 6-inch pots. Each group should have three pots of corn. As the corn begins to grow, have students monitor the moisture levels by using a moisture probe. (These can be purchased at a dollar store.) As they begin their growth, alter the amount of water given to each pot of corn. For example, give one pot optimal water, and allow it to reach field capacity. To the second pot, give a smaller amount. Give no water to the third plant. Have students determine the water moisture level, field capacity, and permanent wilting point. Use VM–A through VM–E during a class discussion.

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**Objective 2:** Compare and contrast the irrigation methods used in agriculture.

**Anticipated Problem:** How are the irrigation methods used in agriculture alike and different?

II. The use of irrigation water takes a lot of planning and monitoring throughout the growing season. Irrigation water may be applied in different ways and methods.

A. **Subsurface irrigation** is a system that waters plants and their roots lower in the soil profile.

B. **Surface irrigation** is a system in which the soil surface is flooded as water is released from canals, streams, or piping systems.

   1. Surface irrigation is best on moderately permeable soils and on slightly sloping or gently sloping land.
2. Piped in water comes from canals, lakes, or streams and uses gravity to carry it to farm fields.

3. **Border-strip irrigation** is a system in which the entire surface of a field is covered in water.
   a. This system is used when fields are divided into smaller areas by the use of low dykes.
   b. Since the surface is flooded, some loss of water occurs due to evapotranspiration.

C. **Furrow irrigation** is a situation in which water is distributed through furrows with the crops being grown between the furrows.
   1. Furrow irrigation is best for row crops being grown.
   2. In furrow irrigation, evapotranspiration is not as much an issue because water is distributed in the furrow, not flooded on the surface.

D. **Sprinkler irrigation** is a system in which water is pumped under pressure through pipes to sprinklers located on a long boom and then sprayed out in a circular pattern.
   1. This system may be used where the soil is too permeable or too impermeable or if the ground is not level.
   2. **Chemigation** is a situation in which sprinkler systems are used in conjunction with fertilizers or herbicides. The fertilizers and herbicides are added to the main water source and are mixed with the irrigation water. It is a good and economical way to add these inputs.

E. **Center-pivot irrigation** is a system that operates on a central pivot point with the watering line elevated several feet above the growing crops.
   1. As this system operates, the line slowly turns around the pivot point.
   2. This method is the least laborious method of all the irrigation systems used in agriculture.

F. **Wheel-move irrigation** is a system that has a line of sprinklers mounted on the wheels of the system and rolls slowly down the field until it reaches the end of an attached hose.

G. The trickle or drip irrigation uses hard plastic pipes on the ground that run parallel with the crop row, with special-sized emitters evenly spaced up and down the pipe.
   1. The emitters drip or trickle water through them and onto the soil (at controlled amounts) at the soil surface.
   2. This system is effective. After several operations, however, the emitters may become plugged. Then the water is not emitted at a proper rate or at all.

H. Using irrigation systems is a wise investment if the area to be watered is dry and if the soil types are conducive to extensive irrigating. A wise practice is to fully understand the needs of the crop and the soil properties in order to use the appropriate irrigation system.
**Teaching Strategy:** At the beginning of this unit, write each irrigation system type on a note card. Place students in groups of three. Each group may draw one note card. Students are to investigate the irrigation system that they chose and provide a description. In addition, they must explain how it is used, where it is used, and what types of crops the system irrigates. Each group should provide a detailed report to the class. Summarize by asking informal questions about each system. Use VM–F through VM–I during class discussions to illustrate points.

**Objective 3:** Demonstrate how to calibrate and maintain irrigation systems.

**Anticipated Problem:** What are the steps in calibrating and maintaining irrigation systems?

III. Irrigating crops is beneficial when planned and used in an efficient crop management program. Each irrigation system is designed differently and must be fully understood for proper operation. Calibration and maintenance of irrigation focuses on the overall performance or efficiency of a system. **Water efficiency,** or water output divided by water input, may include various water concepts and is used in calibration of the various irrigation systems.

A. **Water-conveyance efficiency** is a situation in which the water output is delivered by a distribution system, and the input is the water introduced into the distribution system.

B. **Water-application efficiency** is the output of the water being stored in the root zone by irrigation, and the input is the water being delivered to the crops being irrigated.

C. **Water-use efficiency** is a situation in which the output is the water being beneficially used, and the input is the water delivered to be used as irrigation water.

D. When calibrating and maintaining irrigations systems, it is necessary to consider:
   1. Using the most water-efficient system practical to each cropping system and uniform in water distribution
   2. Leveling and designing land to reuse any excess water
   3. Scheduling the irrigation water system to water crops when they actually need it, not on a “time” schedule

**Teaching Strategy:** Have students practice measuring water input and output by using a garden hose with a sprinkler system and by observing the efficiency of the sprinkler. Find several irrigation systems on the Internet, and have a discussion as to the input and output water for each system. Ask questions about efficiency. Use VM–J.
Objective 4: Explain and perform the maintenance procedures of irrigation systems.

Anticipated Problem: What are the maintenance procedures of irrigation systems?

IV. It is essential to always follow the manufacturer’s recommendations found in the owner’s manual for the irrigation system purchased. The operator’s manual provides the best use and maintenance of the irrigation system and provides a listing of parts needed if breakdowns occur.

A. Water pollution should be avoided at all costs, and the most efficient system should be used when irrigating crops.

B. It is important to use the best method of irrigation that preserves or saves on water usage. Water should never be wasted. For pump systems, saving water means decreased energy costs.

C. The steps in the operating manual should be followed for all maintenance procedures so water is always used efficiently. If there is sand in soils, there could be sand at the nozzle openings on some irrigation systems. Knowing this in advance will help in keeping nozzles cleaned properly. All systems should contain devices to measure and control water flow.

Teaching Strategy: After reviewing an operator’s manual for a specific irrigation system, take students to the agriculture laboratory (shop) where the irrigation system is located. Use the manual as a guide, and have students find the various parts of the system and point them out. Ask students to locate nozzles and hook up the system to a hose. Turn on the water, and have students check the output from the nozzles. Ask the following: Are the nozzles efficiently emitting water? Why or why not? Have them use the operating manual to compare the patterns of water being emitted. As a class, conduct a final maintenance check on the irrigation system, and summarize the various maintenance items with students. Assign LS–A.

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 perspective. Questions at the ends of chapters may be included in the Review/Summary.

Application. Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

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 activities. A sample written test is provided.
Answers to Sample Test:

Part One: Matching
1. d  
2. b  
3. e  
4. c  
5. j  
6. f  
7. g  
8. h  
9. a  
10. i

Part Two: Completion
1. water efficiency  
2. Surface irrigation  
3. water-conveyance efficiency  
4. border-strip irrigation  
5. furrow irrigation  
6. subsurface irrigation

Part Three: Multiple Choice
1. b  
2. d  
3. c  
4. a  
5. b  
6. d  
7. b  
8. c
## Irrigation Systems

### Part One: Matching

*Instructions: Match the term with the correct definition.*

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. available water</td>
<td>1. A situation in which the lower limit of water is available to plants</td>
</tr>
<tr>
<td>b. evapotranspiration</td>
<td>2. Moisture lost from the plant due to evaporation and transpiration</td>
</tr>
<tr>
<td>c. field capacity</td>
<td>3. A situation in which sprinkler systems are used in conjunction with fertilizers or herbicides</td>
</tr>
<tr>
<td>d. permanent wilting point</td>
<td>4. A situation in which the soil is wetted and allowed to drain for a couple days</td>
</tr>
<tr>
<td>e. chemigation</td>
<td>5. A system in which water is pumped under pressure through pipes to sprinklers located on a long boom and then sprayed out in a circular pattern</td>
</tr>
<tr>
<td>f. furrow irrigation</td>
<td>6. A situation in which water is distributed through furrows with the crops being grown between the furrows</td>
</tr>
<tr>
<td>g. surface irrigation</td>
<td>7. A system in which the soil surface is flooded as water is released from canals, streams, or piping systems</td>
</tr>
<tr>
<td>h. center-pivot irrigation</td>
<td>8. A system that operates on a central pivot point with the watering line elevated several feet above the growing crops</td>
</tr>
<tr>
<td>i. border-strip irrigation</td>
<td>9. Water that plants may consume</td>
</tr>
<tr>
<td>j. sprinkler irrigation</td>
<td>10. A system in which the entire surface of a field is covered in water</td>
</tr>
</tbody>
</table>
Part Two: Completion

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

1. The purpose of _________________________ is water output divided by water input.

2. _________________________ is an irrigation system in which the soil is flooded as water is released from canals, streams, or piping systems.

3. When the output of water is delivered by a distribution system and the input water is introduced into the distribution system, the concept is _________________________.

4. The _________________________ system is used when fields are divided into smaller areas by the use of low dykes.

5. The type of irrigation considered best for row crops is _________________________.

6. The _________________________ system irrigates plants and their roots lower in the soil profile.

Part Three: Multiple Choice

Instructions: Circle the letter of the correct answer.

1. When _____ occurs, moisture is lost from the plant due to evaporation and transpiration.
   a. evaporative water
   b. evapotranspiration
   c. transpiration water
   d. unused water

2. _____ is a situation in which sprinkler systems are used in conjunction with fertilizers or herbicides.
   a. Spot fertilizer
   b. Irrigation water
   c. Prairie fertilizer
   d. Chemigation

3. In _____, the output is the water being beneficially used, and the input is the water delivered to be used as irrigation water.
   a. water efficiency
   b. water-application efficiency
   c. water-use efficiency
   d. water-conveyance efficiency
4. In the _____ irrigation system, a line of sprinklers are mounted on wheels and rolled slowly down the field until it reaches the end of an attached hose.
   a. wheel-move
   b. wheel-might
   c. wheel-carry
   d. wheel-tip

5. The _____ method of irrigation is the least labor intense of all irrigation systems.
   a. border-strip
   b. center-pivot
   c. sprinkler
   d. furrow

6. The _____ method of irrigation is distributed through furrows with the crops grown between the rows.
   a. sprinkler
   b. trickle
   c. drip
   d. furrow

7. The best way to maintain irrigation systems is to _____.
   a. ask a neighbor who has the same system
   b. read and follow the operator’s manual
   c. check the tires on the system
   d. test it out first

8. _____ is water that plants may consume.
   a. Permanent wilt
   b. Air
   c. Available water
   d. Soft water
OPERATING PRINCIPLES OF IRRIGATION SYSTEMS

- Evapotranspiration
- Field capacity
- Permanent wilting point
- Available water
TYPES OF IRRIGATION SYSTEMS

♦ Subsurface
♦ Surface
♦ Border strip
♦ Furrow
♦ Sprinkler
♦ Center-pivot
♦ Wheel-move
CALIBRATION OF IRRIGATION SYSTEMS

- Water-conveyance efficiency
- Water-application efficiency
- Water-use efficiency
TESTING SOIL MOISTURE: A TENSIOMETER IN VEGETABLES
SPRINKLER SYSTEM IRRIGATING A VEGETABLE FIELD
AERIAL VIEW OF FARMLAND AND CROP CIRCLES CREATED BY CENTER-PIVOT SYSTEMS
WHEEL-MOVE IRRIGATION IN ACTION ON LARGE ACREAGES
CALIBRATING IRRIGATORS PRODUCES OPTIMAL WATER OUTPUT
Exploring Irrigation Systems

Purpose

The purpose of this activity is to explore the types of irrigation systems used in agriculture.

Objective

Explore the various types of irrigation systems, and create a data table of the various irrigators used in agriculture.

Materials

- computer or other source with Internet (e.g., tablet or mobile device)
- agriculture magazines
- graph paper or lined paper
- writing utensil
- ruler
- index cards
- printer
- scissors
- glue

Procedure

1. Search online and in agriculture magazines for pictures of the various irrigation systems discussed.
2. Print and/or cut out the pictures. Glue them on the index cards (one picture per card). Write the title of each picture on the card.
3. On the graph or lined paper, create a data table (using the ruler). Write each irrigation system on the left side of the data table. After each, provide a description of the irrigator next to its name. Create a column in which the total water output may be recorded for each irrigation system. Use the index cards as study aids to learn how to identify each system.