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PRECISION
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AGRICULTURAL MECHANICS

Fundamentals and Applications

7TH edition



Ray V. Herren



AGRICULTURAL MECHANICS

Fundamentals and Applications

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Ray V. Herren, Ed.D.



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PREFACE

Agricultural mechanics is one of the most widely taught courses in agricultural education programs. It is taught in all 50 states and is considered to be among the most useful courses taught. Like any applied science, this discipline is constantly changing as new advances are made and new techniques and equipment are put into use. *Agricultural Mechanics: Fundamentals and Applications* has for many years been a standard text for students studying agricultural mechanics. It grew out of the need for an easy-to-read, easy-to-understand, and highly illustrated text on modern agricultural mechanics for high school and post-secondary programs. This edition addresses the specific needs of students enrolled in agriscience, production agriculture, ornamental horticulture, agribusiness, agricultural mechanics, and natural resources programs. All of these areas require basic knowledge and skills in mechanics to succeed in a career path. The text starts with very basic and general information, such as career opportunities, and then provides instruction on basic mechanical skills and applications.

This seventh edition focuses on additional technical information, as needed, throughout. The text is consistent in format, easy to use for individualized instruction, easy to teach from, and simple for

substitute teachers. It also provides easy methods to assess student progress. Each unit is part of a section, and each includes (1) a statement of objective, (2) competencies to be developed, (3) a list of new terms, (4) a materials list, (5) highly illustrated text material, (6) student activities, and (7) self-evaluation. This edition contains updated relevant websites that provide more information on the unit topics. All new terms are carefully defined in the text as well as in the glossary.

The appendices include 40 project plans with bills of materials and construction procedures. The projects were carefully selected to match the skills covered in the text. Plans include some projects that have become classics in the field, some that cover targeted enterprises, and some that are new and innovative. The projects were also chosen because they are used in high school agriculture/agribusiness, agriscience, or related programs.

The appendices also include 36 tables containing information for estimating, planning, selecting, purchasing, and building in agricultural mechanics. The project plans, tables, glossary, and index provide unique reference materials that, for many users, are alone worth the price of the text.

AGRICULTURAL MECHANICS

New and Enhanced Content for Seventh Edition

**PRECISION
EXAMS**

The *Precision Exam Edition of Agricultural Mechanics: Fundamentals and Applications, 7E* combines current top-notch content with new information aligned to Precision Exams' *Agricultural Systems Technology I* exam, part of the *Agriculture, Food and Natural Resources* Career Cluster. The *Agriculture, Food and Natural Resources* pathway connects industry with skills taught in the classroom to help students successfully transition from high school to college and/or career. For more information on how to administer the *Agricultural Systems Technology I* exam or any of the 170+ exams available to your students, contact your local NGL/Cengage Sales Consultant.

Features that remain in this enhanced text, and continue to engage and educate students, include the following:

- Updated statistics dealing with agricultural mechanics.
- Expanded coverage of safety using power hand tools, stationary power equipment, and other areas.
- Updated Relevant Websites at the end of each unit provide clearer search information in the event web links change or become out of date.
- Integrates agricultural mechanization with plant, animal, and environmental sciences to provide students with a broad view of the world of agriculture.
- Every unit combines theory with practice.
- Mathematical skill development is emphasized throughout.
- Each unit has been updated to include the latest information on agricultural mechanics.
- Over 350 new and modernized illustrations and photographs offer improved detail and modern equipment related to small engines and power mechanics, plumbing, planning and constructing agricultural structures, and more. New photos depict actual high school students working in the agricultural mechanics workshop.

UNIT SPECIFIC UPDATES

Units 1 through 3

- Many of the photos in these units have been replaced with updated images that depict modern equipment, practices, and professionals in the field of agricultural mechanics.

Unit 4: Personal Safety in Agricultural Mechanics

- New photographs related to workplace safety, including guards or shields on moving parts, safety switches, first aid stations, radiation hazards, wearing eye protection, coveralls, and work boots

Unit 5: Reducing Hazards in Agricultural Mechanics

- New images related to electrical fires, fire extinguisher safety, and fire classification

Unit 6: Shop Cleanup and Organization

- New photos of a clean work shop and a dust collector/dust collection ducts

Unit 7: Hand Tools, Fasteners, and Hardware

- No changes aside from Relevant Websites

Unit 8: Layout Tools and Procedures

- New images of layout tools, stainless steel tools, aluminum tools, plastic tools
- New image showing how patterns can be made from fiber board or card stock

- New images illustrating CAD (computer-aided design) and 3-dimensional designs

Unit 9: Selecting, Cutting, and Shaping Wood

- New images of green lumber, rough lumber, a kerf, and files
- New images of drying lumber (stacking to air dry and drying in kilns)

Unit 10: Fastening Wood

- Expanded discussion of using biscuit joints
- New photo of deck screws
- New photo and information on lag screws

Unit 11: Finishing Wood

- Updates related to types of fillers and wood-finishing products
- New photos of proper sanding technique, applying clear finishes, applying an oil finish, applying polyurethane, applying lacquer, and applying penetrating wood stains

Unit 12: Identifying, Marking, Cutting, and Bending Metal

- New images of structural steel, iron, cast iron, wrought iron, and the carbon content of steel, stainless steel, aluminum, copper, and lead

Unit 13: Fastening Metal

- New image and information on taps and dies
- Updated images of soldering

Unit 14: Portable Power Tools

- New photos of portable power tools (cordless drill, handsaw, belt sander, finishing sander, saber saw, reciprocating saw) and a ground-fault circuit

Unit 15: Woodworking with Power Machines

- New photos related to safe operation of machinery using safety guards, eye and hearing protection; using a bandsaw, jigsaw blades, a contractor's saw, table saw blade guard, and anti-kickback

device; blades with carbide tips; using a radial-arm saw, a miter saw, a sliding compound miter saw, proper standing position when feeding a board into a planer, etc.

- New information related to a newer type of locking table saw that protects against finger/hand injuries
- Updated safety information related to sawing and cross cutting
- New paragraph and photo illustrating careless use of a table saw

Unit 16: Adjusting and Maintaining Power Woodworking Equipment

- No changes aside from Relevant Websites

Unit 17: Metalworking with Power Machines

- New photos of a grinding wheel, wire wheels, a tool rest, and an abrasive cutoff saw
- New safety information and photo related to grinders

Unit 18: Sketching and Drawing Projects

- New images providing updated examples of sketching and drawing projects

Units 19 and 20

- No changes aside from Relevant Websites

Unit 21: Repairing and Reconditioning Tools

- New images of various tools, including types of farm and household tools, metal tools, a mushroomed head, a wedge, an improperly installed handle, and a split handle

Unit 22: Sharpening Tools

- New images of a hand stone, bench stones, sharpening a rotary mower blade
- New information and an image of an overheated tool with damaged temper

- New information and images related to various types of knife sharpeners
- New image depicting the last step in sharpening a wood chisel (lay the blade on its back and remove the wire edge)
- New information and images depicting the differences between a dull drill bit and a sharp drill bit

Unit 23: Using Gas Welding Equipment

- New information about acetylene gas including precautions when using

Unit 24: Cutting with Oxyfuels and Other Gases

- New images related to cutting torches and the brazing process
- Updated photo of plasma arc cutting

Unit 25: Brazing and Welding with Oxyacetylene

- No changes aside from Relevant Websites

Unit 26: Selecting and Using Arc Welding Equipment

- New photos of a welding machine
- New information about proper storage of electrodes along with images of corroded electrodes

Unit 27: Arc Welding Mild Steel and GMAW/GTAW Welding

- New photo related to proper positioning of an electrode
- Updated photos and images related to welding equipment and personal protective equipment
- New photos of plasma arc welding and automated/robotic welding

Unit 28: Preparing Wood and Metal for Painting

- New photo related to primer
- Updated photos of using wood preservatives and removing loose paint

Unit 29: Selecting and Applying Painting Materials

- Updated information about enamels including interior and exterior enamels along with a new photo
- Updated information about paint color and color matching, including a new photo
- Expanded information about different types of paintbrushes and when to use each kind, including a new photo
- Updated photos depicting painting with brushes, applying paint with a roller, and an HVLP spray gun

Unit 30: Fundamentals of Small Engines

- New photos of early engines powered by steam; use of eye and ear protection and proper shoes when using small engine equipment
- New images of a modern two-cycle engine, piston rings, and a type of governor
- New information about gasoline additives
- New information and images related to setting the gap using a spark plug gauge when replacing spark plugs

Unit 31: Small Engine Maintenance and Repair

- Minor updates related to additives and gasoline volatility
- New photos of spark plugs—one in good condition and one in need of replacement; setting the gap using a spark plug gauge
- New photo and reference to lubricating linkages
- Updated illustrations throughout this unit better depicting changing oil, the flywheel key, pulling a flywheel, checking valve stem clearance, and other tasks related to small engine maintenance and repair
- New photo and information related to OHC (overhead cam)

Unit 32: Diesel Engines and Tractor Maintenance

- New photos of a diesel engine; inventor Rudolf Diesel; modern diesel engines; checking oil; a hydrometer; a dirty radiator/grill to illustrate importance of regular cleaning; proper

maintenance of tires (tire gauge); cleaning grease fittings; and batteries

- New illustration of an injector pump
- Updated illustrations of oil flow through an oil filter; the function of the radiator; properly adjusting tension on drive belt
- New information about air filtering systems in the fuel system including a new series of photos related to cleaning a modern dry filter
- New photos related to hydraulic system maintenance including use of a dipstick to monitor fluid levels; servicing fluid filters; and disconnecting quick couplings

Unit 33: Electrical Principles and Wiring Materials

- Expanded information and a new photo related to fluorescent lighting
- Updated images illustrating magnetism, including a new photo of a strong magnet
- New photos of the commutator and the armature, and a modern electric motor
- New photos of nonmetallic sheathed cable, armored cable, and conduit

Unit 34: Installing Branch Circuits

- New photos related to new work installations; wiring boxes; wire nuts; using a wire stripper; connecting wire to a fixture

Unit 35: Electronics in Agriculture

- Updated photos of modern electronic devices; resistors; analog and digital meters; an oscilloscope; integrated circuit packages; water analysis equipment; diode packages; and microcomputers

Unit 36: Electric Motors, Drives, and Controls

- New image of a modern electric motor
- Updated illustrations depicting a power generation and distribution system and the movement of electrical current from the local transformer to a building's distribution panel

Unit 37: Plumbing

- Most illustrations in this unit updated to modernize the fixtures and equipment shown, including the steps for soldering or sweating copper tubing, the steps involved in cementing plastic pipe, plastic vent and drain systems, common pipe fittings and valves, parts of a washer-type faucet, and parts of float valve and flush valve assemblies
- New and updated photos depicting a pipe wrench and pipe vise; a tube cutter; using a flaring tool; and tools used for cutting plastic pipe

Unit 38: Irrigation Technology

- Several new illustrations including updated depictions of irrigation wells and plant rooting pattern and moisture sensor placement

Unit 39: Hydraulic, Pneumatic, and Robotic Power

- Updated illustrations of automotive braking systems and hydraulic systems

Unit 40: Concrete and Masonry

- New photos related to the history of masonry; sizes of aggregates; slag; recycling concrete; sand being flushed with water to remove clay and silt; and a broom finish
- Updated illustrations related to proper form construction and pouring and floating concrete

Unit 41: Planning and Constructing Agricultural Structures

- No changes aside from updates to Relevant Websites

Unit 42: Aquaculture, Greenhouse, and Hydroponics Structures

- Updated photos of net pens; mechanical aerators; fish feeders; maintenance of dissolved oxygen levels; greenhouse production; types of greenhouses; fans; cooling pad; hydroponic crops; and trickle irrigation

Unit 43: Fence Design and Construction

- No changes aside from Relevant Websites

EXTENSIVE TEACHING/ LEARNING PACKAGE

The complete supplement package was developed to achieve two goals:

1. To assist students in learning the essential information needed to continue their exploration into the exciting field of agricultural mechanics
2. To assist instructors in planning and implementing their instructional programs for the most efficient use of time and other resources

LAB MANUAL TO ACCOMPANY AGRICULTURAL MECHANICS, 7TH EDITION

ISBN-13: 978-1-28505-901-3

This comprehensive workbook tests students' knowledge and reinforces learning of text content. Job sheets for each unit include an objective, tools and materials needed, and a procedure with short-answer questions, procedural checklists, image labeling activities, or other activities meant to reinforce comprehension of unit content.

MINDTAP FOR AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 7E PRECISION EXAMS EDITION

The MindTap for *Agricultural Mechanics: Fundamentals and Applications, 7E Precision Exams Edition* features an integrated course offering a complete digital

experience for the student and teacher. This MindTap is highly customizable and combines an enhanced, interactive ebook along with a multitude of engaging activities and assignments including powerpoint, videos, matching, image labeling, crossword puzzles, job sheets, and auto-graded quizzing to enable students to directly analyze and apply what they are learning and allow teachers to measure skills and outcomes with ease.

CLASSMASTER CD-ROM TO ACCOMPANY AGRICULTURAL MECHANICS, 7TH EDITION

ISBN-13: 978-1-28505-899-3

This technology supplement provides the instructor with valuable resources to simplify the planning and implementation of the instructional program. It has been expanded for this edition to include the following support materials:

- A **PDF Instructor's Manual** provides objectives, competencies, glossary terms with definitions, and answers to the end-of-unit question. New to this edition, the instructor's manual now includes lesson plan outlines for each unit with suggested class activities, a correlation guide to the National AFNR Career Cluster Standards, and additional suggested resources.
- A **PDF Lab Manual Instructor's Guide** provides answers to lab manual exercises and additional guidance for the instructor. It has been expanded for this edition to include more answer keys for the lab exercises found in the lab manual.
- A **computerized test bank** created in ExamView® makes generating tests and quizzes a snap. Expanded to include 1,500+ questions with different question formats to choose from, you can create customized assessments for your students with the click of a button. Add your own unique questions and print rationales for easy class preparation.
- **Instructor support slide presentations that can be customized** in PowerPoint® format focusing on key points for each chapter. There is a slide

presentation for each unit available to accompany the textbook.

- New! An **Image Library** with all of the illustrations from the textbook can be used in slide presentations or as part of classroom discussion.
- New! **Correlation guides** include content mapping to STEM, National AFNR Career Cluster Standards, and National Science Standards.

INSTRUCTOR COMPANION WEBSITE

NEW! The instructor companion website provides online access to many of the instructor support materials provided on the ClassMaster CD-ROM, including the Instructor's Manual, Lab Manual Instructor's Guide, computerized test bank files, correlation guides, and support slides. To access the available materials, sign up for a faculty account at login.cengage.com. Add the core textbook to your bookshelf using the 13-digit ISBN that appears on the back cover of the textbook.



ABOUT THE AUTHOR

Dr. Ray V. Herren grew up on a diversified farm near Carbon Hill, Alabama. He earned a B.S. in Agricultural Education at Auburn University, an M.S. in Agribusiness at Alabama A&M University, and an Ed.D. in Vocational Education at Virginia Tech University. He taught high school agriculture in Gaylesville, Alabama, for 9 years and was on the faculty at Oregon State University for 5 years. He is currently Professor Emeritus in the Department of Agricultural Leadership, Education, and Communication at the University of Georgia. He has traveled extensively throughout the world and has authored and coauthored several books.

Dr. Herren has been involved with agricultural mechanics almost all of his life. From practical experience on the farm to teaching preservice and in-service courses, he is well versed in most areas of technical agricultural mechanics. As a hobby, he is an accomplished woodworker.

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HOW TO USE THIS TEXTBOOK

Agricultural Mechanics: Fundamentals and Applications has been carefully designed to enhance the study of mechanics and technology in agriscience programs. For best results, you may want to become familiar with the features incorporated into this text and accompanying learning tools.

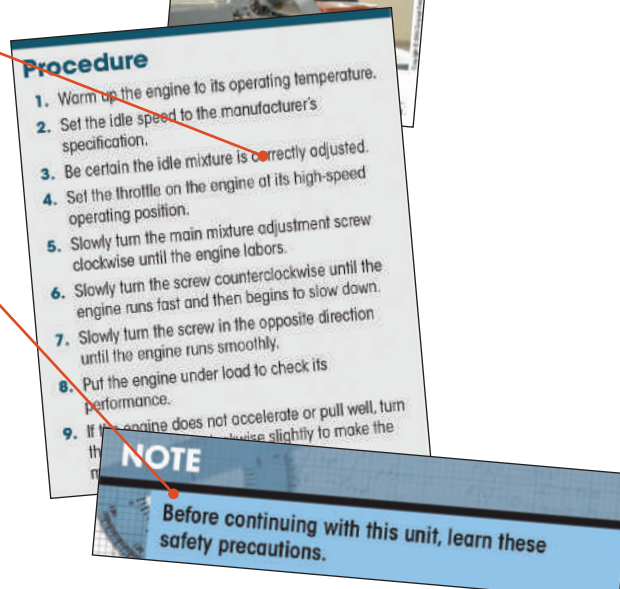
Each unit begins with the following tools:

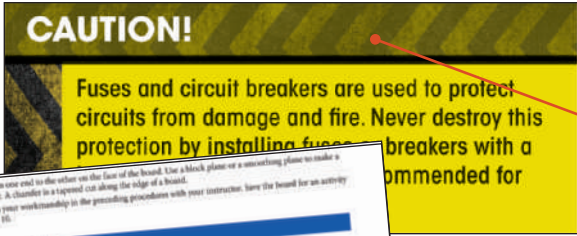
- a core *objective* explains the purpose of the unit;
- *competencies to be developed* list specific goals to meet as you read and review the unit;
- a *materials list* identifies items you will need to complete the unit; and
- a list of *Terms to Know* identifies key vocabulary to master.



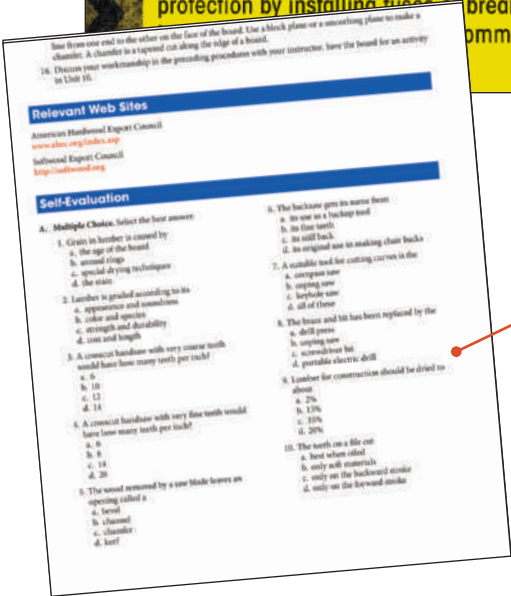
SPECIAL FEATURES

- Hundreds of new full-color photographs provide up-to-date visual references for the procedures described throughout the textbook.
- Procedures are highlighted throughout the textbook in order to highlight the basic steps in performing specific tasks covered in each unit.
- Notes emphasize important items you should be aware of before proceeding with a unit.





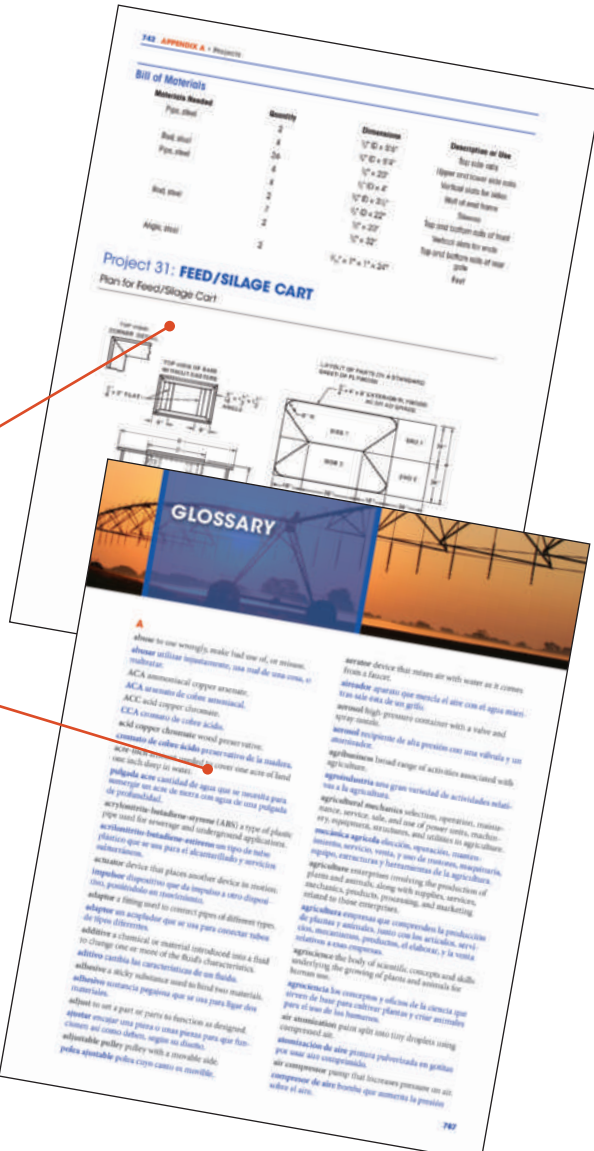
- Caution! features indicate safety precautions you need to be aware of.
- End of unit review materials include:



- a unit summary;
- student activities, including supervised agricultural experiences;
- a list of relevant websites for further information and research; and
- *Self-Evaluations*, which allow you to review the unit content using multiple choice, matching, and completion question.

OTHER RESOURCES AVAILABLE

- The appendices offer numerous project plans with bill of materials and construction procedures as well as tables containing information for estimating, planning, selecting, purchasing, and building in agricultural mechanics.
- An English–Spanish glossary with over 425 definitions provides an excellent study aid and reference.



Section 1

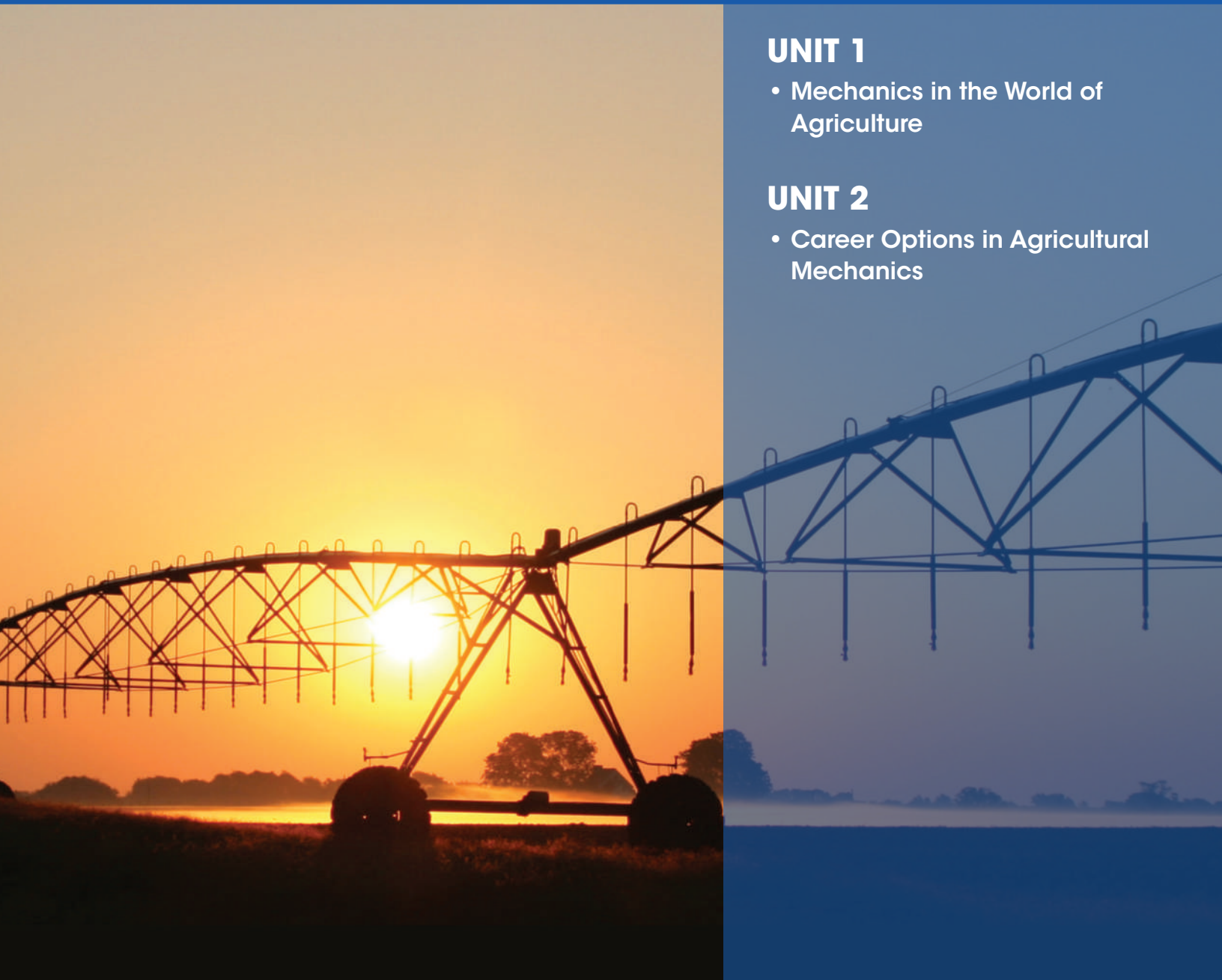
EXPLORING CAREERS IN AGRICULTURAL MECHANICS

UNIT 1

- Mechanics in the World of Agriculture

UNIT 2

- Career Options in Agricultural Mechanics



UNIT 1

Mechanics in the World of Agriculture

Objective

To determine how mechanical skills, concepts, and principles are used in agriculture and related occupations.

Competencies to be developed

After studying this unit, you should be able to:

- Define *agriculture* and *agricultural mechanics*.
- Define *occupation* and describe an occupational cluster.
- Describe the role of mechanics and mechanical applications in society.
- Demonstrate knowledge of contributions made by mechanical application to the development of agriculture.
- Name eight inventors of important agricultural machines.

Materials List

- Pencil
- Paper
- Encyclopedias

Terms to Know

- agriculture
- agriscience
- renewable natural resources
- agricultural mechanics
- efficiency

To many people, the term **agriculture** refers to production agriculture—farming or the production of plants and animals. However, agriculture is a very broad industry that includes not only producing plants and animals, but also all the related supplies, services, mechanics, products, processing, and marketing related to producing plants and animals, and keeping the environment sound.

Agriculture is a very complex industry. The industry produces plant and animal products from which thousands of commodities are made. Because every person and many industries depend upon agriculture, it is said to be a basic industry. Some products of agriculture are food, oils, fiber, lumber, ornamental trees and shrubs, flowers, leather, fertilizers, feed, seed, and more. Basic agricultural products form the raw materials for many items of everyday living.

Fabrics for clothing, curtains, and floor coverings are made from oils such as corn oil, soybean oil, and cottonseed oil. Plastics of all kinds are also made from vegetable oils. Products from animals are used to make materials such as glue, leather, and paint. Many medicines come from plants and animals. The manufacture of automobiles, furniture, airplanes, radios, stereos, and computers depends on agriculture for certain raw materials. The construction of homes, boats, and factories depends on agriculture for lumber, fiber, and other basic commodities. Most dwellings in America are surrounded by lawn, shrubs, or other plants for beautification. These are also agricultural commodities.

Agriculture is, indeed, a basic industry upon which all people depend. It is the backbone of the American society. Even though the number of farms has dramatically decreased over the past 150 years, the amount of agricultural production has increased manifold. For example, in 1940 there were about 6.5 million U.S. farms and one farmer fed about 19 people. Today there are a little over 2.2 million U.S. farms. Of these, 98 percent are family farms with only about 2 percent corporate operations. The families who live on and operate our farms and ranches comprise only about 2 percent of the U.S. population. The producers have become so efficient that one farmer feeds about 155 people (Figure 1-1). A lot of different factors contributed to this increase in efficiency. Scientific research that developed better varieties, more efficient fertilization programs, more effective insect and disease control, and an overall better understanding of how plants and animals reproduce has been a tremendous factor. However, just as important is the development of agricultural mechanics that brought



FIGURE 1-1 The average American farmer produces enough food to feed about 155 people.

electricity to all rural areas and developed the marvelous machines and implements that made human labor much more efficient.

The term **agriscience** refers to the science involved with the industry of agriculture. Agriculture is a science that involves most of the knowledge we process concerning the growth and reproduction of plants and animals. In fact, when one considers all the vast knowledge we have in biology, there are only three applications: medicine, ecology, and agriculture. Agriculture plays a vital role in both medicine and ecology, so our knowledge in biology is applied in agriculture.

Renewable natural resources are considered to be a part of agriculture. These are the resources provided by nature that can be replaced or renewed. Examples of such resources are our forests; fish in our streams, lakes, and oceans; and our wildlife such as game animals. At one time most natural resources were not managed, and humans relied on nature to replenish the resources. As our population began to grow, nature could not replenish natural resources as fast as they were being consumed. A large industry began to develop that helps to manage our resources. Most U.S. forestland is now managed—in terms of planting and cultivating trees, regulating harvesting, and managing fire-control efforts (Figure 1-2). Large hatcheries now produce young fish that are released into the wild. Both commercial and sport fishing are closely regulated to prevent the depletion of fish populations. Game animals are closely regulated to prevent overhunting and to control population numbers to prevent overpopulation (Figure 1-3). Just think of all the industry that is needed to support the management and enjoyment of our natural resources!



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FIGURE 1-2 Managed forests are a renewable resource.

Think of all the industry that goes with fishing—everything from the production of fishing lures, rods and reels to fishing boats.

American farmers are among the world’s most efficient businesspeople. Much of this efficiency and success is due to the invention, development, and



© iStockphoto/nwildlife

FIGURE 1-3 Game animals account for a significant part of our natural-resource industry.

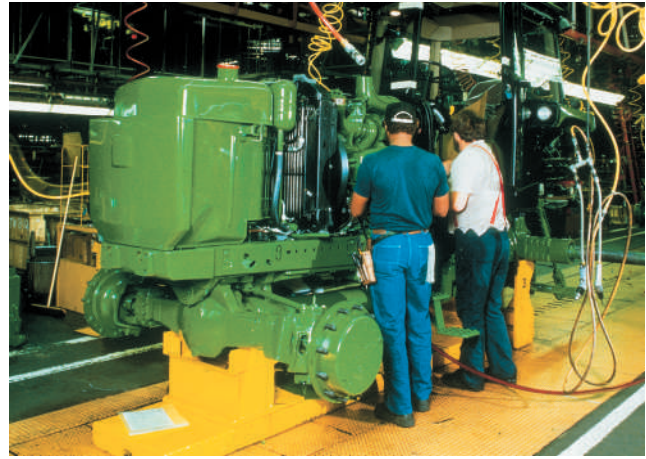


Photo by John Deere

FIGURE 1-4 Workers in agricultural mechanics are responsible for the design, manufacture, testing, sales, and service of farm machinery.

maintenance of modern farm machinery. Also, consider all the machinery needed to plant, cultivate, and harvest trees (Figure 1-4). Consider all that goes into the construction and maintenance of buildings that house agricultural products, equipment, supplies, and machinery. A large industry is built around agricultural construction (Figure 1-5).



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FIGURE 1-5 Agricultural construction is an important part of agricultural mechanics.

THE ROLE OF AGRICULTURAL MECHANICS

Mechanical applications are found throughout agriculture. A few examples of people whose occupations involve **agricultural mechanics** are:

- the engineer who designs tractors and other farm and ranch machines (Figure 1-6)
- the forester who keeps chainsaws and other equipment going
- the builder who constructs processing plants, farm buildings, and aquaculture facilities
- the electrician who installs climate controls, silo unloaders, and milling equipment
- the soil conservationist who constructs terraces to control erosion
- the hardware store employee who obtains and stocks repair parts for agricultural tools and machines (Figure 1-7)
- the specialist who creates air-conditioning and refrigeration systems in processing and storage facilities
- the specialist who designs and installs drainage and irrigation systems for fields, turf, landscaping, and golf courses (Figure 1-8)
- the lawn equipment service mechanic who repairs lawn tractors
- the welder who repairs farm machinery
- the mechanic who keeps diesel trucks and machines in good repair

Processing plants for field crops, livestock, poultry, fruits, and vegetables all use machinery. Machines



FIGURE 1-6 Engineers are needed to design machinery.



FIGURE 1-7 Machinery parts can be ordered by computer.



FIGURE 1-8 Agricultural mechanics is needed in urban areas. Ball fields, parks, and golf courses rely on machinery to install and maintain turf, plants, and landscaping.

require designers, engineers, operators, maintenance and repair personnel, and construction workers. Even people with jobs in finance, publishing, and communications may need some knowledge of mechanics when their assignments deal with agriculture. All are likely to use computers and computer applications in their work.

THE INFLUENCE OF MECHANIZATION

At the birth of the United States in 1776, more than 90 percent of the American colonists were farmers, yet many of General Washington's troops at Valley Forge died for lack of food and clothing. Today, less than 10 percent of all Americans work in production

agriculture, yet there are generally food surpluses in America. The ratio of farm workers to nonfarm workers in America approximately reversed in the last 230 years. In 1776, the farm-to-nonfarm ratio was approximately 9:1. Today, the ratio of production agricultural workers to the remaining population is approximately 1:9. Mechanization has played a major role in this rise in production efficiency. **Efficiency** means the ability to produce with a minimum waste of time, energy, and materials.

America provided the inventors for many of the world's most important agricultural machines. For example, grain has always been a basic food for humans. For thousands of years people have planted, cultivated, and harvested grain to eat whole or to make bread. One of the most labor-intensive jobs was that of cutting the plants and threshing out the grain. This was done from prehistoric times until the early part of the 1800s. Cyrus McCormick invented the reaper in 1834 to cut small grain crops. This machine used horse power to pull the reaper that cut the mature grain plants. This allowed one person to do the work of many people and the labor was easier. This still left the job of threshing out the wheat. Later, a machine called a combine was invented, which both cut and threshed the grain in the field. The name *combine* was adopted because the machine combined the job of cutting and threshing. Today, one modern combine operator can cut and thresh as much grain in one

day as 100 people could cut and bundle in one day in the 1830s (Figure 1-9).

Two inventions had a profound influence on the settling of this country. The first was by a man named John Deere, who developed a steel plow that replaced an iron plow invented by Thomas Jefferson. The plow, invented by Deere in 1837, allowed farmers to break up the tough sod that previously had prevented pioneers from cultivating the rich prairie soils. Previously plowshares (the parts that cut through the soil) were made either of wood or cast iron. Both of these materials were so heavy that the plow could not be drawn through the sod. Deere constructed plowshares out of steel that was both lighter and tough enough to cut through the sod. Settlers inhabited all of the Midwest and Plains region where so much of our food is grown today. From this beginning, John Deere became one of the world's leading manufacturers of agricultural and construction implements (Figure 1-10).

The other invention that affected settlement was by Eli Whitney, who developed a machine, called a gin (short for "engine"), to remove seeds from cotton. Prior to his invention in 1793, seeds were removed from cotton by hand. The seeds could be separated from the cotton, but it was a time-consuming task. Another problem was the type of cotton grown. Cotton with loose seeds was the Sea Island or



FIGURE 1-9 A combine cuts and threshes grain in one operation.



Photo by John Deere

FIGURE 1-10 John Deere invented a plow that could cut through the heavy sod of the Midwest.

long-staple variety that would grow only along the coast of Georgia and the Carolinas. Upland cotton would grow anywhere in the South, but the seeds of this type were almost impossible to separate by hand. Whitney's gin not only saved labor, but it also opened up the entire southern portion of the nation for cultivation of upland cotton.

The power for agricultural machines was first supplied by horses, oxen, and mules. Later, as heavier and more complex machines were developed, power was supplied by steam. Steam engines had proven to be very effective in powering boats, ships, and trains. They provided more power than animals, but they were extremely heavy and cumbersome on land (Figure 1-11). The internal combustion engine made machines tremendously efficient. Machinery equipped with these relatively lightweight, powerful engines replaced the steam-powered machines,



© Alan Eglington/Shutterstock.com

FIGURE 1-11 Heavy, bulky steam engines began to replace animals as a power source in the 1800s. This antique tractor has been restored.

revolutionizing the production of food and fiber. Today, most of the machinery used in agricultural production is based on the internal combustion engine.

Perhaps no invention has had more impact on agriculture and on the lives of people than the invention of refrigeration. Prior to its invention, produce and meats had to be sold fresh, and their shelf life was very short. With mechanical refrigeration, meats and produce could not only be stored much longer, but could also be transported long distances. Refrigerated railcars and trucks allowed livestock, fruits, and vegetables to be produced in one part of the country and shipped across the country to large cities. For the first time in history, people could have fresh meats and vegetables year-round.

The machines discussed here are only a few of the ones that have revolutionized agriculture. Our entire modern agricultural industry is based on complex, efficient machinery that performs crucial roles, all the way from the research laboratories that develop agricultural inputs to the businesses that harvest, store, process, and transport commodities to the consumer. All of these thousands of different types of machines and implements that keep the agricultural industry going rely on a complex support system that designs, produces, installs, maintains, and repairs them. Agriculture has become highly mechanized in all of the developed countries of the world. In undeveloped countries, many engineers, teachers, and technicians have sought simple, tough, and reliable small machines to improve agriculture. In such countries, America's highly developed, complex, computerized, expensive machinery will not do, in part because these countries lack people trained for the variety of agricultural mechanics jobs that are needed to support agriculture in the United States.

Many features, such as rubber tires, have been standard equipment on American farms since the 1930s. Yet a machine with rubber tires is useless if a tire gets damaged and repair services are not available. This is the case in most undeveloped countries in Central and South America, Asia, and Africa. Much of the world cannot compete with American agriculture because the related agricultural products and services are not available to support farm workers.

The efficiency of American agriculture will increase in the future as computer-controlled machines and robotics play an important part. It is exciting to envision the changes in store for agricultural mechanization in the twenty-first century.

SUMMARY

Agricultural mechanics has been fundamental to the development of the agricultural industry in this country. Much of the tremendous increase in the efficiency of the American producers is due to innovations in mechanics. The wiring of buildings to supply power, the repairing of engines and equipment, the laying of pipes for water supplies, and constructing buildings are only a few examples of mechanics in agriculture. As further advances are made, the role of mechanics in agriculture will be as prominent in the future as it has been in the past.

Student Activities

1. Define the Terms to Know in this unit.
2. Interview a cooperative extension specialist for agricultural resources in your county or city. Ask the specialist to describe the different agricultural or agriculturally related jobs that people do in your locality.
3. Look up “inventors” or “inventions” in an encyclopedia. Pick out the inventions that relate to agriculture, and report your findings to the class.
4. Select three or five classmates to join you in a debate on the role of agriculture in society. One team should support the position that agriculture is the backbone of society. The opposing team should support the notion that it is not.
5. Consider an everyday product such as bread, milk, leather gloves, or a corsage for Mother’s Day. Trace the production, processing, and marketing of the item from its source to its sale as a finished product. List points along the way where agricultural mechanics is involved.

Relevant Web Sites

About.com’s web page on Inventors, Agriculture, and Farm Innovations

<http://inventors.about.com/library/inventors/blfarm.htm>

Delaware Agricultural Museum & Village

www.agriculturalmuseum.org

National FFA Online, Teacher’s Workroom

<http://web.missouri.edu/~schumacher1/natcon.html>

Online Encyclopedia Britannica

www.britannica.com

Self-Evaluation

A. Multiple Choice. Select the best answer.

1. The production of plants and animals and the provision and management of related supplies, services, mechanics, products, processing, and marketing defines
 - a. horticulture
 - b. renewable natural resources
 - c. agricultural mechanics
 - d. agriculture
2. Agriscience is
 - a. the same as agricultural mechanics
 - b. limited to the sale of agricultural products
 - c. business stemming from agriculture
 - d. the science that is behind agricultural production
3. Examples of renewable natural resources are
 - a. oil, gas, and coal
 - b. fish, trees, and wildlife
 - c. rubber, steel, and water
 - d. air, soil, and minerals
4. Over the past 230 years, the number of American farms has
 - a. decreased
 - b. increased
 - c. remained about the same
 - d. not been measured
5. Agricultural mechanics stems mostly from
 - a. physics
 - b. biology
 - c. medicine
 - d. horticulture
6. Agricultural products come from
 - a. soil and coal
 - b. plants and animals
 - c. iron ore and aluminum
 - d. atomic fuel
7. Products of agriculture include
 - a. leather seat covers
 - b. paint
 - c. flower arrangements
 - d. all of these
8. Agricultural mechanics includes the occupation of
 - a. garden tractor repairperson
 - b. automobile mechanic
 - c. pile driver
 - d. systems analyst

9. Mechanization of agriculture has resulted in
 - a. decreased soil production
 - b. decreased farm expenses
 - c. increased production efficiency
 - d. increased numbers of farm workers

10. Cyrus McCormick invented the
 - a. steel plow
 - b. cotton gin
 - c. milking machine
 - d. reaper

B. Matching. Match the items in column I with those in column II.

Column I

1. efficiency
2. agricultural mechanics
3. Thomas Jefferson
4. loose seeds
5. John Deere
6. steam engines
7. Eli Whitney
8. mechanic
9. technician
10. trade

Column II

- a. one who is specifically trained to perform tasks having to do with a machine, a mechanism, or machinery
- b. the iron plow
- c. the selection, operation, maintenance, servicing, selling, and use of power units, machinery, equipment structures, and utilities used in agriculture
- d. the ability to produce with minimum waste of time, energy, and materials
- e. Sea Island cotton
- f. heavy and cumbersome
- g. specific kinds of work or business, especially those that require skilled mechanical work
- h. the cotton gin
- i. a mechanic who uses high technology
- j. the steel plow