

Science of Agricultural Mechanization

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The Research and Curriculum Unit, located in Starkville, MS, as part of Mississippi State University, was established to foster educational enhancements and innovations. In keeping with the land grant mission of Mississippi State University, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances intellectual and professional development of Mississippi students and educators, while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

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Mr. William Harold Jones, Chair
Mr. Charles McClelland, Vice Chair
Ms. Kami Bumgarner
Mr. Howell "Hal" N. Gage
Dr. O. Wayne Gann
Mr. Claude Hartley
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Dr. Sue Matheson

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Finally, standards in the *Science of Agricultural Environment Curriculum Framework and Supporting Materials* are based on the following:

National Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards

The National AFNR Career Cluster Content Standards were developed by the National Council on Agricultural Education to serve as a guide for what students should know or be able to do through a study of agriculture in grades 9–12 and 2-year postsecondary programs. The standards were extensively researched and reviewed by leaders in the agricultural industry, secondary and postsecondary instructors, and university specialists. The standards consist of a pathway content standard for each of the eight career pathways. For each content standard, performance elements representing major topic areas with accompanying performance indicators were developed. Measurements of assessment of the performance elements and performance indicators were developed at the basic, intermediate, and advanced levels. A complete copy of the standards can be accessed at <https://aged.learn.com>. The National AFNR Career Cluster Content Standards are copyrighted to the National Council for Agricultural Education and are used by permission.

Applied Academic Credit Benchmarks

Mississippi Department of Education 2010 Mississippi Science Framework

21st Century Skills and Information and Communication Technologies Literacy Standards

In defining 21st century learning, the Partnership for 21st Century Skills has embraced five content and skill areas that represent the essential knowledge for the 21st century: global awareness; civic engagement; financial, economic, and business literacy; learning skills that encompass problem-solving, critical-thinking, and self-directional skills; and Information and Communication Technology (ICT) literacy.

National Educational Technology Standards for Students

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ACT College Readiness Standards



The College Readiness Standards are sets of statements intended to help students understand what is expected of them in preparation for the ACT. These standards are integrated into teaching and assessment strategies throughout the curriculum framework.

Preface

Secondary vocational–technical education programs in Mississippi are faced with many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing true learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, Mississippi Code of 1972, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, ch. 487, §14; Laws, 1991, ch. 423, §1; Laws, 1992, ch. 519, §4 eff. from and after July 1, 1992; Carl D. Perkins Vocational Education Act IV, 2007; and No Child Left Behind Act of 2001).

Research Synopsis

Agricultural and Environmental Science and Technology Research

The Agricultural Sciences Career Cluster covers the broad field of occupations related to the production and use of plants and animals for food, fiber, aesthetic, and environmental purposes. According to the U.S. Department of Labor, the growing interest in worldwide standardization of agricultural equipment should result in increased employment of agricultural engineers. Job opportunities should also result from the increasing demand for agricultural products, the continued efforts for more efficient agricultural production, and the increasing emphasis on the conservation of resources. The sales of food and fiber products amounted to 5.8 billion dollars in 2005 according to USDA statistics. Additionally, the Mississippi Department of Agriculture and Commerce estimates that 30% of the state's workforce is employed in jobs relating directly or indirectly to agriculture.

Agriculture and Environmental Science and Technology will target careers at the professional and technical levels in agriculture. Students enrolled in these courses should be better prepared to pursue degrees at the community college and 4-year college level.

Employment Projections

Data for this synopsis were compiled from employment projections prepared by the Mississippi Department of Employment Security and the U. S. Department of Labor. The National Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards developed by the National Council for Agricultural Education and scholarly research articles were also reviewed as a guide for the redesign of the Agriculture and Natural Resources Cluster.

Industry Job Data – Employment Projections 2006 to 2016 for Mississippi

Note: Compiled by Mississippi Department of Employment Security and Labor Market Information Department

Animal Breeders	9,770	9,870	100	1.0	165
Agricultural and Food Science Technicians	260	310	50	19.2	10
Agricultural Equipment Operators	1,090	1,190	100	9.2	40
Agricultural Sciences Teachers, Postsecondary	190	240	50	26.3	20
Conservation Scientists	790	890	100	12.7	30
Custodial and Caretaking Supervisors and Workers	46,920	54,110	7,190	15.3	2,320
Environmental Engineers	270	320	50	18.5	10

Environmental Engineering Technicians	50	100	50	100.0	0
Environmental Scientists and Specialists	420	470	50	11.9	10
Environmental Science and Protection Technicians	100	150	50	50.0	5
Farmworkers and Laborers, Crop, Nursery, and Greenhouse	5,160	5,810	650	12.6	225
Farmworkers, Farm and Ranch Animals	1,400	1,550	150	10.7	65
First-Line Supervisors / Managers of Farming, Fishing, and Forestry Workers	1,390	1,540	150	10.8	40
Food Processing Workers	14,920	18,320	3,400	22.8	680
Foresters	470	520	50	10.6	20
Forest and Conservation Technicians	390	440	50	12.8	15
Forest and Conservation Workers	880	980	100	11.4	30
Grounds Maintenance Workers	10,310	11,810	1,500	14.5	375
Logging Equipment Operators	3,910	4,210	300	7.7	100
Purchasing Agents and Buyers, Farm Products	80	130	50	62.5	5
Soil and Plant Scientists	430	480	50	11.6	10
Veterinarians	540	640	100	18.5	25
Veterinary Assistants and Laboratory Animal Caretakers	690	890	200	29.0	35
Veterinary Technologists and Technicians	440	540	100	22.7	15

Note: Data was retrieved from the Mississippi Department of Employment Security (2009).

Occupational Employment and Wage Estimates for Mississippi May 2006

Farmers and Ranchers	2,760	\$17.85	\$43,560.00
Farm Managers and Supervisors	2,640	\$23.23	\$48,360.00
Logging Equipment Operators	3,890	\$14.28	\$30,880.00
Landscaping Supervisors	2,990	\$17.93	\$40,240.00
Landscape Workers	8,560	\$10.22	\$23,010.00
Agricultural Scientists/Technicians	29,680	\$18.33	\$38,555.00

Note: Data was retrieved from the U.S. Bureau of Labor Statistics (2009)

Curriculum Content

In compiling the research for the Agricultural Sciences cluster, face-to-face and telephone interviews were conducted with representatives of agricultural employers and agricultural agencies. The following comments summarize the results of these interviews:

- While opportunities to enter farming on a full-scale commercial enterprise basis are limited, opportunities do exist and are expected to increase as current operators retire and begin to rent their land to companies and individuals. Opportunities are also expected to increase for consultants and technicians who support production enterprises by providing specialized services to producers.
- There was general agreement among all persons interviewed that all students need to better develop skills related to leadership, teamwork, communication, and work ethics, habits, and values. All respondents also indicated that a basic knowledge of economics, recordkeeping, budgeting, and business decision-making skills will be essential in today’s “lean” environment.
- Opportunities for high school graduates in all fields of agriculture are limited to the basic entry-level positions. More abundant opportunities exist for students who have received advanced training at the community college or 4-year college.
- All respondents agreed that a common core of knowledge and skills existed across all three major pathways related to the following themes: Leadership and personal development; principles of plant science and production; principles of soil science and air and water quality; principles of agricultural power, structures, and technology; and principles of economics and management. A sixth theme, principles of animal science and production, exists for students in the AEST and Agriculture and Natural Resources pathway.
- All respondents agreed that students in all three pathways should be exposed to the process by which agricultural products are grown, managed, harvested, processed, and marketed. As students study this process, they should be also exposed to the different careers that are involved in all segments of the industry.
- The role of federal and state agencies including the USDA, OSHA, FDA, EPA, and so forth should be discussed. Also, the role of agricultural organizations such as the Poultry Association, Nurseryman’s Association, and Farm Bureau needs to be investigated.

Results of the survey of employers and agricultural agency representatives show that there are six major themes or topics that apply to a majority of occupations in the agriculture and natural resources area. These themes and their respective pathways are listed below.

Principles of Leadership, Personal Development, and Career Success	X	X	X
Principles of Plant Science and Production	X	X	X
Principles of Animal Science and Production	X	X	
Principles of Soil, Water, and Air Quality, Conservation, and Use	X	X	X
Principles of Agricultural Power, Structures, and Technological Systems	X	X	X
Principles of Management, Economics, and Marketing	X	X	X

Executive Summary

Program Description

Science of Agricultural Mechanization is an advanced level course for the Agricultural and Environmental Science and Technology Program. The course focuses on the development of skills and knowledge related to the management, maintenance, and operation of agricultural machinery. Instruction is provided on machinery management, principles of electricity-electronics, hydraulics, and pneumatics, internal combustion engines, machinery maintenance, and metal fabrication. The course carries 1 Carnegie unit of credit that counts as an elective credit for high school graduation. Students may also earn an additional ½ Carnegie unit by completing a successful supervised agricultural experience program.

Industry Certification

No national industry recognized certifications are known to exist at this time in the field of Agriscience. Competencies and suggested performance indicators in the *Science of Agricultural Mechanization* course have been correlated, however to the National Agriculture, Food, and Natural Resources (AFNR) Career Cluster Content Standards that have been reviewed and endorsed at the national level by the National Council on Agricultural Education.

Articulation

The following articulation plan is in place for the AEST Pathway.

High School Program	Community College Program	Community College Course
Agricultural & Environmental Science & Tech – Concepts (CIP: 01.9999)	Ag Business & Mgmt Tech(Program CIP: 01.0304 – Field Crops)	AGT 1111 - Survey of Agriculture
Agricultural & Environmental Science & Tech – Environments (CIP: 03.0104)	Ag Business & Mgmt Tech(CIP: 01.0304 – Field Crops)	AGT 1313 - Applied Principles of Plant Production
Agricultural & Environmental Science & Tech – Animals (CIP: 01.0901)	Ag Business & MgmtTech (CIP 01.0302) Agricultural Animal Husbandry/Production)	AGT 1214 - Applied Principles of Animal Production
Agricultural & Environmental Science & Tech – Plants (CIP: 01.1101)	Ag Business & Mgmt Tech(CIP: 01.0304 – Field Crops)	AGT 1313 - Applied Principles of Plant Production
Agricultural & Environmental Science & Tech – Agricultural Mechanization (CIP: 01.0201)	Ag Business & Mgmt Tech(Program CIP: 01.0304 – Field Crops)	AGT 2563 - Agricultural Machinery and Shop Management

Assessment

Students will be assessed using the AEST MS-CPAS2 test. All students will be tested on *Concepts of Agriscience* and the second course that they may take in their chosen path of study. The second course may be one of the following:

- Science of Agricultural Animals
- Science of Agricultural Environment
- Science of Agricultural Mechanization
- Science of Agricultural Plants

The MS-CPAS2 blueprint can be found at <http://redesign.rcu.msstate.edu/curriculum/>. If there are questions regarding assessment of this program, please contact the instructional design specialist at the Research and Curriculum Unit at 662.325.2510.

Student Prerequisites

Prior to enrolling in *Science of Agricultural Mechanization*, a student must have completed *Concepts of Agriscience*. *Science of Agricultural Mechanization* may be offered to students in grades 10–12. It is recommended that students enrolling in the course possess at least a C average in other science courses and a TABE reading score at the eighth grade level or higher.

Proposed Applied Academic Credit

The academic credit is still pending for this curriculum.

Licensure Requirements

A 992 endorsement is currently required to teach any course in the Agricultural and Environmental Science and Technology Program. In order to receive a 992 endorsement, applicants must do the following:

1. Hold a valid Mississippi Educator License with endorsement #301 – Vocational Agriculture Education Programs or #302 – Agriculture.
2. Possess a baccalaureate degree in an agricultural subject area.
3. Complete the 3 semester credit hour course devoted to the teaching of Agricultural and Environmental Science and Technology courses. The course, AIS 6113 - Methods of Teaching Agriscience, is currently offered by Mississippi State University.
4. Applicant must enroll immediately in the Vocational Instructor Preparation (VIP) or the Redesign Education Program (REP).
5. Applicant must complete the individualized Professional Development Plan (PDP) requirements of the VIP or REP prior to the expiration date of the 3-year vocational license.
6. Applicant must successfully complete an MDE-approved computer literacy certification exam.
7. Applicant must successfully complete a certification for an online learning workshop, module, or course that is approved by the MDE.

Note: If the applicant meets all requirements listed above, that applicant will be issued a (992) endorsement—a 5-year license. If the applicant does not meet **all** requirements, the applicant will be issued a 3-year endorsement (license), and all requirements stated above must be satisfied prior to the ending date of that license.

Professional Learning

The professional learning itinerary for the middle school or individual pathways can be found at <http://redesign.rcu.msstate.edu>. If you have specific questions about the content of each training session provided, please contact the Research and Curriculum Unit at 662.325.2510 and ask for the Professional Learning Specialist.

Course Outlines

Course Description: Science of Agricultural Mechanization is a course that includes physical science principles and applications in agricultural technology, agricultural mechanics, and agricultural mechanization. Topics of instruction are: safety; physics technology, including work and power, mechanics, heat, light, sound, and magnetism and electricity; concepts of agricultural mechanization; electricity/electronics technology systems; computer technology in agricultural mechanization; hydraulics and pneumatics systems; internal combustion engines; and preventive maintenance and diagnostics.

Science of Agricultural Mechanization (One Carnegie Unit) - Course Code: 991004

Unit	Title	Hours
1	Introduction to Agricultural Mechanization*	10
2	Management and Operation of Agricultural Equipment	20
3	Analyzing Electrical and Electronic Systems	10
4	Using Hydraulic and Pneumatic Systems	15
5	Principles of Internal Combustion Engines	20
6	Principles of Metal Fabrication (Arc Welding)	15
7	Principles of Metal Fabrication (Oxyfuel Cutting)	10
		100

* Note: These units are not tested by MS-CPAS2.

Using This Document

Unit Number and Title

Suggested Time on Task

An estimated number of clock hours of instruction that should be required to teach the competencies and objectives of the unit. A minimum of 140 hours of instruction is required for each Carnegie unit credit. The curriculum framework should account for approximately 75–80% of the time in the course.

Competencies and Suggested Objectives

A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students will be expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level.

Suggested Teaching Strategies

This section of each unit indicates research-based strategies that can be used to enable students to master each competency. Emphasis has been placed on strategies that reflect active learning methodologies. Teachers should feel free to modify or enhance these suggestions based on needs of their students and resources available in order to provide optimum learning experiences for their students.

Suggested Assessment Strategies

This section indicates research-based strategies that can be used to measure student mastery. Examples of suggested strategies could include rubrics, class participation, reflection, and journaling. Again, teachers should feel free to modify or enhance these suggested assessment strategies based on local needs and resources.

Integrated Academic Topics, 21st Century Skills and Information and Communication Technology Literacy Standards, ACT College Readiness Standards, and Technology Standards for Students

This section identifies related academic topics as required in the Subject Area Testing Program (SATP) in Algebra I, Biology I, English II, and U.S. History from 1877, which are integrated into the content of the unit. Research-based teaching strategies also incorporate ACT College Readiness standards. This section also identifies the 21st Century Skills and Information and Communication Technology Literacy skills. In addition, national technology standards for students associated with the competencies and suggested objectives for the unit are also identified.

References

A list of suggested references is provided for each unit. The list includes some of the primary instructional resources that may be used to teach the competencies and suggested objectives. Again, these resources are suggested, and the list may be modified or enhanced based on needs and abilities of students and on available resources.

Science of Agricultural Mechanization

Unit 1: Introduction to Agricultural Mechanization

10 Hours

Competency 1: Investigate the role of mechanical technology in agriculture. ^{PST.01}

Suggested Enduring Understandings

1. Mechanization and technology have resulted in a reduction in the amount of labor required to produce a crop and in more acreage and larger yields per acre.
2. Mechanization and technology continue to evolve as producers try to reduce costs while increasing returns.

Suggested Essential Questions

1. How has mechanization changed the way in which food and fiber are produced?
2. What are some evolving mechanization technologies being adopted by producers?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss how mechanization and technology have changed the production of food and fiber. (DOK 1)	a. Introduce the competency by having students view the Web page A History of American Agriculture: Farm Machinery and Technology . Have students prepare a series of graphs showing how mechanization and technology have reduced the amount of labor and increased yields for agricultural crops such as corn, wheat, and cotton from 1830 to the present. ^{CS1, CS2, S4, T1, T2, T4, S1, M5}	a. Evaluate student graphs for accuracy and completeness.
b. Describe the role of emerging technologies in agricultural mechanization. (DOK 3)	b. Divide the class into pairs of students, and have each pair search for information on the Internet and through other sources regarding an emerging technology in agricultural mechanization (GPS, GIS, remote sensing, variable rate technology, yield mapping, auto steering, etc.). Have the students prepare a one-page fact sheet that shows a picture or graphic illustrating the technology and describes how, where, and why the technology is used. ^{CS1, CS2, CS3, CS4, T1, T2, T3, T4, T6, R1, R2, R4, R5, W2, W4, W5}	b. Use the <i>Emerging Technology Fact Sheet Rubric (1.1)</i> to evaluate student performance on this indicator.
c. Define power, and discuss how it is generated and measured. (DOK 1)	c. Use the PowerPoint presentation Tractor Power Flow to lead a discussion of the definition of power and how it is generated in a tractor and transmitted to the wheels. Distinguish between the terms work, torque, force, and power, and discuss the measurement of power in terms of horsepower or watts. ^{CS1, CS2, CS4}	c. Use a written test to evaluate student performance on this indicator.
d. Describe sources of power used in agricultural mechanization, and associate each source with common applications. (DOK 1)	d. Identify and describe the two most common sources of power for agricultural mechanization: internal combustion engines and electric motors. Lead a discussion on the advantages and limitations of each source, and provide illustrations of where each source is used. ^{CS1, CS2, CS4}	d. Use a written test to evaluate student performance on this indicator.
e. Trace the flow of power in a vehicle from the	e. Use the illustration from Tractor Power Flow to trace the flow of power from the engine to the flywheel	e. Evaluate flowchart for accuracy and

piston through the drive wheels or tracks. (DOK 1)	through the transmission and transaxle(s) to the drive wheels or tracks. Discuss the function of each component. Have students create a flowchart showing how power is transmitted. <small>CS2, CS4, S1</small>	completeness.
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Competency 2: Identify science applications in agricultural mechanization technology. PST.01, PHYI 2

Suggested Enduring Understandings

1. Many basic mathematical skills and operations are related to agricultural mechanization.
2. All machines used in agriculture are combinations of the six basic simple machines.
3. Mechanical advantage is a mathematical statistic that tells how effective a simple machine is in accomplishing work.

Suggested Essential Questions

1. What mathematical operations are used in agricultural mechanization?
2. What are the six simple machines, and how are they used in agricultural mechanization?
3. What is mechanical advantage, and how is it applied in agricultural mechanization?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
<p>a. Name the six simple machines, and describe applications in agricultural mechanization for each machine. (DOK 2)</p>	<p>a. Use the PowerPoint presentation Understanding Simple Machines to identify and illustrate how the six simple machines are integrated into agricultural mechanization technology. Divide the class into groups of 2–3 students, and assign a simple machine to each group. Have the group develop a drawing of one application of its machines in agriculture. <small>CS1, CS2, CS3, CS4</small></p>	<p>a. Evaluate the drawing of the application for clarity, accuracy, and completeness.</p>
<p>b. Calculate the mechanical advantage of a simple machine such as a lever, pulley, or wedge. (DOK 1)</p>	<p>b. Point out to the students that each of the six simple machines is used to provide an advantage that makes work easier. Demonstrate how a 5-lb sack of sand can be used with a lever to lift a 10-lb sack of sand. Define mechanical advantage (MA), and identify and demonstrate the use of the formula that is used to calculate MA. Have students complete an assignment to calculate MA of different machine applications. <small>CS1, CS2, CS4, M1</small></p>	<p>b. Evaluate the assignment for accuracy and completion.</p>

Competency 3: Demonstrate career and leadership skills required for employment in the agricultural mechanization industry.

Suggested Enduring Understandings

1. Most careers in the agricultural mechanization industry require knowledge of basic mechanical principles, electricity/electronics, hydraulics, pneumatics, internal combustion engines, and metal fabrication techniques.
2. In addition to technical skills in agricultural mechanization, leadership, human relations, and general workplace skills are essential for success and advancement in a career.

Suggested Essential Questions

1. What different skill areas are needed for agricultural mechanization careers?
2. What leadership, human relations, and general workplace skills are needed?

Suggested Performance Indicators:	Suggested Teaching Strategies:	Suggested Assessment Strategies:
a. Identify and explore careers in the agricultural mechanization industry including major skill areas required by employees. (DOK 2)	a. Provide a list of career areas in the agricultural mechanization industry. Have each student select an area of personal interest and prepare a PowerPoint presentation on the area. The presentation should include information on major skill areas, educational requirements, salary, specific skills, and occupational outlook. <small>CS2, CS4, T2, T3, T4, T6, R1, R2, R4, R5, W4, W5</small>	a. Evaluate student PowerPoint for accuracy and completeness.
b. Demonstrate leadership, human relations, and workplace skills. (DOK 2)	b. Provide students with the listing of <i>21st Century Life and Career Skills (1.3)</i> found in this unit. Lead students in a discussion of how these skills apply to their current career as students and will apply to their career success after school. Provide students with a copy of the rubric that will be used to evaluate each student's demonstration of life and career skills. Have students self-evaluate their current score on this rubric, and explain that they will be periodically (at least once a grading period) be graded on their ability to demonstrate these skills. <small>CS1, CS2, CS3, CS4, CS5, T6</small>	b. Use the <i>21st Century Life and Career Skills Rubric (1.4)</i> to evaluate student attainment. This is an ongoing assessment throughout the year.

Competency 4: Identify safety precautions and equipment for the work site and school laboratory.

Suggested Enduring Understandings

1. Safety in the workplace is a major concern for both employees and employers. Employees should be fully informed of all safety policies and expected to adhere to these policies at all times.
2. Employers are responsible for informing employees about all safety equipment and devices in a workplace, including fire alarms and extinguishers, safety color codes, first aid equipment, and procedures for reporting accidents and injuries.
3. All employees should be expected to wear appropriate personal protection devices and clothing while on the work site.
4. Power tools have increased productivity but increased danger to workers. A worker should be fully aware of hazards and safety precautions before operating any power tool.

Suggested Essential Questions

1. What procedures should be followed to maintain a safe and orderly workplace?
2. What safety equipment and indicators (colors, signs, etc.) are used to promote safety?
3. What personal protection devices are needed, and when should they be used in order to work safely?
4. What are the basic safety rules for working with power tools?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Apply procedures for working in and maintaining a safe and orderly	a. Provide students with policies related to working in and maintaining a safe and orderly work site. Have students and their parents sign that they have read and understand the policies. <small>CS1, CS2, CS4, CS5</small>	a. Observation of student behavior will be conducted on a continuous basis throughout the course and

workplace. (DOK 1)		integrated into all lab activities.
b. Describe work site and laboratory organization. (DOK 1)	b. Take students on a tour of the agricultural mechanization laboratory. Identify safety equipment and indicators (including safety colors) that promote safety. Discuss procedures to follow in case of an emergency, and identify specific hazards and dangerous equipment. <small>CS1, CS2, CS4, CS5</small>	b. Use a written test on laboratory safety equipment, organization, and procedures. Students must score 90% or higher on the test in order to work in the laboratory.
c. Demonstrate safe use of head, eye, hearing, body, hand, and foot protective devices. (DOK 2)	c. Identify and demonstrate the proper use of personal protection devices. Discuss the appropriate devices to be used with specific equipment and on specific jobs. <small>CS1, CS2, CS4, CS5</small>	c. Observation of student behavior will be conducted on a continuous basis throughout the course and integrated into all lab activities.
d. Demonstrate rules for power tools including basic operation, safeguards in place, danger points, observer safety, and electrical safety. (DOK 2)	d. Identify each power tool that is present in the laboratory and any potential danger points or hazards associated with the use of the tool. Demonstrate the safe and proper use of the tool and the use of appropriate personal protective devices. Have students summarize the important points about each tool, and transcribe them into their electronic journals or notebooks. <small>CS1, CS2, CS3, CS4, CS5</small>	d. Use a written test on power tool use and safety. Students must score 90% or higher before being allowed to use these tools.

Standards

AFNR Industry Standards

PST.01. Use physical science principles and engineering applications with power, structural, and technical systems to solve problems and improve performance.

Applied Academic Credit Standards

Physics I

PHYI 2 Develop an understanding of concepts related to forces and motion.

21st Century Learning Standards

CS1 Flexibility & Adaptability
CS2 Initiative & Self-Direction
CS3 Social & Cross-Cultural Skills
CS4 Productivity & Accountability
CS5 Leadership & Responsibility

National Education Technology Standards for Students (NETS)

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T6 Technology Operations and Concepts

ACT College Readiness Standards

M1 Basic Operations and Applications
M5 Graphical Representations
R1 Main Ideas and Author's Approach
R2 Supporting Details
R4 Meaning of Words
R5 Generalizations and Conclusions
S1 Interpretation of Data
W2 Focusing on the Topic
W4 Organizing Ideas
W5 Using Language

Suggested References

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Science of Agricultural Mechanization

Unit 2: Management and Operation of Agricultural Equipment

10 Hours

Competency 1: Examine concepts of machinery management and maintenance. PST.02, PST.03

Suggested Enduring Understandings

1. Proper management and maintenance of equipment extends the life of the machine, reduces failures and operating costs, and increases safety for operators.
2. An important part of machinery management is the documentation of maintenance and repairs to the machine.
3. Work orders for machinery maintenance and repair should detail the parts and supplies used and the amount of labor required.

Suggested Essential Questions

1. Why are machinery management and maintenance important?
2. How are records of maintenance and repairs kept for a machine?
3. How is a work order for machinery maintenance and repair completed?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe the importance of machinery management and maintenance. (DOK 1)	a. Discuss the importance of a machinery management and maintenance from the standpoint of extended equipment life, reduced failures and operating costs, and increased worker safety. Ask students to cite examples of how machinery has failed because of poor management and maintenance. Have students find machinery owner's manuals on the Internet for different types of equipment. Ask them to locate the section on preventive maintenance and identify common maintenance jobs for all equipment. <small>CS1, CS2, CS4, T3, T6, R2, R4, R5</small>	a. Use a written test to evaluate student understanding of this indicator.
b. Complete a work order for a given repair or maintenance procedure, and calculate cost of the repair. (DOK 2)	b. Discuss the essential elements for a work order included identifying information, parts used, labor charges, and taxes. Have students set up a database or spreadsheet that can be used to generate work orders. Using the scenarios in <i>Equipment Repair Work Order Assignment (2.2)</i> , have students use their forms to calculate costs for different repairs. <small>CS1, CS2, CS4, T1, T3, T4, T6</small>	b. Evaluate assignment for accuracy and completeness.

Competency 2: Operate mechanized equipment in a safe and proper manner. PST.02

Suggested Enduring Understandings

1. Controls that are common on most agricultural vehicles include a throttle, clutch, transmission shift controls, brakes, hydraulic valves, switches, and solenoids.
2. Pre-inspection of an engine includes checking fluid levels, tires, controls and gauges.
3. Operating equipment in a safe and proper manner

Suggested Essential Questions

1. What are the common controls on most vehicles?
2. What is involved in inspecting an engine before starting?
3. What is involved in safely operating an engine or vehicle?

involves controlling engine and vehicle speed and maintaining control of the equipment at all times.

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify common equipment controls, and describe their use and function. (DOK 1)	a. Using a tractor, riding lawn mower, or ATV, identify the common machinery controls, and describe their function and use. (Common controls include throttle, clutch, transmission shift control, brakes, hydraulic valves, switches, solenoids, etc.) Have students list each control and its function in their electronic journals or notebooks. <small>CS2, CS4, T6, W2, W4, W5</small>	a. Use a written test to evaluate student performance on this indicator.
b. Demonstrate procedures for pre-inspection and start-up of an internal combustion engine. (DOK 1)	b. Using the <i>Vehicle Inspection, Start-up, and Operation Checklist (2.3)</i> , discuss and demonstrate the procedures in the checklist. Have students perform a pre-inspection and start-up on an engine. <small>CS2, CS4</small>	b. Use the <i>Vehicle Inspection, Start-up, and Operation Checklist (2.3)</i> to evaluate student ability to perform this task.
c. Operate equipment in a safe and proper manner. (DOK 1)	c. Using the <i>Vehicle Inspection, Start-up, and Operation Checklist (2.3)</i> , discuss and demonstrate the procedures for operating a vehicle in a safe and proper manner. Have students practice maneuvering an obstacle course to show that they understand the procedures. <small>CS2, CS4</small>	c. Use the <i>Vehicle Inspection, Start-up, and Operation Checklist (2.3)</i> to evaluate student ability to perform this task.

Competency 3: Describe and perform principles of preventive maintenance. PST.01, PST.02, PST.03, PHY1.5, PS 1, PS 2

Suggested Enduring Understandings

1. Preventive maintenance programs are designed to extend equipment life, reduce repair costs, and provide for better safety for operators.
2. In performing preventive maintenance, it is important to follow all safety procedures related to the use of tools and equipment, handling and disposal of hazardous materials, and personal protection.
3. The owner’s manual is the primary reference for planning and performing preventive maintenance on a regular schedule.
4. Daily maintenance of equipment includes checking engine oil and transmission/hydraulic levels, checking tires, checking coolant levels, and visually inspecting the machine.

Suggested Essential Questions

1. What are the purpose and goals of preventive maintenance?
2. What safety procedures should be followed in performing preventive maintenance?
3. What information can be found in an owner’s manual regarding preventive maintenance?
4. What items should be checked on a machine on a daily basis?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss the meaning of “preventive maintenance.”	a. Prior to teaching this competency, have students read the chapter on <i>Diesel Engines and Tractor Maintenance</i> in the text (Herren, 2010). Ask students	a. Use a written test to evaluate student understanding of this

(DOK 1)	how often oil is changed in their family cars and what determines when the oil is changed. Use this introduction to lead into the concept of preventive maintenance and how it can prevent costly repairs and extend the life of a piece of equipment. <small>CS4, CS5, R2</small>	indicator.
b. List and describe the safety precautions to follow while performing preventive maintenance. (DOK 1)	b. Use the PowerPoint presentation Tractor Safety, Operation and Maintenance to review safety precautions when operating and performing preventive maintenance on tractors and other large equipment. Have students summarize the major points and record in their electronic notebooks or journals. <small>CS4, CS5, E1 E2, E3, M5, M7, R2, W2, W4, W5</small>	b. Use a written test to evaluate student understanding of this indicator.
c. Locate and interpret preventative maintenance information in the owner's manual. (DOK 1)	c. Have students locate an owner's manual for a specific piece of equipment on the manufacturer's Web site or bring one from home. Have students complete the assignment <i>Tractor Service Intervals and Specifications (2.4)</i> to find specific service interval information on a piece of equipment. <small>CS4, CS5, M5, M7, R2</small>	c. Evaluate the <i>Tractor Service Intervals and Specifications (2.4)</i> assignment for accuracy and completeness.
d. Perform the following maintenance routines: (DOK 2)	d. Using the owner's manual for a specific piece of equipment, have students demonstrate the procedure for performing daily maintenance checks. <small>CS4, CS5, M5, M7, R2</small>	d. Use the <i>Daily Maintenance Checklist (2.5)</i> to evaluate the students' ability to perform this indicator.
	<p>Using the operator's manual or technical manual for a specific piece of equipment, have the students inspect and service the following: <small>CS1, CS2, CS4, T6, R2, R4, R5</small></p> <ul style="list-style-type: none"> • air cleaner. • lubrication system • fuel system • belts and hoses. • and liquid coolant system. <p>The procedure must include disposing of used oil and filters. <small>CS1, CS2, CS4, T6, R2, R4, R5</small></p>	Use the <i>Preventive Maintenance Checklist (2.5)</i> to evaluate student ability to perform this service.

Competency 4: Perform preventive maintenance services. PST.01, PST.02, PST.03, PHYI 5, PS 1, PS 2

Suggested Enduring Understandings

1. Preventive maintenance jobs that are usually performed by the owner-operator include inspecting and servicing the air cleaner, inspecting and servicing the lubrication system, inspecting and servicing the fuel system, inspecting and servicing belts and hoses, and inspecting and servicing the cooling system.

Suggested Essential Questions

1. What are the general procedures for inspecting and servicing an air cleaner?
2. What are the general procedures for inspecting and servicing the lubrication system?
3. What are the general procedures for inspecting and servicing the fuel system?
4. What are the general procedures for inspecting and servicing belts and hoses?

5. What are the general procedures for inspecting and servicing the coolant system?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Inspect and service an air cleaner. (DOK 2)	a. Using the operator’s manual or technical manual for a specific piece of equipment, have the students inspect and service the air cleaner. <small>CS1, CS2, CS4, T6, R2, R4, R5</small>	a. Use the <i>Preventive Maintenance Checklist (2.7)</i> to evaluate student ability to perform this service.
b. Inspect and service the lubrication system. (DOK 2)	b. Using the operator’s manual or technical manual for a specific piece of equipment, have the students inspect and service the lubrication system. The procedure must include disposing of used oil and filters. <small>CS1, CS2, CS4, T6, R2, R4, R5</small>	b. Use the <i>Preventive Maintenance Checklist (2.7)</i> to evaluate student ability to perform this service.
c. Inspect and service the fuel system. (DOK 2)	c. Using an operator’s manual for a specific piece of equipment, have the students inspect and service the fuel system. <small>CS1, CS2, CS4, T6, R2, R4, R5</small>	c. Use the <i>Preventive Maintenance Checklist (2.7)</i> to evaluate student ability to perform this service.
d. Inspect and service belts and hoses. (DOK 2)	d. Using the operator’s manual or technical manual for a specific piece of equipment, have the students inspect and service belts and hoses on the machine. <small>CS1, CS2, CS4, T6, R2, R4, R5</small>	d. Use the <i>Preventive Maintenance Checklist (2.7)</i> to evaluate student ability to perform this service.
e. Inspect and service a liquid coolant system. (DOK 2)	e. Using the operator’s manual or technical manual for a specific piece of equipment, have the students inspect and service the coolant system to include checking coolant condition and freeze point. <small>CS1, CS2, CS4, T6, R2, R4, R5</small>	e. Use the <i>Preventive Maintenance Checklist (2.7)</i> to evaluate student ability to perform this service.

Competency 5: Apply principles of engine diagnostics and testing. PST.01, PST.02, PST.03, PHYI 5, PS 1, PS 2

Suggested Enduring Understandings

1. Engine troubleshooting should begin by looking for the simplest solution to the problem and working forward. Troubleshooting involves determining if the problem is with the fuel, ignition, or compression system.
2. Testing an ignition system begins by establishing if the spark plug is sparking.
3. Low compression results in loss of power, excessive oil consumption, and hard starting capability.

Suggested Essential Questions

1. What are the steps in the troubleshooting process?
2. What is the process for testing a spark plug?
3. What is the process for testing compression?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe the steps in the diagnostic process. (DOK 1)	a. Use the Troubleshoot Small Engines PowerPoint presentation to provide information on the troubleshooting process and procedures. Provide the student with a scenario based on a piece of equipment that is not functioning properly. Ask the students to discuss what they think the potential cause of the problem is. From the discussion, lead into the meaning and importance of diagnosis as related to reducing repair costs and downtime. Based on scenario, identify the steps in the diagnosis problem, and provide specific examples of each step in solving the problem. <small>CS1, CS2, T6, R2</small>	a. Use a written test to evaluate student understanding of this indicator.
b. Test an ignition system. (DOK 2)	b. Use the Small Engine Troubleshooting PowerPoint presentation to discuss the procedures for testing an ignition system on a small engine. Have the students use these procedures to check a spark plug. <small>CS1, CS2, T3, T6</small>	b. Use the <i>Small Engine Troubleshooting Rubric (2.6)</i> to evaluate student performance on this indicator.
c. Test engine compression. (DOK 2)	c. Use the Small Engine Troubleshooting PowerPoint presentation to discuss the procedures for testing engine compression on a small engine. Have the students use these procedures to check a spark plug. <small>CS1, CS2, T6</small>	c. Use the <i>Small Engine Troubleshooting Rubric (2.6)</i> to evaluate student performance on this indicator.

Standards

AFNR Industry Standards

- PST.01. Use physical science principles and engineering applications with power, structural, and technical systems to solve problems and improve performance.
- PST.02. Design, operate, and maintain mechanical equipment, structures, biological systems, land treatment, power, and technology.
- PST.03. Service and repair mechanical equipment and power systems.

Applied Academic Credit Standards

Physics I

- PHYI 3 Develop an understanding of concepts related to work and energy.

Physical Science

- PS 2 Describe and explain how forces affect motion.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability

National Education Technology Standards for Students (NETS)

- T1 Creativity and Innovation
- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- R2 Supporting Details
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- S1 Interpretation of Data
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

Burkybile, C., Johnson, D., Lee, J., & Shelhamer, C. (2005). *Agricultural power & technology*. Upper Saddle River, NJ: Pearson.

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Phipps, L., Miller, G., & Lee, J. (2004). *Introduction to agricultural mechanics*. Upper Saddle River, NJ: Pearson.

Spurlin, J. (n.d.). *Troubleshooting Small Engines*. Retrieved June 11, 2010 from http://aged.ces.uga.edu/Browseable_Folders/Power_Points/Mechanics/Troubleshooting_Small_Engines.ppt

Science of Agricultural Mechanization

Unit 3: Analyzing Electrical and Electronic Systems

10 Hours

Competency 1: Describe and apply the use of electronic components and systems in agricultural equipment. PST.01, PST.02, PST.05, PHYI 5, PS 2

Suggested Enduring Understandings

1. The ability to read and interpret electronic drawings and schematics is necessary in order to service, troubleshoot, and repair electronic devices and systems.
2. The ability to measure and calculate voltage, resistance, and current in an electronic circuit is necessary in order to service, troubleshoot, and repair electronic devices and systems.
3. Understanding of the functions of basic electronic devices is necessary in order to service, troubleshoot, and repair electronic devices and systems.
4. Understanding of series, parallel, and series-parallel circuits is necessary in order to service, troubleshoot, and repair electronic devices and systems.

Suggested Essential Questions

1. What symbols are used in drawings and schematics to represent electronic devices?
2. How are voltage, resistance, and current measured in electronic circuits?
3. What is the function of devices commonly used in electronic circuits?
4. How are series, parallel, and series-parallel circuits constructed and tested?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Explore the use of integrated systems in agriculture and natural resources. (DOK 1)	a. Students will complete exercises in the <i>Discovery IV Electronics Trainer</i> module to gain experience and understanding of the different types of integrated systems. <small>CS1, CS2, CS4, T3, T4, T6, R2, R4, R5</small>	a. Use the evaluation activities (worksheets and posttests) in the <i>Discovery IV Electronics Trainer</i> module to evaluate student performance on this indicator.
b. Interpret symbols, schematics, and drawings of electrical and electronic systems. (DOK 2)	b. Have students complete the activities in Day 2 of the <i>Discovery IV Electronics Trainer</i> module to include becoming familiar with the main components of the trainer and with graphic symbols and schematics. <small>CS1, CS2, CS4, R2, R4</small>	b. Use the evaluation activities (worksheets and posttests) in the <i>Discovery IV Electronics Trainer</i> module to evaluate student performance on this indicator.
c. Measure and calculate resistance, voltage, and current in a circuit. (DOK 1)	c. Have the students complete activities in Day 3, Day 6, and Day 7 of the <i>Discovery IV Electronics Trainer</i> module to include use of the multimeter and measurement of resistance, voltage, and current in a circuit. <small>CS1, CS2, CS4, T4, T6, M1, M4, M7, R2, R4</small>	c. Use the evaluation activities (worksheets and posttests) in the <i>Discovery IV Electronics Trainer</i> module to evaluate student performance

		on this indicator.
d. Explore functions of basic electric and electronic devices (conductors, switches, diodes, rheostats, resistors, semiconductors, potentiometers, etc.). (DOK 2)	d. Students will study functions of basic electronic devices as integral parts of all of the activities in the <i>Discovery IV Electronics Trainer</i> module. <small>CS1, CS2, CS4, R2, R4</small>	d. Use the evaluation activities (worksheets and posttests) in the <i>Discovery IV Electronics Trainer</i> module to evaluate student performance on this indicator.
e. Construct, operate, and test electrical circuits for current, voltage, and resistance. (DOK 3)	e. Students will construct, operate, and test series, parallel, and series-parallel circuits as part of the activities in the <i>Discovery IV Electronics Trainer</i> module (days 9, 10, and 11). <small>CS1, CS2, CS4, T4, T6, M1, M4, R2, R4</small>	e. Use the evaluation activities (worksheets and posttests) in the <i>Discovery IV Electronics Trainer</i> module to evaluate student performance on this indicator.

Standards

AFNR Industry Standards

- PST.01. Use physical science principles and engineering applications with power, structural, and technical systems to solve problems and improve performance.
- PST.02. Design, operate, and maintain mechanical equipment, structures, biological systems, land treatment, power, and technology.
- PST.05. Apply technology principles in the use of agricultural technical systems.

Applied Academic Credit Standards

Physical Science

- PS 2 Describe and explain how forces affect motion.

Physics I

- PHY1 5 Apply an understanding of magnetism, electric fields, and electricity.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability

National Education Technology Standards for Students (NETS)

- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- M1 Basic Operations and Applications
- M4 Expressions, Equations, and Inequalities
- M7 Measurement
- R2 Supporting Details
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

Burkybile, C., Johnson, D., Lee, J., & Shelhamer, C. (2005). *Agricultural power & technology*. Upper Saddle River, NJ: Pearson.

CEV Video. (n.d.). *CEV Pathway: Power, Structural & Technical Systems Pathway* [DVD]. Lubbock, TX: Author.

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Science of Agricultural Mechanization

Unit 4: Using Hydraulic and Pneumatic Systems

15 Hours

Competency 1: Apply principles of hydraulics. PST.01, PST.02, PS 3

Suggested Enduring Understandings

1. Pascal’s law states that when pressure is applied to a confined liquid, it is transmitted equally to all surfaces.
2. The amount of force that can be generated by a hydraulic cylinder is determined by the surface area of the cylinder and the amount of pressure that is applied to the cylinder.
3. All hydraulic systems must contain an input source (pump or cylinder), a method of transmission (hose or tube), a control (valve or switch), and an output source (cylinder or motor).
4. Schematics and flowcharts for hydraulic systems show the placement, sequence, and fluid flow path.
5. Hydraulic circuits control pressure, flow, and force using valves, regulators, pumps, motors, and cylinders.

Suggested Essential Questions

1. How does Pascal’s law apply to hydraulic circuits?
2. What is the relationship between pressure and piston area?
3. What are the major parts of a hydraulic system, and how do they function?
4. What do symbols and graphics on a hydraulic system schematic represent?
5. How do I construct, operate, and test a hydraulic circuit?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe and apply Pascal’s law. (DOK 2)	a. Have students read and complete Experiment 4 in the <i>Discovery II: Discovering Hydraulics</i> module. <small>CS1, CS2, CS4, T3, T4, T6, M1, M4, M5, R3, R4, R5, S1, S2, S3</small>	a. Evaluate the worksheets in the <i>Discovery II: Discovering Hydraulics</i> student guide and the posttest.
b. Apply the relationship of area and force to pressure in a hydraulic system. (DOK 2)	b. Have the students read and complete the activities in Experiment 8 of the <i>Discovery II: Discovering Hydraulics</i> module. <small>CS1, CS2, CS4, T3, T4, T6, M1, M4, M5, R3, R4, R5, S1, S2, S3</small>	b. Evaluate the worksheets in the <i>Discovery II: Discovering Hydraulics</i> student guide and the posttest.
c. Identify the major components of a hydraulic system, and describe their purpose and function. (DOK 1)	c. Have students read and complete the activities in Experiment 1 of the <i>Discovery II: Discovering Hydraulics</i> student guide. <small>CS1, CS2, CS4, T3, T4, T6, M1, M4, M5, R3, R4, R5, S1, S2, S3</small>	c. Evaluate the worksheets in the <i>Discovery II: Discovering Hydraulics</i> student guide and the posttest.
d. Read and interpret a flowchart and schematic for a	d. Have students read and complete the activities in Experiment 2 of the <i>Discovery II: Discovering Hydraulics</i> student guide. <small>CS1, CS2, CS4, T3, T4, T6, M1, M4, M5, R3,</small>	d. Evaluate the worksheets in the <i>Discovery II:</i>

hydraulic system. (DOK 2)	R4, R5, S1, S2, S3	<i>Discovering Hydraulics</i> student guide and the posttest.
e. Construct, operate, and test hydraulic systems using valves, cylinders, hoses, and other devices. (DOK 2)	e. Have students complete experiments 5, 6, 7, and 8 of the <i>Discovery II: Discovering Hydraulics</i> student guide. CS1, CS2, CS4, T3, T4, T6, M1, M4, M5, R3, R4, R5, S1, S2, S3	e. Evaluate the worksheets in the <i>Discovery II: Discovering Hydraulics</i> student guide and the posttest.

Competency 2: Apply principles of pneumatics. PST.01, PST.02, PS 3

Suggested Enduring Understandings

1. Pneumatic systems function through the use of compressed gas or air to transmit power. Basic laws of physics that apply to pneumatic systems include Pascal's, Boyles, Bernoulli's, and Charles'.
2. Pneumatic systems do not transmit force as efficiently as hydraulic systems but offer advantages of speed, cost, and maintenance.
3. Pneumatic circuits and systems consist of a source, lines, controller valves and switches, and cylinders and motors.

Suggested Essential Questions

1. How do the basic laws of gases and fluids apply to pneumatic systems?
2. How are pneumatic systems different from hydraulic systems?
3. How are pneumatic system circuits constructed?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe and apply basic laws of pneumatic systems. (DOK 2)	a. Have students read and complete activities for Experiment 3 in the <i>Discovery I: Discovering Pneumatics</i> laboratory manual. This experiment covers Pascal's, Boyles, Bernoulli's and Charles' laws on fluids and gases. CS1, CS2, CS4, T3, T4, T6, M1, M4, M5, R3, R4, R5, S1, S2, S3	a. Evaluate the worksheets and quiz associated with Experiment 3.
b. Compare and contrast the operation of a pneumatic system to the operation of a hydraulic system. (DOK 2)	b. After completing both the hydraulic and pneumatic systems competencies, have students create a chart that describes the commonalities and differences in the two systems. Characteristics that should be included on the chart include transport medium used (gas verses liquid), speed of action, safety factors, cost, compressibility of medium, and type of system (open, closed, or both). CS1, CS2, CS4, T3, T4, T6, R3, R4, R5, W2, W4, W5	b. Evaluate the students' charts using the <i>Hydraulic/Pneumatic System Comparison Chart Rubric (4.1)</i> .
c. Construct, operate, and test a pneumatic system using various valves, cylinders, and other devices. (DOK 2)	c. Have students complete experiments 4–13 in the <i>Discovery I: Discovering Pneumatics</i> laboratory manual covering the different components of a pneumatic system including filters, lubricators, flow control valves, regulators, flowmeters, directional control valves, and cylinders. CS1, CS2, CS4, T3, T4, T6, M1, M4, M5, R3, R4, R5, S1, S2, S3	c. Evaluate the worksheets and quiz associated with each experiment.

Standards

AFNR Industry Standards

- PST.01. Use physical science principles and engineering applications with power, structural, and technical systems to solve problems and improve performance.
- PST.02. Design, operate, and maintain mechanical equipment, structures, biological systems, land treatment, power, and technology.

Applied Academic Credit Standards

Physical Science

- PS 3 Demonstrate an understanding of general properties and characteristics of waves.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability

National Education Technology Standards for Students (NETS)

- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- M1 Basic Operations and Applications
- M4 Expressions, Equations, and Inequalities
- M5 Graphical Representations
- R3 Sequential, Comparative, and Cause–Effect Relationships
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- S1 Interpretation of Data
- S2 Scientific Investigation
- S3 Evaluation of Models, Inferences, and Experimental Results
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

- Burkybile, C., Johnson, D., Lee, J., & Shelhamer, C. (2005). *Agricultural power & technology*. Upper Saddle River, NJ: Pearson.
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Science of Agricultural Mechanization

Unit 5: Principles of Internal Combustion Engines

20 Hours

Competency 1: Describe the functions and operation of major systems of a small gasoline engine. ^{PST.01,}

PST.03, PS 1, PS 2, PS 5, PHYI 2, PHYI 3

Suggested Enduring Understandings

1. When working with any small engine, it is essential that proper safety procedures be followed to protect the person working on the engine and others.
2. In a small engine, power is obtained by the combustion of a fuel–air mixture that pushes a piston down and turns a crankshaft.
3. Four-stroke cycle engines generate one power stroke for each four strokes of the piston, while two-stroke cycle engines generate power on every second stroke.
4. Gasoline engines depend upon a spark for ignition, are usually lighter in weight, and are usually less expensive to purchase. Diesel engines use compression to ignite the fuel–air mixture to provide more power and are less expensive to operate and maintain.
5. The engine lubrication system functions to reduce friction and wear, increase compression, clean carbon deposits, and help cool the engine.
6. Engine oil is selected on the basis of quality (API classification) and viscosity (thickness). Gasoline is selected on the basis of its octane rating, and diesel fuel is selected based on a cetane rating. It is critical to select the proper fuel and lubricants for an engine.
7. In air cooled engines, most of the cooling is done by the flywheel fins and the shroud.
8. Small gasoline engine fuel systems are usually composed of a fuel tank and a carburetor.
9. Most small engines today use a solid-state (breakerless) ignition system.

Suggested Essential Questions

1. What safety rules must be followed in working with small engines?
2. Where does the power in a small engine come from?
3. What is the difference in a four-stroke and two-stroke small engine?
4. What are the major differences in gasoline and diesel small engines?
5. What are the functions of the lubrication system in a small engine?
6. How are engine lubricants and fuels selected?
7. How do the flywheel fins and engine shroud help keep a small engine cool?
8. What is the function of a small engine fuel system?
9. What is the function of a small gasoline engine ignition system?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss and apply safety principles while working on engines. (DOK 1)	a. Prior to teaching this competency, have students read the chapter on <i>Fundamental of Small Engines</i> from the text (Herren, 2010). Introduce the competency by asking students how many different uses they can name for internal combustion engines. Use the PowerPoint presentation Small Engine Safety to discuss the importance of safety practices in working on or around small engines. Have students	a. Use a written test to evaluate student performance on this competency.

	summarize the major points of the presentation in their electronic journals or blogs. <small>CS1, CS2, T6, R1, R2, R4, R5, W2, W4, W5</small>	
b. Describe the basic principle of combustion and force as it is applied to an internal combustion engine. (DOK 1)	b. Use the PowerPoint presentation Small Engines: Principles of Operation to describe, discuss, and illustrate the basic principle of combustion and force in an internal combustion engine. Have students summarize the major points of the presentation in their electronic journals or blogs. <small>CS1, CS2, T6, R1, R2, R4, R5, W2, W4, W5</small>	b. Use a written test to evaluate student performance on this competency.
c. Compare and contrast the operating principles of four-stroke and two-stroke gasoline engines. (DOK 2)	c. Use the PowerPoint presentation Small Engines: Principles of Operation to describe, discuss, and contrast the operation of four-stroke and two-stroke internal combustion engines. Have students associate each engine with its different applications and discuss the advantages and disadvantages of each engine. <small>CS1, CS2</small>	c. Use a written test to evaluate student performance on this competency.
d. Compare and contrast the operating principles of gasoline and diesel engines. (DOK 2)	d. Have students research gasoline and diesel engines and complete a worksheet that compares and contrasts the operation principles and features of each. Conduct a class discussion to summarize major points, and have students record these points in their electronic journals or notebooks. <small>CS1, CS2, T3, T6, R1, R2, R4, R5, W2, W4, W5</small>	d. Use a written test to evaluate student performance on this competency.
e. Describe the parts and functions of the lubrication system. (DOK 1)	e. Have students view the video Engine Lubrication and make notes on the parts of different types of lubrication systems (splash, dipper, and pressure fed) and the functions that lubrication plays in the operation of an engine (reducing friction, cooling the engine, etc.). <small>CS1, CS2, R1, R2, R4, R5</small>	e. Have students post their work to their journals or blogs.
f. Select proper lubricants and fuels based on the manufacturer's recommendation. (DOK 1)	f. Using the information gained from the Engine Lubrication Systems Web page, discuss the concepts of grade and quality of fuel and lubricants including octane and cetane rating, viscosity, and quality grade. List major points on the LCD projector, and have students record these points in their electronic journals or notebooks. <small>CS1, CS2, T6, W2, W4, W5</small>	f. Use a written test to evaluate student performance on this competency.
g. Describe the parts and function of an air cooled engine cooling system. (DOK 1)	g. On a partially disassembled engine, show students how the shroud and cooling fins channel air over the engine to prevent it from overheating. Discuss the importance of keeping these items free of dust and debris to prevent overheating. <small>CS1, CS2</small>	g. Use a written test to evaluate student performance on this competency.
h. Describe the parts and function of small gasoline engine fuel system. (DOK 1)	h. Use the PowerPoint presentation Carburetion to show students how air and fuel are mixed in the carburetor of an engine to form a mixture for combustion. Discuss the concepts of air flow associated with carburetion and adjustments that can be made to the fuel-air mixture. <small>CS1, CS2</small>	h. Use a written test to evaluate student performance on this competency.
i. Describe the parts and functions of a small gasoline engine ignition system.	i. Have students read the information on the Ignition System Web page. Discuss the two types of ignition systems commonly used on small gasoline engines today (solid state and breaker point), and describe	i. Use a written test to evaluate student performance on this competency.

(DOK 1) how they function. ^{CS1, CS2}

Competency 2: Disassemble, inspect, and reassemble a small gasoline engine. ^{PST.03, PS 1, PS 2}

Suggested Enduring Understandings

1. Disassembly, inspection, and reassembly of an engine involve a knowledge of basic engine operating principles and the ability to follow directions and use tools.

Suggested Essential Questions

1. How is a small gasoline engine disassembled?
2. How are disassembled small gasoline engines inspected?
3. How are small gasoline engines reassembled?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Disassemble a small gasoline engine to include removing the head, oil pan, piston and crankshaft assembly, and valves. (DOK 2)	a. Divide the class into groups of 2–3 students, and assign each student an engine. Using the Web site Engine Dissection Project , have students follow the steps in dissecting an engine. ^{CS1, CS2, CS4, T3, T4, T6}	a. Use the <i>Engine Dissection, Inspection, and Reassembly Checklist (5.1)</i> to evaluate student performance on this indicator.
b. Inspect and measure parts part of the engine to verify that it is within tolerances as set by the manufacturer. (DOK 2)	b. Provide students with a set of manufacturer’s specifications and tolerances for engine parts. Demonstrate how to take proper measurements using feeler gauges, micrometers, or calipers. ^{CS1, CS2, CS4, T4, T6, M1, M7}	b. Use the <i>Engine Dissection, Inspection, and Reassembly Checklist (5.1)</i> to evaluate student performance on this indicator.
c. Reassemble the engine and test for proper operation (compression, ignition, etc.). (DOK 2)	c. Have students follow the reassembly steps found on the Web site Engine Dissection Project . ^{CS1, CS2, CS4, T4, T6}	c. Use the <i>Engine Dissection, Inspection, and Reassembly Checklist (5.1)</i> to evaluate student performance on this indicator.

Standards

AFNR Industry Standards

- PST.01. Use physical science principles and engineering applications with power, structural, and technical systems to solve problems and improve performance.
- PST.02. Design, operate, and maintain mechanical equipment, structures, biological systems, land treatment, power, and technology.
- PST.03. Service and repair mechanical equipment and power systems.

Applied Academic Credit Standards

Physical Science

- PS 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- PS 2 Describe and explain how forces affect motion.
- PS 5 Investigate and apply principles of physical and chemical changes in matter.

Physics I

- PHYI 2 Develop an understanding of concepts related to forces and motion.
- PHYI 3 Develop an understanding of concepts related to work and energy.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability

National Education Technology Standards for Students (NETS)

- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- M1 Basic Operations and Applications
- M7 Measurement
- R1 Main Ideas and Author's Approach
- R2 Supporting Details
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- W2 Focusing on the Topic
- W3 Developing a Position
- W4 Organizing Ideas
- W5 Using Language

Suggested References

- Briggs & Stratton. (n.d.). *Ignition System* Retrieved February 23, 2009, from http://faqs.custhelp.com/cgi-bin/faqs.cfg/php/enduser/std_adp.php?p_faqid=3426&p_created=1098407641&p_sid=YOk1dcrj&p_accessibility=0&p_redirect=&p_lva=3427&p_sp=cF9zcmNoPTEmcF9zb3J0X2J5PSZwX2dyaWRzb3J0PSZwX3Jvd19jbnQ9NzcsNzcmcF9wcm9kc30mcf9jYXRzPTAmcF9wdj0
- Briggs & Stratton. (n.d.). *Engine lubrication, single*. Retrieved February 23, 2009, from http://www.briggsandstratton.com/videos/vp_modeltypecode4.html
- Burkybile, C., Johnson, D., Lee, J., & Shelhamer, C. (2005). *Agricultural power & technology*. Upper Saddle River, NJ: Pearson.
- Carburetion*. (n.d.). Retrieved February 23, 2009, from http://aged.ces.uga.edu/browseable_folders/power_points/Mechanics/Carburetion.ppt
- CEV Video. (n.d.). *CEV Pathway: Power, Structural & Technical Systems Pathway* [DVD]. Lubbock, TX: Author.
- Dufour, G., Chifor, G., & Frise, P. (n.d.). *Engine dissection project*. Retrieved on February 23, 2009, from http://staff.washington.edu/ryanlee/Engine/Handouts/01_hnd_EngineIntro.htm
- Engine Lubrication Systems*. (n.d.). Retrieved February 23, 2009, from <http://www.tarleton.edu/~mcgregor/A%20EN%202013/2013%20Labs/Lubrication/Lubric%20Systems%20Lab.pdf>
- Herren, R. (2010). *Agricultural mechanics: Fundamentals & applications*. Clifton Park, NJ: Delmar/Cengage.
- Morris, J. *Small engine safety*. (n.d.). (PowerPoint) Retrieved February 23, 2009, from http://aged.ces.uga.edu/Browseable_Folders/Power_Points/Mechanics/Small_Engine_Safety.ppt
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Science of Agricultural Mechanization

Unit 6: Principles of Metal Fabrication (Arc Welding)

15 Hours

Competency 1: Describe basic equipment, operations, and procedures, including safety precautions, of arc welding. ^{PST.03}

Suggested Enduring Understandings

1. Arc welding involves the use of high voltage electrical current and generates high temperatures and toxic fumes. The use of personal protective devices and safety precautions is essential to protect the health of the welder.
2. The most common types of arc welders are the SMAW (stick), GAMW (MIG), and GTAW (TIG). Each type has its strengths and limitations and can be used for several different types of welding.
3. Welding accessories that must be used in arc welding include electrode holders, grounding clamps, wire brushes, chipping hammers, and work clamps and guides.
4. SMAW electrodes consist of a metal rod surrounded by a flux that shields the arc from outside air. Electrodes are classified by tensile strength, diameter, type of metal, and welding position.
5. In setting up an arc welder for a given job, a welder must take into consideration the type and thickness of the metal being welded before selecting the appropriate electrode and setting the machine controls.
6. Welds are classified as to type (fillet or groove), joint (butt, corner, edge, lap and T), and position (flat, vertical horizontal, and overhead).
7. In making a weld, the angle of the electrode, speed of electrode travel, motion of the electrode, and machine settings must be controlled. Different welds and positions require different procedures.

Suggested Essential Questions

1. What personal protection devices are necessary for safely using an arc welder?
2. What safety procedures are necessary for safely using an arc welder?
4. What are the most common types of arc welding machines, and where are they used?
5. What accessories are used in arc welding, and what is their purpose?
6. What factors must be taken into account in selecting a specific electrode for a job?
7. What factors must be considered in setting up an arc welding machine for a specific job?
8. What are the different weld types, joints, and positions?
9. What factors must be taken into consideration in making a weld?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
<p>a. Identify and describe the function and use of personal safety equipment and apparel (clothing, gloves, helmets, safety glasses/goggles etc.). (DOK 1)</p>	<p>a. Prior to teaching this competency, have the students read the chapter on Arc Welding Mild Steel and GAMW/GTAW Welding in the text (Herren, 2010). Discuss potential dangers from arc welding including damage to eyes, lungs, and skin. Display each piece of safety equipment, and discuss how it contributes to a safe working environment. ^{CS1, CS2, CS4,R2, R4, R5}</p>	<p>a. Use a written test to initially evaluate student understanding of this indicator. Students must score 90% or more to work in lab. Students will be</p>

		observed during laboratory practice and scored on their use of safety procedures and equipment.
b. Discuss and demonstrate safety precautions to use to prevent electrical shock, eye and skin damage, and respiratory damage while welding. (DOK 1)	b. Use the PowerPoint presentation Arc Welding Safety Notes to lead a discussion on common hazards associated with welding and the precautions that can be followed to prevent accidents or damages. Summarize major points, and have students record them in their electronic journals or notebooks. <small>CS1, CS2, CS4</small>	b. Observe students in preparing welding area for lab work. Make corrections as needed.
c. List the three major types of arc welders (SMAW, MIG, and TIG) used in agricultural equipment repair and fabrication, and discuss their characteristics and applications. (DOK 1)	c. Introduce the competency by providing a definition of arc welding. Use the PowerPoint presentation Arc Welding Methods and Processes to present information on types of welders, accessories and tools, and electrodes and their use and application. Invite a welder to speak to the class on his or her career and present information about the different types of welders and equipment used by welders. <small>CS1, CS2, CS4, T6</small>	c. Use a written test to evaluate student understanding of this indicator.
d. Describe the purpose/function of tools and accessories used in arc welding (electrode holder, ground clamp, cables, electrodes, wire, chipping hammer, and wire brushes). (DOK 1)	d. Demonstrate the proper use and function of welders and equipment. <small>CS1, CS2, CS4, T6</small>	d. Use a written test to evaluate student understanding of this indicator. Students will be further evaluated on proper use of tools and accessories during laboratory practice.
e. Associate common SMAW electrodes and GMAW wire with their weld characteristics and proper use. (DOK 2)	e. Prepare a PowerPoint presentation to present information on the following electrodes to the students including explaining their use and application (E6011, E6013 for AC, and E6010, E7014, E7018 for DC, GTAW wire). <small>CS1, CS2, CS4, T6</small>	e. Use a written test to evaluate student understanding of this indicator.
f. Examine the relationship of amperage, voltage, and electrode type and diameter to electrode and metal type and thickness. (DOK 1)	f. Have students read and interpret the amperage chart associated with the welding machines in the laboratory to determine the proper settings for different sizes and types of electrodes and thickness and type of metal. Discuss the results of improper amperage adjustment on weld appearance and strength. (Sample metals used should be mild steel, high strength steel to include stainless steel, cast iron, and aluminum.) <small>CS1, CS2, CS4, T6</small>	f. Use a written test to evaluate student understanding of this indicator. Students will be further evaluated on their ability to select the correct amperage and voltage for a given job during laboratory practice.

g. Identify the difference between a bead, groove, and fillet weld and how they are used in the four weld joints (butt, lap, corner, and T-weld). (DOK 1)	g. Using the PowerPoint presentation Types of Welds and Weld Joints , show the students a model of the difference types of welds. Show students how these welds are used in the four joints: butt, corner, edge, and fillet. <small>CS1, CS2, CS4, T6</small>	g. Use a written test to evaluate student understanding of this indicator.
h. Compare welding procedures for welding in different welding positions. (DOK 1)	h. Demonstrate to students the different types of welding positions, and explain how different techniques are used for each position including angle of electrode, speed of travel, machine adjustment, and electrode motion. <small>CS1, CS2, CS4, T6</small>	h. Use a written test to evaluate student understanding of this indicator. Students will be further evaluated on their ability to demonstrate correct welding procedures for a given job during laboratory practice.

Competency 2: Perform arc welding techniques. PST.03

Suggested Enduring Understandings

1. Striking an arc is very similar to striking a match. This procedure must be mastered before attempting to construct a weld.
2. A flat butt weld involves welding two pieces of metal that are side by side in the flat position.
3. A flat fillet weld involves welding two pieces of metal that are at an angle to each other.

Suggested Essential Questions

1. What is the procedure for striking an arc and running a flat bead?
2. What is the procedure for constructing a flat butt weld?
3. What is the procedure for constructing a flat fillet weld?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Demonstrate the procedure for striking an arc and running a flat bead. (DOK 2)	a. Use a SMAW welder and appropriate electrode such as an E6011 and a mild steel plate; demonstrate to students the proper procedure for striking and running a bead. Have students practice in the laboratory. <small>CS1, CS2, CS4, T6</small>	a. Use the <i>Weld Joint Construction Rubric (6.1)</i> to evaluate student performance on this indicator.
b. Construct a flat butt weld. (DOK 2)	b. Demonstrate how to construct a flat butt weld. Use a job sheet to detail the procedures for welding a flat butt weld. Have students complete a flat butt weld in the laboratory for evaluation. <small>CS1, CS2, CS4, T6</small>	b. Use the <i>Weld Joint Construction Rubric (6.1)</i> to evaluate student performance on this indicator.
c. Construct a flat fillet weld. (DOK 2)	c. Demonstrate how to make a fillet weld. Use a Job sheet to detail the procedure to follow in making a fillet weld. Have students complete a flat butt weld in the laboratory for evaluation. <small>CS1, CS2, CS4, T6</small>	c. Use the <i>Weld Joint Construction Rubric (6.1)</i> rubric to evaluate student performance on this indicator.

Standards

AFNR Industry Standards

PST.03 Service and repair mechanical equipment and power systems.

21st Century Learning Standards

CS1 Flexibility & Adaptability

CS2 Initiative & Self-Direction

CS4 Productivity & Accountability

National Education Technology Standards for Students (NETS)

T6 Technology Operations and Concepts

ACT College Readiness Standards

R2 Supporting Details

R4 Meaning of Words

R5 Generalizations and Conclusions

Suggested References

- Arc welding safety notes*. (n.d.). (PowerPoint). Retrieved June 11, 2010 from http://www.nebo.edu/misc/learning_resources/ppt/6-12/arc_welding_safety.ppt
- Burkybile, C., Johnson, D., Lee, J., & Shelhamer, C. (2005). *Agricultural power & technology*. Upper Saddle River, NJ: Pearson.
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- Klepec, B. (n.d.). *Types of welds and weld joints* (PowerPoint). Retrieved June 11, 2010 from http://aged.ces.uga.edu/Browseable_Folders/Power_Points/Mechanics/Types_of_Welds_and_Welded_Joints.ppt
- Phipps, L., Miller, G., & Lee, J. (2004). *Introduction to agricultural mechanics*. Upper Saddle River, NJ: Pearson.
- Sadler, H. (n.d.). *Arc welding methods and processes* (PowerPoint). Retrieved June 11, 2010 from http://www.ncsea.com/downloads/events/conference2008/Arc_Welding_Fundamentals.pdf

Science of Agricultural Mechanization

Unit 7: Principles of Metal Fabrication (Oxyacetylene Cutting Operations)

10 Hours

Competency 1: Describe and demonstrate principles of oxyfuel cutting procedures. ^{PST.03}

Suggested Enduring Understandings

1. Mixtures of oxygen and acetylene gases are potentially explosive, and proper safety procedures and personal protection are necessary for safe operation.
2. The major parts of an oxyacetylene cutting unit are the cylinders, regulators, hoses, torch body, and cutting attachment.
3. There is a set procedure for safely setting up, igniting, and shutting down an oxyacetylene torch unit that must be followed at all times.
4. There are three different types of flames that can be generated by an oxyacetylene torch: oxidizing, neutral, and carbonizing.
5. Making a cut with an oxyacetylene cutting torch involves preheating the metal and moving the torch in a steady smooth motion at the proper distance and speed across the metal.

Suggested Essential Questions

1. What safety and personal protection procedures are necessary for oxyacetylene torch operation?
2. What are the major parts of an oxyacetylene cutting unit?
3. What is the procedure for setting up, igniting, and shutting down an oxyacetylene torch?
4. What are the characteristics of the three different types of flames that can be generated by an oxyacetylene torch?
5. What is the procedure for making a cut in mild steel with an oxyacetylene cutting torch?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe and apply safety procedures and personal protection equipment for oxyfuel cutting. (DOK 3)	a. Prior to teaching this competency, have students read the chapter on Using Gas Welding Equipment in the text (Herren, 2010). Provide each student with a copy of the material on Oxyacetylene Welding Safety , and lead a class discussion with demonstrations where appropriate on safety procedures and equipment. <small>CS1, CS2, CS4, T6</small>	a. Use a written test to evaluate student understanding of this indicator. Students should score 90% or higher before being allowed to use the oxyfuel equipment. Student will be further rated on safety performance in laboratory activities.
b. Identify and describe the function of the different parts of the oxyfuel cutting unit. (DOK 1)	b. Use the PowerPoint presentation Oxyacetylene Welding and an actual welding and cutting unit to discuss parts and function of oxyfuel cutting unit to include cylinders, regulators, hoses, and torch styles and attachments. <small>CS4, CS5 NETS T1, T2, T3, T4, E1 E2, E3, M5, M7, R2 S1, W2, W4</small>	b. Have students record information in journals or blogs. Have students conduct a presentation to the instructor and corrections as needed.

c. Set up, ignite, and shut down oxyfuel cutting equipment. (DOK 3)	c. The instructor will provide students with detailed instructions on how to set up equipment for making cut in mild steel, ignite and adjust the torch, and shut down the equipment. The instructor will then demonstrate each step of the procedure. <small>CS1, CS2, CS4, T6</small>	c. Use a written test to evaluate student understanding of this indicator. Students will be further rated using the <i>Oxyacetylene Cutting Operations Checklist (7.1)</i> during laboratory exercises.
d. Describe the characteristics and uses of the different oxyfuel flames (neutral, oxidizing, and carbonizing). (DOK 3)	d. Use the PowerPoint presentation Oxyacetylene Welding and an actual welding and cutting unit, the instructor should demonstrate the set up of a cutting torch to produce neutral, carburizing, and oxidizing flames and describe the characteristics and uses of each flame. <small>CS1, CS2, CS4, T6</small>	d. Use the <i>Oxyacetylene Cutting Operations Checklist (7.1)</i> to evaluate student performance on this indicator.
e. Demonstrate how to make a cut in a mild steel plate. (DOK 3)	e. The instructor will provide students with a mild steel plate and observe students for safety and proper procedure. The instructor will make corrections as necessary. <small>CS1, CS2, CS4, T6</small>	e. Use the <i>Oxyacetylene Cutting Operations Checklist (7.1)</i> to evaluate student performance on this indicator.

Standards

AFNR Industry Standards

PST.03. Service and repair mechanical equipment and power systems.

21st Century Learning Standards

CS1 Flexibility & Adaptability

CS2 Initiative & Self-Direction

CS4 Productivity & Accountability

National Education Technology Standards for Students (NETS)

T6 Technology Operations and Concepts

Suggested References

- American Welding Society. (n.d.). *Oxyacetylene welding (OAW)* (PowerPoint). Retrieved February 24, 2009, from www.aws.org/educators/Library/0000/000631.ppt
- Burkybile, C., Johnson, D., Lee, J., & Shelhamer, C. (2005). *Agricultural power & technology*. Upper Saddle River, NJ: Pearson.
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Science of Agricultural Mechanization

Student Competency Profile

Student Name: _____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student and serve as a cumulative record of competencies achieved in the course. In the blank before each competency, place the date on which the student mastered the competency.

Unit 1: Introduction to Agricultural Mechanization

- _____ 1. Investigate the role of mechanical technology in agriculture.
- _____ 2. Identify science applications in agricultural mechanization technology.
Demonstrate career and leadership skills required for employment in the agricultural
- _____ 3. mechanization industry.
- _____ 4. Identify safety precautions and equipment for the work site and school laboratory.

Unit 2: Management and Operation of Agricultural Equipment

- _____ 1. Examine concepts of machinery management and maintenance.
- _____ 2. Operate mechanized equipment in a safe and proper manner.
- _____ 3. Describe and perform principles of preventive maintenance.
- _____ 4. Perform preventive maintenance services.
- _____ 5. Apply principles of engine diagnostics and testing.

Unit 3: Analyzing Electrical and Electronic Systems

- _____ 1. Describe and apply the use of electronic components and systems in agricultural equipment.

Unit 4: Using Hydraulic and Pneumatic Systems

- _____ 1. Apply principles of hydraulics.
- _____ 2. Apply principles of pneumatics.

Unit 5: Principles of Internal Combustion Engines

- _____ 1. Describe the functions and operations of major systems of a small gasoline engine.
- _____ 2. Disassemble, inspect, and reassemble a small gasoline engine.

Unit 6: Principles of Metal Fabrication (Arc Welding)

Describe basic equipment, operations, and procedures, including safety precautions, of arc

- _____ 1. welding.
- _____ 2. Perform arc welding techniques.

Unit 7: Principles of Metal Fabrication (Oxyacetylene Cutting Operations)

- _____ 1. Describe and demonstrate principles of oxyfuel cutting procedures.

Appendix A: Suggested Rubrics, Assignments, and Checklists

Name: _____

Date: _____

Period: _____

Emerging Technology Fact Sheet Rubric (1.1)

<i>The student does the following:</i>	Excellent	Good	Needs Improvement	Unacceptable
	4	3	2	1
Graphic or picture clearly illustrates the technology.				
A clear concise description of how the technology is used is provided.				
A clear concise description of where the technology is used is provided.				
Spelling, grammar, and punctuation are correct.				
Sentence structure including subject verb agreement is correct.				
All information provided is accurate and current.				

Name: _____

Date: _____

Period: _____

Calculating Area and Volume Assignment (1.2)

Use a calculator if necessary to solve the problems below. Show the formula or calculations that you used in each step.

1. A lawn is 200 ft wide and 120 ft long. How many square feet are in the lawn? If a soil test indicates that you need to apply 2.4 lb of 8-8-8 fertilizer per 1,000 sq ft, how many pounds of fertilizer should be applied?
2. A field is 1,320 feet square. How many acres are in the field if an acre is equal to 43,560 sq ft? If you wanted to apply 50 lb of ammonium nitrate to each acre, how many pounds of this material would you need to buy?
3. A grain bin has a radius of 16 ft and stands 30 ft in height from the edge of the roof. How many cubic feet of grain can be stored in the bin if it is filled to the top of the wall? If cubic foot is equal to 0.8 bushel of grain, how many bushels of grain will the bin hold if filled to edge of the roof?
4. A grain bin has a diameter of 32 ft and stands 36 ft in height from the edge of the roof to the ground. How many cubic feet of grain can be stored in the bin if it is filled to the top of the wall? If cubic foot is equal to 0.8 bushel of grain, how many bushels of grain will the bin hold if filled to edge of the roof?
5. A fuel tank has a radius of 2 ft and a length of 8 ft. How many cubic feet are in the tank? If one cubic foot of fuel is equal to approximately 7.5 gal., how many gallons will the tank hold if filled to the top?

Name: _____
Date: _____
Period: _____

21st Century Life and Career Skills (1.3)

Today's life and work environments require far more than thinking skills and content knowledge. The ability to navigate the complex life and work environments in the globally competitive information age requires students to pay rigorous attention to developing adequate life and career skills.

CS1 Global Awareness

1. Using 21st century skills to understand and address global issues
2. Learning from and working collaboratively with individuals representing diverse cultures, religions and lifestyles in a spirit of mutual respect and open dialogue in personal, work and community contexts
3. Understanding other nations and cultures, including the use of non-English languages

CS2 Financial, Economic, Business and Entrepreneurial Literacy

1. Knowing how to make appropriate personal economic choices
2. Understanding the role of the economy in society
3. Using entrepreneurial skills to enhance workplace productivity and career options

CS3 Civic Literacy

1. Participating effectively in civic life through knowing how to stay informed and understanding governmental processes
2. Exercising the rights and obligations of citizenship at local, state, national and global levels
3. Understanding the local and global implications of civic decisions

CS4 Health Literacy

1. Obtaining, interpreting and understanding basic health information and services and using such information and services in ways that enhance health
2. Understanding preventive physical and mental health measures, including proper diet, nutrition, exercise, risk avoidance and stress reduction
3. Using available information to make appropriate health-related decisions
4. Establishing and monitoring personal and family health goals
5. Understanding national and international public health and safety issues

CS5 Environmental Literacy

1. Demonstrate knowledge and understanding of the environment and the circumstances and conditions affecting it, particularly as relates to air, climate, land, food, energy, water and ecosystems
2. Demonstrate knowledge and understanding of society's impact on the natural world (e.g., population growth, population development, resource consumption rate, etc.)
3. Investigate and analyze environmental issues, and make accurate conclusions about effective solutions
4. Take individual and collective action towards addressing environmental challenges (e.g., participating in global actions, designing solutions that inspire action on environmental issues)

CSS2-Learning and Innovation Skills

CS6 Creativity and Innovation

1. Think Creatively
2. Work Creatively with Others
3. Implement Innovations

CS7 Critical Thinking and Problem Solving

1. Reason Effectively
2. Use Systems Thinking
3. Make Judgments and Decisions
4. Solve Problems

CS8 Communication and Collaboration

1. Communicate Clearly
2. Collaborate with Others

CSS3-Information, Media and Technology Skills

CS9 Information Literacy

1. Access and Evaluate Information
2. Use and Manage Information

CS10 Media Literacy

1. Analyze Media
2. Create Media Products

CS11 ICT Literacy

1. Apply Technology Effectively

CSS4-Life and Career Skills

CS12 Flexibility and Adaptability

1. Adapt to change
2. Be Flexible

CS13 Initiative and Self-Direction

1. Manage Goals and Time
2. Work Independently
3. Be Self-directed Learners

CS14 Social and Cross-Cultural Skills

1. Interact Effectively with others
2. Work Effectively in Diverse Teams

CS15 Productivity and Accountability

1. Manage Projects
2. Produce Results

CS16 Leadership and Responsibility

1. Guide and Lead Others
2. Be Responsible to Others

Name: _____
Date: _____
Period: _____

21st Century Life and Career Skills Assessment Rubric (1.4)

The following scale can be used to assess application of each of the Life and Career Skills of students.

- | | |
|-------------|---|
| Superior | (18–20 points) The student consistently demonstrates all aspects of this skill in classroom and laboratory activities. |
| Exceptional | (15–17 points) The student consistently demonstrates most of the aspects of this skills in classroom and laboratory activities but lapses at times on one to two of the indicators. |
| Adequate | (12–14 points) The student demonstrates knowledge of the skill during classroom and laboratory activities but lapses on three or more indicators from time to time. |
| Improving | (9–11 points) The student is vaguely aware of the skill but shows only marginal evidence of being able to apply it in the classroom or laboratory. |
| Minimal | (0–8 points) The student consistently fails to demonstrate knowledge or application of the skill. |

**Flexibility and
Adaptability**

**Initiative & Self-
Direction**

**Social & Cross-Cultural
Skills**

**Productivity &
Accountability**

**Leadership &
Responsibility**

TOTAL SCORE

Name: _____
Date: _____
Period: _____

Equipment Maintenance Record Rubric (2.1)

Equipment Identification: Provided fields for equipment name, model number, serial number, date of purchase, purchase price, and expected life	20
Scheduled Maintenance: For each item that is listed on the manufacturer's maintenance schedule, a field is provided for the date of service, materials and supplies used, and next estimated date of service.	40
Repairs and Replacements: A field is provided for each repair or replacement not covered under scheduled maintenance to include date of repair, parts and materials used, and costs.	40
TOTAL SCORE	100

Name: _____
Date: _____
Period: _____

Equipment Repair Work Order Assignment (2.2)

Scenario #1: Replace belts and blades on a riding lawn mower. Parts used: 1 – main drive belt (\$22.00); 1 – secondary drive belt (18.00); 2- 22-in. lawnmower blades (\$13.50). Labor used 1.5 hr at \$22.00 per hour. Tax 7% of parts and labor

Scenario #2: Perform annual maintenance on a diesel tractor. Parts used: 1 oil filter (\$14.75); 6 qt SAE 30 motor oil (\$3.45/qt); 1 pleated air filter (\$35.00); 2 fuel filters (\$18.00); 1 hydraulic system filter (\$35.00); 8 gal. SAE90 hydraulic fluid (\$14.00/gal.); 3 gal. antifreeze (\$6.00/gal.). 1 lower radiator hose (\$16.70), 1 upper radiator hose (\$18.30). Labor 3 hr at \$35.00 per hour. Tax 7% of parts and labor

Scenario #3: Repair string trimmer engine. Parts used: 1 carburetor (\$35.00). Labor used: 1 hr at \$22.00 per hour. Tax 7% of parts and labor

Scenario #4: Service push type lawn mower. Parts used: 1 qt SAE 30 motor oil (\$3.00); 1 spark plug (\$3.25); 1 foam type air cleaner (\$4.45). Labor used 1 hr at \$22.00 per hour. Tax 7% of parts and labor

Name: _____
Date: _____
Period: _____

Vehicle Inspection, Start-up, and Operation Checklist (2.3)

Place a check mark in the appropriate space for each item.

Pre-start Inspection

- Checked engine oil
- Checked fuel level
- Checked coolant level
- Checked transmission and/or hydraulic fluid level
- Checked tires
- Checked engine, transmission, and hydraulic system for visible fluid leaks
- Checked warning lamps or horns and/or SMV emblem
- Checked brakes
- Checked transmission shift control
- Checked clutch position
- Checked throttle position
- Checked instrument panel warning lights for operation before starting

Post Start Inspection

- Checked engine oil pressure, ammeter, ammeter, and temperature instruments

Operating Procedures

- Smoothly engaged clutch or transmission shift lever
- Selected proper engine speed
- Selected proper ground speed
- Wore seat belt at all times
- Set throttle and parking brake before getting off tractor
- Maintained control of tractor at all times
- Retarded throttle and set parking brake before shutting down the engine

Name: _____
Date: _____
Period: _____

Tractor Service Intervals and Specifications Assignment (2.4)

Use an owner's manual to determine the following information regarding tractor maintenance intervals and specifications.

1. How often should engine oil be changed, and what viscosity and classification of oil should be used? _____
2. How often should be engine oil filter be changed?

3. How often should the transmission and/or hydraulic fluid be changed, and what viscosity and classification of fluid should be used?

4. How often should the air filter be serviced or replaced?

5. How often should the cooling system be flushed and refilled, and what type of coolant should be used?

6. How often should the fuel system be serviced?

7. How often should the battery be cleaned and inspected?

8. What items should be checked on a daily basis or every 10 hr of operation?

Name: _____

Date: _____

Period: _____

Daily Maintenance Checklist (2.5)

Rate the student's ability to perform the following maintenance checks and procedures using the following scale:

4 – Can perform consistently and accurately without need of any supervision or direction

3 – Can perform consistently and accurately with minimum supervision or direction

2 – Can perform consistently and accurately with moderate supervision or direction

1 – Cannot perform consistently or accurately without direct supervision

_____ 1. Check engine oil level.

_____ 2. Check transmission/hydraulic fluid level.

_____ 3. Check coolant level.

_____ 4. Check tires for proper inflation.

_____ 5. Visually inspect machine for visible fluid leaks, broken parts, and so forth.

Name: _____

Date: _____

Period: _____

Small Engine Troubleshooting Rubric (2.6)

Rate the student's ability to perform the following maintenance checks and procedures using the following scale:

- 4 – Can perform consistently and accurately without need of any supervision or direction
- 3 – Can perform consistently and accurately with minimum supervision or direction
- 2 – Can perform consistently and accurately with moderate supervision or direction
- 1 – Cannot perform consistently or accurately without direct supervision

Testing a Spark Plug

- _____ 1. Removed and visually inspected plug for excessive oil or carbon buildup
- _____ 2. Checked and adjusted spark plug gap
- _____ 3. Reinstalled spark plug and used spark plug tester to determine if electricity was being supplied

Testing Engine Compression

- _____ 1. Visually inspected cylinder head gasket for signs of leakage
- _____ 2. Checked compression by turning crankshaft backward and noting "rebound" or by using a compression tester

Name: _____
Date: _____
Period: _____

Preventive Maintenance Checklist (2.7)

Rate the student’s ability to perform the following maintenance checks and procedures using the following scale:

- 4– Can perform consistently and accurately without need of any supervision or direction
- 3– Can perform consistently and accurately with minimum supervision or direction
- 2 – Can perform consistently and accurately with moderate supervision or direction
- 1 – Cannot perform consistently or accurately without direct supervision

Inspect and Service An Air Cleaner (Pleated Paper Type)

- _____ 1. Removed air cleaner element
- _____ 2. Visually inspected element and determined if it should be serviced or replaced
- _____ 3. If serviceable, serviced element by tapping out small amounts of visible dust and trash
- _____ 4. Replaced air cleaner element
- _____ 5. Used all tools and supplies in a safe and proper manner
- _____ 6. Observed personal safety rules and used appropriate personal safety equipment at all times

Inspect and Service Lubrication System

- _____ 1. Prepared engine for servicing by running to normal operating temperature
- _____ 2. Drained engine oil into appropriate container
- _____ 3. Removed and drained oil filter(s)
- _____ 4. Replaced oil filters with new filters after coating gaskets with light coat of engine oil
- _____ 5. Replaced drain plug and filled with manufacturer’s recommended quantity and quality of oil
- _____ 6. Ran engine and checked for visible leaks and proper oil pressure
- _____ 7. Checked engine oil level
- _____ 8. Disposed of used oil and oil filters appropriately
- _____ 9. Used all tools and supplies in a safe and proper manner
- _____ 10. Observed personal safety rules and used appropriate personal safety equipment at all times

Inspect and Service Fuel System

- _____ 1. Allowed engine to cool
- _____ 2. Checked fuel sediment bowl for sediment or water. Removed and serviced if necessary
- _____ 3. Closed fuel tank shut off valve
- _____ 4. Removed, drained, and discarded old fuel filter
- _____ 5. Installed new fuel filter
- _____ 6. Installed sediment bowl
- _____ 7. Bled air from system (if required)
- _____ 8. Cranked engine and checked for visible leaks
- _____ 9. Used all tools and supplies in a safe and proper manner
- _____ 10. Observed personal safety rules and used appropriate personal safety equipment at all times

Inspect and Service Belts and Hoses

- _____ 1. Allowed machine to cool before proceeding
- _____ 2. Checked all fuel hoses for signs of cracking or leakage. Replaced as necessary
- _____ 3. Checked all belts for signs of cracking or excessive wear. Replaced as necessary
- _____ 4. Checked all belts for proper tension and made adjustments as necessary
- _____ 5. Used all tools and supplies in a safe and proper manner
- _____ 6. Observed personal safety rules and used appropriate personal safety equipment at all times

Inspect and Service Liquid Coolant Systems

- _____ 1. Allowed machine to cool before proceeding
- _____ 2. Checked coolant level, added coolant if necessary
- _____ 3. Checked radiator and hoses for signs of clogged fins, leaks, or other damage
- _____ 4. Cleaned dust and trash from radiator and area around it
- _____ 5. Checked condition and freezing point of coolant. Added coolant if necessary

(Steps 6–15 apply if coolant is to be replaced)

- _____ 6. Slowly opened radiator cap to relieve any pressure in the system
- _____ 7. Drained coolant from radiator into appropriate container
- _____ 8. Drained engine block coolant into appropriate container
- _____ 9. Drain coolant recovery tank (if present) into appropriate container
- _____ 10. Flushed cooling system with water, then drained engine, radiator, and coolant recovery tank again
- _____ 11. Replaced all drain plugs and refilled engine block, radiator, and coolant recovery tank with manufacturer's recommended coolant mixture
- _____ 12. Checked radiator cap for signs of gasket wear or excessive corrosion and replace if necessary

- _____ 13. Replaced radiator cap and ran engine to operating temperature
- _____ 14. Stopped engine, checked coolant recovery tank for proper level of coolant, and added coolant if necessary
- _____ 15. Disposed of old coolant mixture in appropriate manner
- _____ 16. Used all tools and supplies in a safe and proper manner
- _____ 17. Observed personal safety rules and used appropriate personal safety equipment at all times

Name: _____
 Date: _____
 Period: _____

Hydraulic/Pneumatic System Comparison Chart Rubric (4.1)

Required Content	The chart includes all required content elements as well as additional information.	All required content elements are included on the chart.	All but 1–2 of the required content elements are included on the chart.	Three or more required content elements were missing.
Labels	All items of importance on the chart are clearly labeled with labels that are easy to read.	Almost all items of importance on the chart are clearly labeled with labels that are easy to read.	Many items of importance on the chart are clearly labeled with labels that are easy to read.	Labels are too small to read, or no important items were labeled.
Attractiveness	The chart is exceptionally attractive in terms of design, layout, and neatness.	The chart is attractive in terms of design, layout, and neatness.	The chart is acceptably attractive though it may be a bit messy.	The chart is distractingly messy or very poorly designed.
Grammar	There are no grammatical or mechanical mistakes on the chart.	There are one to two grammatical or mechanical mistakes on the chart.	There are three to four grammatical or mechanical mistakes on the chart.	There are more than four grammatical or mechanical mistakes on the chart.
				TOTAL

Name: _____

Date: _____

Period: _____

Engine Dissection, Inspection, and Reassembly Checklist (5.1)

Place a check by each step that the student completed satisfactorily.

Engine Disassembly

- _____ 1. Removed flywheel shroud, side shroud, and cylinder shroud
- _____ 2. Removed muffler, air vane, and fuel system (carburetor and fuel tank)
- _____ 3. Removed valve spring cover
- _____ 4. Removed spark plug
- _____ 5. Removed cylinder head
- _____ 6. Removed crankcase cover
- _____ 7. Removed camshaft and tappets
- _____ 8. Removed valves
- _____ 9. Removed flywheel
- _____ 10. Remove crankshaft, connecting rod and piston
- _____ 11. Inspected piston, connecting rod, and crankshaft for excessive wear

Engine Inspection

(Measure each part as specified, and compare it to the manufacturer's tolerance. Indicate if the part is still acceptable for use or if it needs to be replaced.)

Spark plug gap

Armature air gap

Piston diameter

Cylinder diameter

Crankshaft diameter

- _____ 1. Inspected gaskets and seals for wear or leakage
- _____ 2. Inspected electrical system for cracked wiring, loose terminals, etc.
- _____ 3. Inspected muffler and exhaust system for wear

Engine Reassembly

- _____ 1. Replaced piston, connecting rod, and crankshaft
- _____ 2. Replaced valves, tappets, and camshaft
- _____ 3. Replaced crankcase cover
- _____ 4. Replaced cylinder head
- _____ 5. Replaced spark plug
- _____ 6. Replaced valve spring cover
- _____ 7. Replaced muffler, air vane, and fuel system
- _____ 8. Replaced shrouds

Engine Testing

- _____ 1. Tested engine compression
- _____ 2. Tested engine spark

General Skills

- _____ 1. Practiced general workplace skills (teamwork, responsibility, etc.)
- _____ 2. Consistently selected and used proper tools in a proper manner
- _____ 3. Consistently followed all safety practices and procedures

Name: _____
Date: _____
Period: _____

Weld Joint Construction Rubric (6.1)

Rate the student's ability to perform the following welding procedures using the following scale:

- 4 – Can perform consistently and accurately without need of any supervision or direction
- 3 – Can perform consistently and accurately with minimum supervision or direction
- 2 – Can perform consistently and accurately with moderate supervision or direction
- 1 – Cannot perform consistently or accurately without direct supervision

Striking an Arc and Running a Flat Bead

- _____ 1. Student used proper safety equipment and followed proper safety procedures.
- _____ 2. Student prepared metal for welding and set up equipment correctly (amperage, polarity, grounding, etc.).
- _____ 3. Student struck an arc and held it until puddle formed.
- _____ 4. Student maintained correct electrode angle, arc length, and speed of travel.
- _____ 5. Student ran a 1–2-in. flat bead that showed evidence of uniform width and proper penetration.
- _____ 6. Student filled in the crater at the end of the bead before breaking the arc.

Constructing a Flat Butt Weld

- _____ 1. Student used proper safety equipment and followed proper safety procedures.
- _____ 2. Student prepared metal for welding and set up equipment correctly (amperage, polarity, grounding, etc.).
- _____ 3. Student positioned metal pieces at proper distance to each other and tacked both ends.
- _____ 4. Student maintained correct electrode angle, arc length, and speed of travel in making the weld.
- _____ 5. Student cleaned weld by chipping slag and using a wire brush.
- _____ 6. Weld showed evidence of uniform width and proper penetration.

Constructing a Flat Fillet Weld

- _____ 1. Student used proper safety equipment and followed proper safety procedures.
- _____ 2. Student prepared metal for welding and set up equipment correctly (amperage, polarity, grounding, etc.).
- _____ 3. Student positioned metal pieces at proper distance to each other and tacked both ends.
- _____ 4. Student maintained correct electrode angle, arc length, and speed of travel in making the weld.
- _____ 5. Student cleaned weld by chipping slag and using a wire brush.
- _____ 6. Weld showed evidence of uniform width and proper penetration.

Name: _____

Date: _____

Period: _____

Oxyacetylene Cutting Operations Checklist (7.1)

Rate the student's ability to perform the following welding procedures using the following scale:

- 4 – Can perform consistently and accurately without need of any supervision or direction
- 3 – Can perform consistently and accurately with minimum supervision or direction
- 2 – Can perform consistently and accurately with moderate supervision or direction
- 1 – Cannot perform consistently or accurately without direct supervision

Set up an Oxyacetylene Cutting Torch

- _____ 1. Student used proper safety equipment and followed proper safety procedures.
- _____ 2. Student checked oxygen and acetylene torch valves to make sure they were closed.
- _____ 3. Student checked oxygen and acetylene regulator adjusting screws to make sure that regulators were not engaged.
- _____ 4. Student opened oxygen cylinder valve slowly until pressure was indicated on regulator, then all the way open.
- _____ 5. Student opened acetylene cylinder valve one-half turn.
- _____ 6. Student opened oxygen and acetylene torch valves one-eighth turn.
- _____ 7. Student set oxygen regulator to appropriate pressure for metal to be cut and tip size.
- _____ 8. Student set acetylene regulator to appropriate pressure for metal to be cut and tip size.
- _____ 9. Student closed the oxygen and acetylene torch valves.
- _____ 10. Student checked all fittings and hoses for visible leaks.

Ignite an Oxyacetylene Torch

- _____ 1. Student used proper safety equipment and followed proper safety procedures.
- _____ 2. Student opened acetylene torch valve one-eighth turn.
- _____ 3. Student held torch away from his or her body and any flammable materials and used a spark igniter to light the acetylene.
- _____ 4. Student opened acetylene torch valve until flame was $\frac{1}{4}$ in. off the torch tip.
- _____ 5. Student opened the oxygen torch valve until a neutral flame was obtained.

Cutting Mild Steel

- _____ 1. Student used proper safety equipment and followed proper safety procedures.
- _____ 2. Student prepared metal for cutting including making sure that slag from the cut would not ignite any flammable materials.
- _____ 3. Student checked torch flame while holding down the oxygen preheat lever and made adjustments as necessary.
- _____ 4. Student held the torch over the edge of the metal to be cut at a slight angle away from the direction of the cut until the edge of the metal became cherry red.

- _____ 5. Student pressed the oxygen lever and moved the torch at an appropriate speed and angle to make the cut.
- _____ 6. Student examined the cut and made adjustments to procedure before proceeding to next cut.

Shutting Down an Oxyacetylene Torch

- _____ 1. Student closed the acetylene torch valve first, then the oxygen torch valve to extinguish the flame.
- _____ 2. Student closed acetylene and oxygen tank valves completely.
- _____ 3. Student opened oxygen and acetylene torch valves to bleed existing gases from the regulators, hoses, and torch body.
- _____ 4. Student closed oxygen and acetylene torch valves.
- _____ 5. Student unscrewed oxygen and acetylene regulator screws until no pressure or resistance was felt on the screw.
- _____ 6. Student coiled hoses and stored all equipment and accessories in assigned location.

Appendix B: 21st Century Skills Standards¹

Today's life and work environments require far more than thinking skills and content knowledge. The ability to navigate the complex life and work environments in the globally competitive information age requires students to pay rigorous attention to developing adequate life and career skills.

CSS1-21st Century Themes

CS1 Global Awareness

1. Using 21st century skills to understand and address global issues
2. Learning from and working collaboratively with individuals representing diverse cultures, religions and lifestyles in a spirit of mutual respect and open dialogue in personal, work and community contexts
3. Understanding other nations and cultures, including the use of non-English languages

CS2 Financial, Economic, Business and Entrepreneurial Literacy

1. Knowing how to make appropriate personal economic choices
2. Understanding the role of the economy in society
3. Using entrepreneurial skills to enhance workplace productivity and career options

CS3 Civic Literacy

1. Participating effectively in civic life through knowing how to stay informed and understanding governmental processes
2. Exercising the rights and obligations of citizenship at local, state, national and global levels
3. Understanding the local and global implications of civic decisions

CS4 Health Literacy

1. Obtaining, interpreting and understanding basic health information and services and using such information and services in ways that enhance health
2. Understanding preventive physical and mental health measures, including proper diet, nutrition, exercise, risk avoidance and stress reduction
3. Using available information to make appropriate health-related decisions
4. Establishing and monitoring personal and family health goals
5. Understanding national and international public health and safety issues

CS5 Environmental Literacy

1. Demonstrate knowledge and understanding of the environment and the circumstances and conditions affecting it, particularly as relates to air, climate, land, food, energy, water and ecosystems
2. Demonstrate knowledge and understanding of society's impact on the natural world (e.g., population growth, population development, resource consumption rate, etc.)
3. Investigate and analyze environmental issues, and make accurate conclusions about effective solutions
4. Take individual and collective action towards addressing environmental challenges (e.g., participating in global actions, designing solutions that inspire action on environmental issues)

CSS2-Learning and Innovation Skills

CS6 Creativity and Innovation

1. Think Creatively
2. Work Creatively with Others
3. Implement Innovations

CS7 Critical Thinking and Problem Solving

1. Reason Effectively

¹21st century skills. (n.d.). Washington, DC: Partnership for 21st Century Skills.

2. Use Systems Thinking
3. Make Judgments and Decisions
4. Solve Problems

CS8 Communication and Collaboration

1. Communicate Clearly
2. Collaborate with Others

CSS3-Information, Media and Technology Skills

CS9 Information Literacy

1. Access and Evaluate Information
2. Use and Manage Information

CS10 Media Literacy

1. Analyze Media
2. Create Media Products

CS11 ICT Literacy

1. Apply Technology Effectively

CSS4-Life and Career Skills

CS12 Flexibility and Adaptability

1. Adapt to change
2. Be Flexible

CS13 Initiative and Self-Direction

1. Manage Goals and Time
2. Work Independently
3. Be Self-directed Learners

CS14 Social and Cross-Cultural Skills

1. Interact Effectively with others
2. Work Effectively in Diverse Teams

CS15 Productivity and Accountability

1. Manage Projects
2. Produce Results

CS16 Leadership and Responsibility

1. Guide and Lead Others
2. Be Responsible to Others

Appendix C: MS Academic Standards

MISSISSIPPI SCIENCE FRAMEWORK 2010

Marine and Aquatic Science

- AQ 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- AQ 2 Develop an understanding of physical and chemical properties of water and aquatic environments.
- AQ 3 Apply an understanding of the diverse organisms found in aquatic environments.
- AQ 4 Draw conclusions about the relationships between human activity and aquatic organisms.

1. **Apply inquiry-based and problem-solving processes and skills to scientific investigations.**
 - a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
 - b. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
2. **Develop an understanding of physical and chemical properties of water and aquatic environments.**
 - a. Analyze the physical and chemical properties of water, and justify why it is essential to living organisms. (DOK 1)
 - b. Explain the causes and characteristics of tides. (DOK 1)
 - c. Research, create diagrams, and summarize principles related to waves and current characteristics and formation. (DOK 2)
 - d. Compare and contrast the physical and chemical parameters of dissolved O₂, pH, temperature, salinity, and results obtained through analysis of different water column depths/zones. (DOK 2)
 - e. Investigate the causes and effects of erosion and discuss conclusions. (DOK 2)
 - f. Describe and differentiate among the major geologic features of specific aquatic environments. (DOK 1)
 - Plate tectonics
 - Rise, slope, elevation, and depth
 - Formation of dunes, reefs, barrier/volcanic islands, and coastal/flood plains
 - Watershed formation as it relates to bodies of freshwater
 - g. Compare and contrast the unique abiotic and biotic characteristics of selected aquatic ecosystems. (DOK 2)
 - Barrier island, coral reef, tidal pool, and ocean
 - River, stream, lake, pond, and swamp
 - Bay, sound, estuary, and marsh
3. **Apply an understanding of the diverse organisms found in aquatic environments.**
 - a. Analyze and explain the diversity and interactions among aquatic life. (DOK 3)
 - Adaptations of representative organisms for their aquatic environments

- Relationship of organisms in food chains/webs within aquatic environments
 - b. Research, calculate, and interpret population data. (DOK 2)
 - c. Research and compare reproductive processes in aquatic organisms. (DOK 2)
 - d. Differentiate among characteristics of planktonic, nektonic, and benthic organisms. (DOK 1)
 - e. Explore the taxonomy of aquatic organisms, and use dichotomous keys to differentiate among the organisms. (DOK 2)
 - f. Research and explain the symbiotic relationships in aquatic ecosystems. (DOK 3)
- 4. Draw conclusions about the relationships between human activity and aquatic organisms.**
- a. Describe the impact of natural and human activity on aquatic ecosystems, and evaluate the effectiveness of various solutions to environmental problems. (DOK 3)
 - Sources of pollution in aquatic environments and methods to reduce the effects of the pollution
 - Effectiveness of a variety of methods of environmental management and stewardship
 - Effects of urbanization on aquatic ecosystems and the effects of continued expansion
 - b. Research and cite evidence of the effects of natural phenomena such as hurricanes, floods, or drought on aquatic habitats and organisms. (DOK 3)
 - c. Discuss the advantages and disadvantages involved in applications of modern technology in aquatic science. (DOK 2)
 - Careers related to aquatic science
 - Modern technology within aquatic science (e.g., mariculture and aquaculture)
 - Contributions of aquatic technology to industry and government

Biology I

BI01 1	Apply inquiry-based and problem-solving processes and skills to scientific investigations.
BI01 2	Describe the biochemical basis of life, and explain how energy flows within and between the living systems.
BI01 3	Investigate and evaluate the interaction between living organisms and their environment.
BI01 4	Analyze and explain the structures and function of the levels of biological organization.
BI01 5	Demonstrate an understanding of the molecular basis of heredity.
BI01 6	Demonstrate an understanding of principles that explain the diversity of life and biological evolution.

- 1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.**
- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
 - d. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - e. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 2)
 - f. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - g. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - h. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - i. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Describe the biochemical basis of life, and explain how energy flows within and between the living systems.

- a. Explain and compare with the use of examples the types of bond formation (e.g., covalent, ionic, hydrogen, etc.) between or among atoms. (DOK 2)
 - Subatomic particles and arrangement in atoms
 - Importance of ions in biological processes
- b. Develop a logical argument defending water as an essential component of living systems (e.g., unique bonding and properties including polarity, high specific heat, surface tension, hydrogen bonding, adhesion, cohesion, and expansion upon freezing). (DOK 2)
- c. Classify solutions as acidic, basic, or neutral, and relate the significance of the pH scale to an organism's survival (e.g., consequences of having different concentrations of hydrogen and hydroxide ions). (DOK 2)
- d. Compare and contrast the structure, properties, and principle functions of carbohydrates, lipids, proteins, and nucleic acids in living organisms. (DOK 2)
 - Basic chemical composition of each group
 - Building components of each group (e.g., amino acids, monosaccharides, nucleotides, etc.)
 - Basic functions (e.g., energy, storage, cellular, heredity) of each group
- e. Examine the life processes to conclude the role enzymes play in regulating biochemical reactions. (DOK 2)
 - Enzyme structure
 - Enzyme function, including enzyme-substrate specificity and factors that affect enzyme function (pH and temperature)
- f. Describe the role of adenosine triphosphate (ATP) in making energy available to cells. (DOK 1)
 - ATP structure
 - ATP function
- g. Analyze and explain the biochemical process of photosynthesis and cellular respiration, and draw conclusions about the roles of the reactant and products in each. (DOK 3)
 - Photosynthesis and respiration (reactants and products)
 - Light-dependent reactions and light independent reactions in photosynthesis, including requirements and products of each
 - Aerobic and anaerobic processes in cellular respiration, including products each and energy differences

3. Investigate and evaluate the interaction between living organisms and their environment.

- a. Compare and contrast the characteristics of the world's major biomes (e.g., deserts, tundra, taiga, grassland, temperate forest, tropical rainforest). (DOK 2)
 - Plant and animal species
 - Climate (temperature and rainfall)
 - Adaptations of organisms
- b. Provide examples to justify the interdependence among environmental elements. (DOK 2)
 - Biotic and abiotic factors in an ecosystem (e.g., water, carbon, oxygen, mold, leaves)
 - Energy flow in ecosystems (e.g., energy pyramids and photosynthetic organisms to herbivores, carnivores, and decomposers)
 - Roles of beneficial bacteria
 - Interrelationships of organisms (e.g., cooperation, predation, parasitism, commensalism, symbiosis, and mutualism)
- c. Examine and evaluate the significance of natural events and human activities on major ecosystems (e.g., succession, population growth, technology, loss of genetic diversity, consumption of resources). (DOK 2)

4. Analyze and explain the structures and function of the levels of biological organization.

- a. Differentiate among plant and animal cells and eukaryotic and prokaryotic cells. (DOK 2)
 - Functions of all major cell organelles and structures (e.g., nucleus, mitochondrion, rough ER, smooth ER, ribosomes, Golgi bodies, vesicles, lysosomes, vacuoles, microtubules,

- microfilaments, chloroplast, cytoskeleton, centrioles, nucleolus, chromosomes, nuclear membrane, cell wall, cell membrane [active and passive transport], cytosol)
- Components of mobility (e.g., cilia, flagella, pseudopodia)
- b. Differentiate between types of cellular reproduction. (DOK 1)
 - Main events in the cell cycle and cell mitosis (including differences in plant and animal cell divisions)
 - Binary fission (e.g., budding, vegetative propagation, etc.)
 - Significance of meiosis in sexual reproduction
 - Significance of crossing over
- c. Describe and differentiate among the organizational levels of organisms (e.g., cells, tissues, organs, systems, types of tissues.) (DOK 1)
- d. Explain and describe how plant structures (vascular and nonvascular) and cellular functions are related to the survival of plants (e.g., movement of materials, plant reproduction). (DOK 1)
- 5. **Demonstrate an understanding of the molecular basis of heredity.**
 - a. Analyze and explain the molecular basis of heredity and the inheritance of traits to successive generations by using the Central Dogma of Molecular Biology. (DOK 3)
 - Structures of DNA and RNA
 - Processes of replication, transcription, and translation
 - Messenger RNA codon charts
 - b. Utilize Mendel's laws to evaluate the results of monohybrid Punnett squares involving complete dominance, incomplete dominance, codominance, sex linked, and multiple alleles (including outcome percentage of both genotypes and phenotypes.) (DOK 2)
 - c. Examine inheritance patterns using current technology (e.g., pedigrees, karyotypes, gel electrophoresis). (DOK 2)
 - d. Discuss the characteristics and implications of both chromosomal and gene mutations. (DOK 2)
 - Significance of nondisjunction, deletion, substitutions, translocation, frame shift mutation in animals
 - Occurrence and significance of genetic disorders such as sickle cell anemia, Tay-Sachs disorder, cystic fibrosis, hemophilia, Down syndrome, color blindness
- 6. **Demonstrate an understanding of principles that explain the diversity of life and biological evolution.**
 - a. Draw conclusions about how organisms are classified into a hierarchy of groups and subgroups based on similarities that reflect their evolutionary relationships. (DOK 2)
 - Characteristics of the six kingdoms
 - Major levels in the hierarchy of taxa (e.g., kingdom, phylum/division, class, order, family, genus, and species)
 - Body plans (symmetry)
 - Methods of sexual reproduction (e.g., conjugation, fertilization, pollination)
 - Methods of asexual reproduction (e.g., budding, binary fission, regeneration, spore formation)
 - b. Critique data (e.g., comparative anatomy, Biogeography, molecular biology, fossil record, etc.) used by scientists (e.g., Redi, Needham, Spallanzani, Pasteur) to develop an understanding of evolutionary processes and patterns. (DOK 3)
 - c. Research and summarize the contributions of scientists (including Darwin, Malthus, Wallace, Lamarck, and Lyell) whose work led to the development of the theory of evolution. (DOK 2)
 - d. Analyze and explain the roles of natural selection, including the mechanisms of speciation (e.g., mutations, adaptations, geographic isolation) and applications of speciation (e.g., pesticide and antibiotic resistance). (DOK 3)
 - e. Differentiate among chemical evolution, organic evolution, and the evolutionary steps along the way to aerobic heterotrophs and photosynthetic autotrophs. (DOK 2)

Biology II

BIOII 1	Apply inquiry-based and problem-solving processes and skills to scientific investigations.
BIOII 2	Describe and contrast the structures, functions, and chemical processes of the cell.
BIOII 3	Investigate and discuss the molecular basis of heredity.
BIOII 4	Demonstrate an understanding of the factors that contribute to evolutionary theory and natural selection.
BIOII 5	Develop an understanding of organism classification.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- Use current technologies such as CD-ROM, DVD, Internet, and on-line data search to explore current research related to a specific topic. (DOK 3)
- Clarify research questions and design laboratory investigations. (DOK 3)
- Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
- Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)

2. Describe and contrast the structures, functions, and chemical processes of the cell.

- Relate the structure and function of a selectively permeable membrane to its role in diffusion and osmosis. (DOK 2)
- Summarize how cell regulation controls and coordinates cell growth and division. (DOK 2)
- Analyze and describe the function of enzymes in biochemical reactions. (DOK 2)
 - The impact of enzymatic reactions on biochemical processes
 - Factors that affect enzyme function (e.g., pH, concentration, temperature, etc.)
- Differentiate between photosynthesis and cellular respiration. (DOK 2)
 - Cellular sites and major pathways of anaerobic and aerobic respiration (with reactants, products, and ATP per monosaccharide)
 - Cellular respiration with respect to the sites at which they take place, the reactions involved, and the energy input and output in each stage (e.g., glycolysis, Krebs cycle, electron transport chain)
 - Pigments, absorption, reflection of light, and light-dependent and light-independent reactions of photosynthesis
 - Oxidation and reduction reactions

3. Investigate and discuss the molecular basis of heredity.

- Explain how the process of meiosis clarifies the mechanism underlying Mendel's conclusions about segregation and independent assortment on a molecular level. (DOK 1)
- Research and explain how major discoveries led to the determination of DNA structure. (DOK 2)
- Relate gene expression (e.g., replication, transcription, translation) to protein structure and function. (DOK 2)
 - Translation of a messenger RNA strand into a protein
 - Processing by organelles so that the protein is appropriately packaged, labeled, and eventually exported by the cell
 - Messenger RNA codon charts to determine the effects of different types of mutations on amino acid sequence and protein structure (e.g., sickle cell anemia resulting from base substitution mutation)
 - Gene expression regulated in organisms so that specific proteins are synthesized only when they are needed by the cell (e.g., allowing cell specialization)
- Assess the potential implications of DNA technology with respect to its impact on society. (DOK 3)

- Modern DNA technologies (e.g., polymerase chain reaction (PCR), gene splicing, gel electrophoresis, transformation, recombinant DNA) in agriculture, medicine, and forensics
 - e. Develop a logical argument defending or refuting bioethical issues arising from applications of genetic technology (e.g., the human genome project, cloning, gene therapy, stem cell research). (DOK 3)
- 4. Demonstrate an understanding of the factors that contribute to evolutionary theory and natural selection.**
- a. Explain the history of life on earth, and infer how geological changes provide opportunities and constraints for biological evolution. (DOK 2)
 - Main periods of the geologic timetable of earth's history
 - Roles of catastrophic and gradualistic processes in shaping planet Earth
 - b. Provide support for the argument based upon evidence from anatomy, embryology, biochemistry, and paleontology that organisms descended with modification from common ancestry. (DOK 2)
 - c. Identify and provide supporting evidence for the evolutionary relationships among various organisms using phylogenetic trees and cladograms. (DOK 2)
 - d. Formulate a scientific explanation based on fossil records of ancient life-forms, and describe how new species could originate as a result of geological isolation and reproductive isolation. (DOK 2)
 - e. Compare and contrast the basic types of selection (e.g., disruptive, stabilizing, directional, etc.). (DOK 2)
 - f. Cite examples to justify behaviors that have evolved through natural selection (e.g., migration, parental care, use of tools, etc.). (DOK 1)
 - g. Research and explain the contributions of 19th century scientists (e.g., Malthus, Wallace, Lyell, and Darwin) on the formulation of ideas about evolution. (DOK 2)
 - h. Develop a logical argument describing ways in which the influences of 20th century science have impacted the development of ideas about evolution (e.g., synthetic theory of evolution, molecular biology). (DOK 3)
 - i. Analyze changes in an ecosystem resulting from natural causes (succession), changes in climate, human activity (pollution and recycling), or introduction of nonnative species. (DOK 2)
- 5. Develop an understanding of organism classification.**
- a. Classify organisms according to traditional Linnaean classification characteristics (e.g., cell structure, biochemistry, anatomy, fossil record, methods of reproduction) and the cladistic approach. (DOK 2)
 - b. Categorize organisms according to the characteristics that distinguish them as Bacteria, Archaea, or Eucarya. (DOK 1)
 - Bacteria, fungi, and protists
 - Characteristics of invertebrates (e.g., habitat, reproduction, body plan, locomotion) as related to phyla (e.g., Porifera, Cnidarians, Nematoda, Annelida, Platyhelminthes, and Arthropoda) and classes (e.g., Insecta, Crustacea, Arachnida, Mollusca, Echinodermata)
 - Characteristics of vertebrates (e.g., habitat, reproduction, body plan, locomotion) as related to classes (e.g., Agnatha, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, Mammalia)
 - Nomenclature of various types of plants (e.g., Bryophyta, Tracheophyta, Gymnospermae, Angiospermae, Monocotyledonae, Dicotyledonae, vascular plants, nonvascular plants)

Botany

- BO 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BO 2 Distinguish among the characteristics of botanical organization, structure, and function.
- BO 3 Demonstrate an understanding of plant reproduction.
- BO 4 Draw conclusions about the factors that affect the adaptation and survival of plants.
- BO 5 Relate an understanding of plant genetics to its uses in modern living.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols

- Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
 - b. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
2. **Distinguish among the characteristics of botanical organization, structure, and function.**
- a. Relate plant cell structures to their functions (e.g., major organelles, cell wall components, photosynthetic chemical reactions, plant pigments, plant tissues, roots, stems, leaves, flowers). (DOK 1)
 - b. Differentiate the characteristics found in various plant divisions. (DOK 2)
 - Differences and similarities of nonvascular plants
 - Characteristics of seed-bearing and non-seed bearing vascular plants relative to taxonomy
 - Major vegetative structures and their modifications in angiosperms and gymnosperms
 - c. Compare and contrast leaf modifications of gymnosperms and angiosperms (e.g., needles, overlapping scales, simple leaves, compound leaves, evergreen trees, and deciduous trees). (DOK 2)
 - d. Apply the modern classification scheme utilized in naming plants to identify plant specimens. (DOK 2)
 - Classification scheme used in botany
 - Classification of native Mississippi plants
 - e. Use inquiry to investigate and discuss the physical and chemical processes of plants. (DOK 3)
 - Relationships among photosynthesis, cellular respiration, and translocation
 - Importance of soil type and soil profiles to plant survival
 - Mechanism of water movement in plants
 - Effects of environmental conditions for plant survival
 - Tropic responses of a plant organ to a given stimulus
3. **Demonstrate an understanding of plant reproduction.**
- a. Compare and contrast reproductive structures (e.g., cones, flowers). (DOK 2)
 - b. Differentiate among the vegetative organs of monocots, herbaceous dicots, and woody dicots. (DOK 1)
 - c. Differentiate between the structures and processes of sexual and asexual reproduction in plants. (DOK 1)
 - Reproductive structures, their modifications, and the mechanisms involved in plant reproduction
 - Functions of flower parts, seeds, cones
 - Spore production in bryophytes and ferns
 - d. Explain and provide examples of the concept of alternation of generations and its examples. (DOK 2)
 - e. Categorize types of fruits and methods of seed distribution in plants. (DOK 1)
 - f. Research and compare various methods of plant propagation. (DOK 2)
4. **Draw conclusions about the factors that affect the adaptation and survival of plants.**
- a. List and assess several adaptations of plants to survive in a given biome. (DOK 2)
 - b. Design and conduct an experiment to determine the effects of environmental factors on photosynthesis. (DOK 3)
 - c. Explain how natural selection and the evolutionary consequences (e.g., adaptation or extinction) support scientific explanations for similarities of ancient life-forms in the fossil record and molecular similarities present in living organisms. (DOK 2)
 - d. Research factors that might influence or alter plant stability, and propose actions that may reduce the negative impacts of human activity. (DOK 2)
5. **Relate an understanding of plant genetics to its uses in modern living.**
- a. Research, prepare, and present a position relating to issues surrounding the current botanical trends involving biotechnology. (DOK 3)

- b. Apply an understanding of the principles of plant genetics to analyze monohybrid and dihybrid crosses, and predict the potential effects the crosses might have on agronomy and agriculture. (DOK 3)
- c. Discuss the effects of genetic engineering of plants on society. (DOK 2)
- d. Describe the chemical compounds extracted from plants, their economical importance, and the impact on humans. (DOK 3)
 - Plant extracts, their function, and origin
 - Impact of the timber industry on local and national economy

Chemistry I

- CHI 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- CHI 2 Demonstrate an understanding of the atomic model of matter by explaining atomic structure and chemical bonding.
- CHI 3 Develop an understanding of the periodic table.
- CHI 4. Analyze the relationship between microscopic and macroscopic models of matter.
- CHI 5 Compare factors associated with acid/base and oxidation/reduction reactions.

1. **Apply inquiry-based and problem-solving processes and skills to scientific investigations.**

- a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
- b. Clarify research questions and design laboratory investigations. (DOK 3)
- c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
- e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)

2. **Demonstrate an understanding of the atomic model of matter by explaining atomic structure and chemical bonding.**

- a. Describe and classify matter based on physical and chemical properties and interactions between molecules or atoms. (DOK 1)
 - Physical properties (e.g., melting points, densities, boiling points) of a variety of substances
 - Substances and mixtures
 - Three states of matter in terms of internal energy, molecular motion, and the phase transitions between them
- b. Research and explain crucial contributions and critical experiments of Dalton, Thomson, Rutherford, Bohr, de Broglie, and Schrödinger, and describe how each discovery contributed to the current model of atomic and nuclear structure. (DOK 2)
- c. Develop a model of atomic and nuclear structure based on theory and knowledge of fundamental particles. (DOK 2)
 - Properties and interactions of the three fundamental particles of the atom
 - Laws of conservation of mass, constant composition, definite proportions, and multiple proportions
- d. Write appropriate equations for nuclear decay reactions, describe how the nucleus changes during these reactions, and compare the resulting radiation with regard to penetrating ability. (DOK 1)
 - Three major types of radioactive decay (e.g., alpha, beta, gamma) and the properties of the emissions (e.g., composition, mass, charge, penetrating power)
 - The concept of half-life for a radioactive isotope (e.g., carbon-14 dating) based on the principle that the decay of any individual atom is a random process

- e. Compare the properties of compounds according to their type of bonding. (DOK 1)
 - Covalent, ionic, and metallic bonding
 - Polar and nonpolar covalent bonding
 - Valence electrons and bonding atoms
 - f. Compare different types of intermolecular forces, and explain the relationship between intermolecular forces, boiling points, and vapor pressure when comparing differences in properties of pure substances. (DOK 1)
 - g. Develop a three-dimensional model of molecular structure. (DOK 2)
 - Lewis dot structures for simple molecules and ionic compounds
 - Valence shell electron pair repulsion theory (VSEPR)
- 3. Develop an understanding of the periodic table.**
- a. Calculate the number of protons, neutrons, and electrons in individual isotopes using atomic numbers and mass numbers, write electron configurations of elements and ions following the Aufbau principle, and balance equations representing nuclear reactions. (DOK 1)
 - b. Analyze patterns and trends in the organization of elements in the periodic table, and compare their relationship to position in the periodic table. (DOK 2)
 - Atomic number, atomic mass, mass number, and number of protons, electrons, and neutrons in isotopes of elements
 - Average atomic mass calculations
 - Chemical characteristics of each region
 - Periodic properties (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity, electron affinity, ionization energy, atomic/covalent/ionic radius)
 - c. Classify chemical reactions by type. (DOK 2)
 - Single displacement, double displacement, synthesis (combination), decomposition, disproportionation, combustion, or precipitation
 - Products (given reactants) or reactants (given products) for each reaction type
 - Solubility rules for precipitation reactions and the activity series for single and double displacement reactions
 - d. Use stoichiometry to calculate the amount of reactants consumed and products formed. (DOK 3)
 - Difference between chemical reactions and chemical equations
 - Formulas and calculations of the molecular (molar) masses
 - Empirical formula given the percent composition of elements
 - Molecular formula given the empirical formula and molar mass
- 4. Analyze the relationship between microscopic and macroscopic models of matter.**
- a. Calculate the number of protons, neutrons, and electrons in individual isotopes using atomic numbers and mass numbers, write electron configurations of elements and ions following the Aufbau principle, and balance equations representing nuclear reactions. (DOK 1)
 - b. Analyze patterns and trends in the organization of elements in the periodic table, and compare their relationship to position in the periodic table. (DOK 2)
 - Atomic number, atomic mass, mass number, and number of protons, electrons, and neutrons in isotopes of elements
 - Average atomic mass calculations
 - Chemical characteristics of each region
 - Periodic properties (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity, electron affinity, ionization energy, atomic/covalent/ionic radius)
 - c. Classify chemical reactions by type. (DOK 2)
 - Single displacement, double displacement, synthesis (combination), decomposition, disproportionation, combustion, or precipitation
 - Products (given reactants) or reactants (given products) for each reaction type
 - Solubility rules for precipitation reactions and the activity series for single and double displacement reactions
 - d. Use stoichiometry to calculate the amount of reactants consumed and products formed. (DOK 3)

- Difference between chemical reactions and chemical equations
- Formulas and calculations of the molecular (molar) masses
- Empirical formula given the percent composition of elements
- Molecular formula given the empirical formula and molar mass

5. Compare factors associated with acid/base and oxidation/reduction reactions.

- a. Analyze and explain acid/base reactions. (DOK 2)
 - Properties of acids and bases, including how they affect indicators and the relative pH of the solution
 - Formation of acidic and basic solutions
 - Definition of pH in terms of the hydronium ion concentration and the hydroxide ion concentration
 - The pH or pOH from the hydrogen ion or hydroxide ion concentrations of solution
 - How a buffer works and examples of buffer solutions
- b. Classify species in aqueous solutions according to the Arrhenius and Bronsted-Lowry definitions respectively, and predict products for aqueous neutralization reactions. (DOK 2)
- c. Analyze a reduction/oxidation reaction (REDOX) to assign oxidation numbers (states) to reaction species, and identify the species oxidized and reduced, the oxidizing agent, and reducing agent. (DOK 2)

Organic Chemistry

- ORGC 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- ORGC 2 Demonstrate an understanding of the properties, structure, and function of organic compounds.
- ORGC 3 Discuss the versatility of polymers and the diverse application of organic chemicals.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results, and make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Demonstrate an understanding of the properties, structure, and function of organic compounds.

- a. Apply International Union of Pure and Applied Chemistry (IUPAC) nomenclature, and differentiate the structure of aliphatic, aromatic, and cyclic hydrocarbon compounds. (DOK 1)
 - Structures of hydrocarbon compounds
 - Isomerism in hydrocarbon compounds
- b. Relate structure to physical and chemical properties of hydrocarbon. (DOK 1)
- c. Apply principles of geometry and hybridization to organic molecules. (DOK 2)
 - Lewis structures for organic molecules
 - Bond angles
 - Hybridization (as it applies to organic molecules)
- d. Write, complete, and classify common reactions for aliphatic, aromatic, and cyclic hydrocarbons. (DOK 1)
- e. Construct, solve, and explain equations representing combustion reactions, substitution reactions, dehydrogenation reactions, and addition reactions. (DOK 2)

- f. Classify functional groups (e.g., alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides, and nitriles) by their structure and properties. (DOK 2)
- Structural formulas from functional group names and vice versa
 - Chemical and physical properties of compounds containing functional groups
 - Equations representing the transformation of one functional group into another
3. **Discuss the versatility of polymers and the diverse application of organic chemicals.**
- a. Describe and classify the synthesis, properties, and uses of polymers. (DOK 2)
- Common polymers
 - Synthesis of polymers from monomers by addition or condensation
 - Condensations of plastics according to their commercial types
 - Elasticity and other polymer properties
- b. Develop a logical argument supporting the use of organic chemicals and their application in industry, drug manufacture, and biological chemistry. (DOK 1)
- Common uses of polymers and organic compounds in medicine, drugs, and personal care products
 - Compounds that have the property to dye materials
 - Petrochemical production
 - Biologically active compounds in terms of functional group substrate interaction
- c. Research and summarize the diversity, applications, and economics of industrial chemicals (solvents, coatings, surfactants, etc.). (DOK 3)

Earth and Space Science

- E1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- E2 Develop an understanding of the history and evolution of the universe and earth.
- E3 Discuss factors that are used to explain the geological history of earth.
- E4 Demonstrate an understanding of earth systems relating to weather and climate.
- E5 Apply an understanding of ecological factors to explain relationships between earth systems.

1. **Apply inquiry-based and problem-solving processes and skills to scientific investigations.**
- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
- Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers.
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
2. **Develop an understanding of the history and evolution of the universe and earth.**
- a. Summarize the origin and evolution of the universe. (DOK 2)
- Big bang theory
 - Microwave background radiation
 - The Hubble constant
 - Evidence of the existence of dark matter and dark energy in the universe and the history of the universe

- b. Differentiate methods used to measure space distances, including astronomical unit, light-year, stellar parallax, Cepheid variables, and the red shift. (DOK 1)
 - c. Interpret how gravitational attraction played a role in the formation of the planetary bodies and how the fusion of hydrogen and other processes in “ordinary” stars and supernovae lead to the formation of all other elements. (DOK 2)
 - d. Summarize the early evolution of the earth, including the formation of Earth’s solid layers (e.g., core, mantle, and crust), the distribution of major elements, the origin of internal heat sources, and the initiation of plate tectonics. (DOK 2)
 - How the decay of radioactive isotopes is used to determine the age of rocks, earth, and the solar system
 - How Earth acquired its initial oceans and atmosphere
- 3. Discuss factors which are used to explain the geological history of earth.**
- a. Develop an understanding of how plate tectonics create certain geological features, materials, and hazards. (DOK 1)
 - Plate tectonic boundaries (e.g., divergent, convergent, and transform)
 - Modern and ancient geological features to each kind of plate tectonic boundary
 - Production of particular groups of igneous and metamorphic rocks and mineral resources
 - Sedimentary basins created and destroyed through time
 - b. Compare and contrast types of mineral deposits/groups (e.g., oxides, carbonates, halides, sulfides, sulfates, silicates, phosphates). (DOK 2)
 - c. Categorize minerals and rocks by determining their physical and/or chemical characteristics. (DOK 2)
 - d. Justify the causes of certain geological hazards (e.g., earthquakes, volcanoes, tsunamis) to their effects on specific plate tectonic locations. (DOK 2)
 - e. Interpret and explain how rock relationships and fossils are used to reconstruct the geologic history of the earth. (DOK 2)
 - f. Apply principles of relative age (e.g., superposition, original horizontality, crosscutting relations, and original lateral continuity) to support an opinion related to earth’s geological history. (DOK 3)
 - Types of unconformity (e.g., disconformity, angular unconformity, nonconformity)
 - Geological timetable
 - g. Apply the principle of uniformitarianism to relate sedimentary rock associations and their fossils to the environments in which the rocks were deposited. (DOK 2)
 - h. Compare and contrast the relative and absolute dating methods (e.g., the principle of fossil succession, radiometric dating, and paleomagnetism) for determining the age of the earth. (DOK 1)
- 4. Demonstrate an understanding of earth systems relating to weather and climate.**
- a. Explain the interaction of earth systems that affect weather and climate. (DOK 1)
 - Latitudinal variations in solar heating
 - The effects of Coriolis forces on ocean currents, cyclones, anticyclones, ocean currents, topography, and air masses (e.g., warm fronts, cold fronts, stationary fronts, and occluded fronts).
 - b. Interpret the patterns in temperature and precipitation that produce the climate regions on earth, and relate them to the hazards associated with extreme weather events and climate change (e.g., hurricanes, tornadoes, El Niño/La Niña, global warming). (DOK 2)
 - c. Justify how changes in global climate and variation in earth/sun relationships contribute to natural and anthropogenic (human-caused) modification of atmospheric composition. (DOK 2)
 - d. Summarize how past and present actions of ice, wind, and water contributed to the types and distributions of erosional and depositional features in landscapes. (DOK 1)
 - e. Research and explain how external forces affect earth’s topography. (DOK 2)
 - How surface water and groundwater act as the major agents of physical and chemical weathering
 - How soil results from weathering and biological processes
 - Processes and hazards associated with both sudden and gradual mass wasting
- 5. Apply an understanding of ecological factors to explain relationships between earth systems.**
- a. Draw conclusions about how life on earth shapes earth systems and responds to the interaction of earth systems (lithosphere, hydrosphere, atmosphere, and biosphere). (DOK 3)

- Nature and distribution of life on earth, including humans, to the chemistry and availability of water
 - Distribution of biomes (e.g., terrestrial, freshwater, and marine) to climate regions through time
 - Geochemical and ecological processes (e.g., rock, hydrologic, carbon, nitrogen) that interact through time to cycle matter and energy and how human activity alters the rates of these processes (e.g., fossil fuel formation and combustion, damming and channeling of rivers)
- b. Interpret the record of shared ancestry (fossils), evolution, and extinction as related to natural selection. (DOK 2)
- c. Identify the cause and effect relationships of the evolutionary innovations that most profoundly shaped earth systems. (DOK 1)
- Photosynthesis and the atmosphere
 - Multicellular animals and marine environments
 - Land plants and terrestrial environments
- d. Cite evidence about how dramatic changes in earth's atmosphere influenced the evolution of life. (DOK 1)

Environmental Science

- ES 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- ES 2 Develop an understanding of the relationship of ecological factors that affect an ecosystem.
- ES 3 Discuss the impact of human activities on the environment, conservation activities, and efforts to maintain and restore ecosystems.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
- Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 3)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK3)

2. Develop an understanding of the relationship of ecological factors that affect an ecosystem.

- a. Compare ways in which the three layers of the biosphere change over time and their influence on an ecosystem's ability to support life. (DOK 2)
- b. Explain the flow of matter and energy in ecosystems. (DOK 2)
- Interactions between biotic and abiotic factors
 - Indigenous plants and animals and their roles in various ecosystems
 - Biogeochemical cycles within the environment
- c. Predict the impact of the introduction, removal, and reintroduction of an organism on an ecosystem. (DOK 3)
- d. Develop a logical argument explaining the relationships and changes within an ecosystem. (DOK 2)
- How a species adapts to its niche
 - Process of primary and secondary succession and its effects on a population
 - How changes in the environment might affect organisms
- e. Explain the causes and effects of changes in population dynamics (e.g., natural selection, exponential growth, predator/prey relationships) to carrying capacity and limiting factors. (DOK 2)

- f. Research and explain how habitat destruction leads to the loss of biodiversity. (DOK 2)
 - g. Compare and contrast the major biomes of the world's ecosystems, including location, climate, adaptations and diversity. (DOK 1)
- 3. Discuss the impact of human activities on the environment, conservation activities, and efforts to maintain and restore ecosystems.**
- a. Summarize the effects of human activities on resources in the local environments. (DOK 2)
 - Sources, uses, quality, and conservation of water
 - Renewable and nonrenewable resources
 - Effects of pollution (e.g., water, noise, air, etc.) on the ecosystem
 - b. Research and evaluate the impacts of human activity and technology on the lithosphere, hydrosphere, and atmosphere, and develop a logical argument to support how communities restore ecosystems. (DOK 3)
 - c. Research and evaluate the use of renewable and nonrenewable resources, and critique efforts to conserve natural resources and reduce global warming in the United States including (but not limited) to Mississippi. (DOK 3)

Genetics

- G 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- G 2 Analyze the structure and function of the cell and cellular organelles.
- G 3 Apply the principles of heredity to demonstrate genetic understandings.

1. Use critical thinking and scientific problem solving in designing and performing biological research and experimentation. (L, P, E)

- a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
- b. Clarify research questions and design laboratory investigations. (DOK 3)
- c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for pie, bar, and line graphs) to draw conclusions and make inferences. (DOK 3)
- e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)

2. Review the structure and function of the cell as it applies to genetics. (L)

- a. Cite evidence to illustrate how the structure and function of cells are involved in the maintenance of life. (DOK 2)
- b. Describe how organic components are integral to biochemical processes. (DOK 2)
- c. Differentiate among the processes by which plants and animals reproduce. (DOK 1)
 - Cell cycle and mitosis
 - Meiosis, spermatogenesis, and oogenesis
- d. Explain the significance of the discovery of nucleic acids. (DOK 1)
- e. Analyze and explain the structure and function of DNA and RNA in replication, transcription, translation and DNA repair. (DOK 2)
- f. Cite examples to compare the consequences of the different types of mutations. (DOK 1)
- g. Draw conclusions about the importance and potential impacts of the process of gene transfer used in biotechnology. (DOK 3)

3. Analyze the structure and function of DNA and RNA molecules. (L, P)

- a. Cite evidence that supports the significance of Mendel's concept of "particulate inheritance" to explain the understanding of heredity. (DOK 1)

- b. Apply classical genetics principles to solve basic genetic problems. (DOK 2)
 - Genes and alleles, dominance, recessiveness, the laws of segregation, and independent assortment
 - Inheritance of autosomal and sex-linked traits
 - Inheritance of traits influenced by multiple alleles and traits with polygenetic inheritance
 - Chromosomal theory of inheritance
- c. Apply population genetic concepts to summarize variability of multicellular organisms. (DOK 2)
 - Genetic variability
 - Hardy-Weinberg formula
 - Migration and genetic drift
 - Natural selection in humans
- d. Distinguish and explain the applications of various tools and techniques used in DNA manipulation. (DOK 1)
 - Steps in genetic engineering experiments
 - Use of restriction enzymes
 - Role of vectors in genetic research
 - Use of transformation techniques
- e. Research and present a justifiable explanation the practical uses of biotechnology (e.g., chromosome mapping, karyotyping, and pedigrees). (DOK 2)
- f. Develop and present a scientifically-based logical argument for or against moral and ethical issues related to genetic engineering. (DOK 3)
- g. Research genomics (human and other organisms), and predict benefits and medical advances that may result from the use of genome projects. (DOK 2)

Geology

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- GE1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- GE2 Develop an understanding of plate tectonics and geochemical and ecological processes that affect earth.

1. **Apply inquiry-based and problem-solving processes and skills to scientific investigations.**
 - a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
 - b. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
2. **Develop an understanding of plate tectonics and geochemical and ecological processes that affect earth.**
 - a. Differentiate the components of the earth's atmosphere and lithosphere. (DOK 1)
 - b. Research and summarize explanations of how earth acquired its initial atmosphere and oceans. (DOK 2)
 - c. Compare the causes and effects of internal and external components that shape earth's topography. (DOK 2)
 - Physical weathering (e.g., atmospheric, glacial, etc.)
 - Chemical weathering agents (e.g., acid precipitation, carbon dioxide, oxygen, water, etc.)

- d. Develop an understanding of how plate tectonics create certain geologic features, materials, and hazards. (DOK 2)
 - Types of crustal movements and the resulting landforms (e.g., seafloor spreading, paleomagnetic measurements, and orogenesis)
 - Processes that create earthquakes and volcanoes
 - Asthenosphere
- e. Summarize the theories of plate development and continental drift, and describe the causes and effects involved in each. (DOK 2)
- f. Develop a logical argument to explain how geochemical and ecological processes (e.g., rock, hydrologic, carbon, nitrogen) interact through time to cycle matter and energy and how human activity alters the rates of these processes (e.g., fossil fuel formation and combustion, damming, and channeling of rivers). (DOK 2)
- g. Interpret how the earth's geological time scale relates to geological history, landforms, and life-forms. (DOK 2)
- h. Research and describe different techniques for determining relative and absolute age of the earth (e.g., index of fossil layers, superposition, radiometric dating, etc.) (DOK 1)
- i. Summarize the geological activity of the New Madrid fault line, and compare and contrast it to geological activity in other parts of the world. (DOK 2)
- j. Identify and differentiate the major geological features in Mississippi (e.g., Delta, Coastal Areas, etc.). (DOK 1)
- k. Evaluate an emergency preparedness plan for natural disasters associated with crustal movement. (DOK 3)

Physical Science

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| PS 1 | Apply inquiry-based and problem-solving processes and skills to scientific investigations. |
| PS 2 | Describe and explain how forces affect motion. |
| PS 3 | Demonstrate an understanding of general properties and characteristics of waves. |
| PS 4 | Develop an understanding of the atom. |
| PS 5 | Investigate and apply principles of physical and chemical changes in matter. |

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Use appropriate laboratory safety symbols and procedures to design and conduct a scientific investigation. (DOK 2)
 - Safety symbols and safety rules in all laboratory activities
 - Proper use and care of the compound light microscope
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Identify questions that can be answered through scientific investigations. (DOK 3)
- c. Identify and apply components of scientific methods in classroom investigations. (DOK 3)
 - Predicting, gathering data, drawing conclusions
 - Recording outcomes and organizing data from a variety of sources (e.g., scientific articles, magazines, student experiments, etc.)
 - Critically analyzing current investigations/problems using periodicals and scientific scenarios
- d. Interpret and generate graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- e. Analyze procedures and data to draw conclusions about the validity of research. (DOK 3)
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- g. Communicate effectively to present and explain scientific results, using appropriate terminology and graphics. (DOK 3)

2. Describe and explain how forces affect motion.

- a. Demonstrate and explain the basic principles of Newton's three laws of motion including calculations of acceleration, force, and momentum. (DOK 2)

- Inertia and distance-time graphs to determine average speed
 - Net force (accounting for gravity, friction, and air resistance) and the resulting motion of objects
 - Effects of the gravitational force on objects on Earth and effects on planetary and lunar motion
 - Simple harmonic motion (oscillation)
- b. Explain the connection between force, work, and energy. (DOK 2)
- Force exerted over a distance (results in work done)
 - Force-distance graph (to determine work)
 - Network on an object that contributes to change in kinetic energy (work-to-energy theorem)
- c. Describe (with supporting details and diagrams) how the kinetic energy of an object can be converted into potential energy (the energy of position) and how energy is transferred or transformed (conservation of energy). (DOK 2)
- d. Draw and assess conclusions about charges and electric current. (DOK 2)
- Static/current electricity and direct current/alternating current
 - Elements in an electric circuit that are in series or parallel
 - Conductors and insulators
 - Relationship between current flowing through a resistor and voltage flowing across a resistor
- e. Cite evidence and explain the application of electric currents and magnetic fields as they relate to their use in everyday living (e.g., the application of fields in motors and generators and the concept of electric current using Ohm's Law). (DOK 2)
- 3. Demonstrate an understanding of general properties and characteristics of waves.**
- a. Differentiate among transverse, longitudinal, and surface waves as they propagate through a medium (e.g., string, air, water, steel beam). (DOK 1)
- b. Compare properties of waves (e.g., superposition, interference, refraction, reflection, diffraction, Doppler effect), and explain the connection among the quantities (e.g., wavelength, frequency, period, amplitude, and velocity). (DOK 2)
- c. Classify the electromagnetic spectrum's regions according to frequency and/or wavelength, and draw conclusions about their impact on life. (DOK 2)
- The emission of light by electrons when moving from higher to lower levels
 - Energy (photons as quanta of light)
 - Additive and subtractive properties of colors
 - Relationship of visible light to the color spectrum
- d. Explain how sound intensity is measured and its relationship to the decibel scale. (DOK 1)
- 4. Develop an understanding of the atom.**
- a. Cite evidence to summarize the atomic theory. (DOK 1)
- Models for atoms
 - Hund's rule and Aufbau process to specify the electron configuration of elements
 - Building blocks of matter (e.g., proton, neutron, and electron) and elementary particles (e.g., positron, mesons, neutrinos, etc.)
 - Atomic orbitals (s, p, d, f) and their basic shapes
- b. Explain the difference between chemical and physical changes, and demonstrate how these changes can be used to separate mixtures and compounds into their components. (DOK 2)
- c. Research the history of the periodic table of the elements, and summarize the contributions that led to the atomic theory. (DOK 2)
- Contributions of scientists (e.g., John Dalton, J.J. Thomson, Ernest Rutherford, Newton, Einstein, Neils, Bohr, Louis de Broglie, Erwin Schrödinger, etc.)
 - Technology (e.g., X-rays, cathode-ray tubes, spectroscopes)
 - Experiments (e.g., gold-foil, cathode-ray, etc.)
- d. Utilize the periodic table to predict and explain patterns and draw conclusions about the structure, properties, and organization of matter. (DOK 2)
- Atomic composition and valence electron configuration (e.g., atomic number, mass number of protons, neutrons, electrons, isotopes, and ions)
 - Periodic trends using the periodic table (e.g., valence, reactivity, atomic radius)

- Average atomic mass from isotopic abundance
- Solids, liquids, and gases
- Periodic properties of elements (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity, electron affinity, ionization energy, atomic/covalent/ionic radius) and how they relate to position in the periodic table

5. Investigate and apply principles of physical and chemical changes in matter.

- Write chemical formulas for compounds comprising monatomic and polyatomic ions. (DOK 1)
- Balance chemical equations. (DOK 2)
- Classify types of chemical reactions (e.g., composition, decomposition, single displacement, double displacement, combustion, acid/base reactions). (DOK 2)

Physics I

- PHYI 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- PHYI 2 Develop an understanding of concepts related to forces and motion.
- PHYI 3 Develop an understanding of concepts related to work and energy.
- PHYI 4 Discuss the characteristics and properties of light and sound.
- PHYI 5 Apply an understanding of magnetism, electric fields, and electricity.
- PHYI 6 Analyze and explain concepts of nuclear physics.

1. Investigate and apply principles of physical and chemical changes in matter.

- Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
- Clarify research questions, and design laboratory investigations. (DOK 3)
- Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
- Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)

2. Develop an understanding of concepts related to forces and motion.

- Use inquiry to investigate and develop an understanding of the kinematics and dynamics of physical bodies. (DOK 3)
 - Vector and scalar quantities
 - Vector problems (solved mathematically and graphically)
 - Vector techniques and free-body diagrams to determine the net force on a body when several forces are acting on it
 - Relations among mass, inertia, and weight
- Analyze, describe, and solve problems by creating and utilizing graphs of one-dimensional motion (e.g., position, distance, displacement, time, speed, velocity, acceleration, the special case of freefall). (DOK 2)
- Analyze real-world applications to draw conclusions about Newton's three laws of motion. (DOK 2)
- Apply the effects of the universal gravitation law to graph and interpret the force between two masses, acceleration due to gravity, and planetary motion. (DOK 2)
 - Situations where g is constant (falling bodies)
 - Concept of centripetal acceleration undergoing uniform circular motion
 - Kepler's third law
 - Oscillatory motion and the mechanics of waves

3. Develop an understanding of concepts related to work and energy.

- Explain and apply the conservation of energy and momentum. (DOK 2)

- Concept of work and applications
 - Concept of kinetic energy, using the elementary work-energy theorem
 - Concept of conservation of energy with simple examples
 - Concepts of energy, work, and power (qualitatively and quantitatively)
 - Principles of impulse in inelastic and elastic collisions
- b. Analyze real-world applications to draw conclusions about mechanical potential energy (the energy of configuration). (DOK 3)
- c. Apply the principles of impulse, and compare conservation of momentum and conservation of kinetic energy in perfectly inelastic and elastic collisions. (DOK 1)
- d. Investigate and summarize the principles of thermodynamics. (DOK 2)
- How heat energy is transferred from higher temperature to lower temperature until equilibrium is reached
 - Temperature and thermal energy as related to molecular motion and states of matter
 - Problems involving specific heat and heat capacity
 - First and second laws of thermodynamics as related to heat engines, refrigerators, and thermal efficiency
- e. Develop the kinetic theory of ideal gases and explain the concept of Carnot efficiency. (DOK 2)
- 4. Discuss the characteristics and properties of light and sound.**
- a. Describe and model the characteristics and properties of mechanical waves. (DOK 2)
- Simple harmonic motion
 - Relationships among wave characteristics such as velocity, period, frequency, amplitude, phase, and wavelength
 - Energy of a wave in terms of amplitude and frequency.
 - Standing waves and waves in specific media (e.g., stretched string, water surface, air, etc.)
- b. Differentiate and explain the Doppler effect as it relates to a moving source and to a moving observer. (DOK 1)
- c. Explain the laws of reflection and refraction, and apply Snell's law to describe the relationship between the angles of incidence and refraction. (DOK 2)
- d. Use ray tracing and the thin lens equation to solve real-world problems involving object distance from lenses. (DOK 2)
- e. Investigate and draw conclusions about the characteristics and properties of electromagnetic waves. (DOK 2)
- 5. Apply an understanding of magnetism, electric fields, and electricity.**
- a. Analyze and explain the relationship between electricity and magnetism. (DOK 2)
- Characteristics of static charge and how a static charge is generated
 - Electric field, electric potential, current, voltage, and resistance as related to Ohm's law
 - Magnetic poles, magnetic flux and field, Ampère's law and Faraday's law
 - Coulomb's law
- b. Use schematic diagrams to analyze the current flow in series and parallel electric circuits, given the component resistances and the imposed electric potential. (DOK 2)
- c. Analyze and explain the relationship between magnetic fields and electrical current by induction, generators, and electric motors. (DOK 2)
- 6. Analyze and explain concepts of nuclear physics.**
- a. Analyze and explain the principles of nuclear physics. (DOK 1)
- The mass number and atomic number of the nucleus of an isotope of a given chemical element
 - The conservation of mass and the conservation of charge
 - Nuclear decay
- b. Defend the wave-particle duality model of light, using observational evidence. (DOK 3)
- Quantum energy and emission spectra
 - Photoelectric and Compton effects

Spatial Information Science

- SP 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
SP 2 Develop an understanding of geographic information systems.

1. Demonstrate the basic concepts of global positioning systems (GPS). (E)

- a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
- b. Clarify research questions, and design laboratory investigations. (DOK 3)
- c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, and theory development). (DOK 3)
- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences). (DOK 3)
- e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)

2. Demonstrate the basic concepts of remote sensing. (E, P)

- a. Describe the characteristics of the electromagnetic spectrum.
- b. Using images and graphs, interpret the absorption/reflection spectrum.
- c. Distinguish between passive vs. active sensor systems.
- d. Analyze the effects of changes in spatial, temporal, and spectral resolution.
- e. Analyze the effects on images due to changes in scale.
- f. Identify the types of sensor platforms.

Zoology

- ZO 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
ZO 2 Develop an understanding of levels of organization and animal classification.
ZO 3 Differentiate among animal life cycles, behaviors, adaptations, and relationships.
ZO 4 Demonstrate an understanding of the principles of animal genetic diversity and evolution.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 3)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Develop an understanding of levels of organization and animal classification.

- a. Explain how organisms are classified, and identify characteristics of major groups. (DOK 1)
 - Levels of organization of structures in animals (e.g., cells, tissues, organs, and systems)

- Characteristics used to classify organisms (e.g., cell structure, biochemistry, anatomy, fossil record, and methods of reproduction)
 - b. Identify and describe characteristics of the major phyla. (DOK 1)
 - Symmetry and body plan
 - Germ layers and embryonic development
 - Organ systems (e.g., digestive, circulatory, excretory, and reproductive)
 - Locomotion and coordination
 - c. Distinguish viruses from bacteria and protists, and give examples. (DOK 1)
 - d. Differentiate among the characteristics of bacteria, archaea, and eucarya. (DOK 1)
 - Phylogenic sequencing of the major phyla
 - Invertebrate characteristics (e.g., habitat, reproduction, body plan, locomotion) of the following phyla: Porifera, Cnidarians, Nematoda, Annelida, Platyhelminthes, Arthropoda, Insecta, Crustacea, Arachnida, Mollusca [Bivalvia and Gastropoda], and Echinodermata
 - Vertebrate characteristics (e.g., habitat, reproduction, body plan, locomotion) of the following classes: Agnatha, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, and Mammalia
- 3. Differentiate among animal life cycles, behaviors, adaptations, and relationships.**
- a. Describe life cycles, alternation of generations, and metamorphosis of various animals, and evaluate the advantages and disadvantages of asexual and sexual reproduction. (DOK 1)
 - b. Describe and explain concepts of animal behavior, and differentiate between learned and innate behavior. (DOK 1)
 - Division of labor within a group of animals
 - Communication within animals groups
 - Degree of parental care given in animal groups
 - c. Evaluate the unique protective adaptations of animals as they relate to survival. (DOK 2)
 - d. Compare and contrast ecological relationships, and make predictions about the survival of populations under given circumstances. (DOK 3)
 - Terrestrial and aquatic ecosystems
 - Herbivores, carnivores, omnivores, decomposers and other feeding relationships
 - Symbiotic relationships such as mutualism, commensalisms, and parasitism
 - e. Contrast food chains and food webs. (DOK 2)
- 4. Demonstrate an understanding of the principles of animal genetic diversity and evolution.**
- a. Categorize and explain sources of genetic variation on the cellular level (e.g., mutations, crossing over, and nondisjunction) and the population level (e.g., nonrandom mating, migration, etc.). (DOK 2)
 - Relationship between natural selection and evolution
 - Mutations, crossing over, non-disjunction
 - Nonrandom mating, migration, etc.
 - Effects of genetic drift on evolution
 - b. Develop a logical argument defending or refuting issues related to genetic engineering of animals. (DOK 3)

Appendix D: ACT College Readiness Standards

English

E1 Topic Development in Terms of Purpose and Focus

- Identify the basic purpose or role of a specified phrase or sentence.
- Delete a clause or sentence because it is obviously irrelevant to the essay.
- Identify the central idea or main topic of a straightforward piece of writing.
- Determine relevancy when presented with a variety of sentence-level details.
- Identify the focus of a simple essay, applying that knowledge to add a sentence that sharpens that focus or to determine if an essay has met a specified goal.
- Delete material primarily because it disturbs the flow and development of the paragraph.
- Add a sentence to accomplish a fairly straightforward purpose such as illustrating a given statement.
- Apply an awareness of the focus and purpose of a fairly involved essay to determine the rhetorical effect and suitability of an existing phrase or sentence or to determine the need to delete plausible but irrelevant material.
- Add a sentence to accomplish a subtle rhetorical purpose such as to emphasize, to add supporting detail, or to express meaning through connotation.
- Determine whether a complex essay has accomplished a specific purpose.
- Add a phrase or sentence to accomplish a complex purpose, often expressed in terms of the main focus of the essay.

E2 Organization, Unity, and Coherence

- Use conjunctive adverbs or phrases to show time relationship in simple narrative essays (e.g., *then, this time, etc.*).
- Select the most logical place to add a sentence in a paragraph.
- Use conjunctive adverbs or phrases to express straightforward logical relationships (e.g., *first, afterward, in response*).
- Decide the most logical place to add a sentence in an essay.
- Add a sentence that introduces a simple paragraph.
- Determine the need for conjunctive adverbs or phrases to create subtle logical connections between sentences (e.g., *therefore, however, in addition*).
- Rearrange the sentences in a fairly uncomplicated paragraph for the sake of logic.
- Add a sentence to introduce or conclude the essay or to provide a transition between paragraphs when the essay is fairly straightforward.
- Make sophisticated distinctions concerning the logical use of conjunctive adverbs or phrases, particularly when signaling a shift between paragraphs.
- Rearrange sentences to improve the logic and coherence of a complex paragraph.
- Add a sentence to introduce or conclude a fairly complex paragraph.
- Consider the need for introductory sentences or transitions, basing decisions on a thorough understanding of both the logic and rhetorical effect of the paragraph and essay.

E3 Word Choice in Terms of Style, Tone, Clarity, and Economy

- Revise sentences to correct awkward and confusing arrangements of sentence elements.
- Revise vague nouns and pronouns that create obvious logic problems.
- Delete obviously synonymous and wordy material in a sentence.
- Revise expressions that deviate from the style of an essay.
- Delete redundant material when information is repeated in different parts of speech (e.g., *alarmingly startled*).
- Use the word or phrase most consistent with the style and tone of a fairly straightforward essay.
- Determine the clearest and most logical conjunction to link clauses.
- Revise a phrase that is redundant in terms of the meaning and logic of the entire sentence.
- Identify and correct ambiguous pronoun references.
- Use the word or phrase most appropriate in terms of the content of the sentence and tone of the essay.
- Correct redundant material that involves sophisticated vocabulary and sounds acceptable as conversational English (e.g., *an aesthetic viewpoint* versus *the outlook of an aesthetic viewpoint*).
- Correct vague and wordy or clumsy and confusing writing containing sophisticated language.
- Delete redundant material that involves subtle concepts or that is redundant in terms of the paragraph as a whole.

E4 Sentence Structure and Formation

- Use conjunctions or punctuation to join simple clauses.
- Revise shifts in verb tense between simple clauses in a sentence or between simple adjoining sentences.
- Determine the need for punctuation and conjunctions to avoid awkward sounding sentence fragments and fused sentences.
- Decide the appropriate verb tense and voice by considering the meaning of the entire sentence.
- Recognize and correct marked disturbances of sentence flow and structure (e.g., participial phrase fragments, missing or incorrect relative pronouns, dangling or misplaced modifiers).
- Revise to avoid faulty placement of phrases and faulty coordination and subordination of clauses in sentences with subtle structural problems.
- Maintain consistent verb tense and pronoun person on the basis of the preceding clause or sentence.
- Use sentence-combining techniques, effectively avoiding problematic comma splices, run-on sentences, and sentence fragments, especially in sentences containing compound subjects or verbs.
- Maintain a consistent and logical use of verb tense and pronoun person on the basis of information in the paragraph or essay as a whole.
- Work comfortably with long sentences and complex clausal relationships within sentences, avoiding weak conjunctions between independent clauses and maintaining parallel structure between clauses.

E5 Conventions of Usage

- Solve such basic grammatical problems as how to form the past and past participle of irregular but commonly used verbs and how to form comparative and superlative adjectives.
- Solve such grammatical problems as whether to use an adverb or adjective form, how to ensure straightforward subject–verb and pronoun–antecedent agreement, and which preposition to use in simple contexts.
- Recognize and use the appropriate word in frequently confused pairs such as *there* and *their*, *past* and *passed*, and *led* and *lead*.
- Use idiomatically appropriate prepositions, especially in combination with verbs (e.g., *long for*, *appeal to*).
- Ensure that a verb agrees with its subject when there is some text between the two.
- Ensure that a pronoun agrees with its antecedent when the two occur in separate clauses or sentences.
- Identify the correct past and past participle forms of irregular and infrequently used verbs, and form present–perfect verbs by using *have* rather than *of*.
- Correctly use reflexive pronouns, the possessive pronouns *its* and *your*, and the relative pronouns *who* and *whom*.

- Ensure that a verb agrees with its subject in unusual situations (e.g., when the subject–verb order is inverted or when the subject is an indefinite pronoun).
- Provide idiomatically and contextually appropriate prepositions following verbs in situations involving sophisticated language or ideas.
- Ensure that a verb agrees with its subject when a phrase or clause between the two suggests a different number for the verb.

E6 Conventions of Punctuation

- Delete commas that create basic sense problems (e.g., between verb and direct object).
- Provide appropriate punctuation in straightforward situations (e.g., items in a series).
- Delete commas that disturb the sentence flow (e.g., between modifier and modified element).
- Use commas to set off simple parenthetical phrases.
- Delete unnecessary commas when an incorrect reading of the sentence suggests a pause that should be punctuated (e.g., between verb and direct object clause).
- Use punctuation to set off complex parenthetical phrases.
- Recognize and delete unnecessary commas based on a careful reading of a complicated sentence (e.g., between the elements of a compound subject or compound verb joined by *and*).
- Use apostrophes to indicate simple possessive nouns.
- Recognize inappropriate uses of colons and semicolons.
- Use commas to set off a nonessential/nonrestrictive appositive or clause.
- Deal with multiple punctuation problems (e.g., compound sentences containing unnecessary commas and phrases that may or may not be parenthetical).
- Use an apostrophe to show possession, especially with irregular plural nouns.
- Use a semicolon to indicate a relationship between closely related independent clauses.
- Use a colon to introduce an example or an elaboration.

Math

M1 Basic Operations and Applications

- Perform one-operation computation with whole numbers and decimals.
- Solve problems in one or two steps using whole numbers.
- Perform common conversions (e.g., inches to feet or hours to minutes).
- Solve routine one-step arithmetic problems (using whole numbers, fractions, and decimals) such as single-step percent.
- Solve some routine two-step arithmetic problems.
- Solve routine two-step or three-step arithmetic problems involving concepts such as rate and proportion, tax added, percentage off, and computing with a given average.
- Solve multistep arithmetic problems that involve planning or converting units of measure (e.g., feet per second to miles per hour).
- Solve word problems containing several rates, proportions, or percentages.
- Solve complex arithmetic problems involving percent of increase or decrease and problems requiring integration of several concepts from pre-algebra and/or pre-geometry (e.g., comparing percentages or averages, using several ratios, and finding ratios in geometry settings).

M2 Probability, Statistics, and Data Analysis

- Calculate the average of a list of positive whole numbers.
- Perform a single computation using information from a table or chart.
- Calculate the average of a list of numbers.
- Calculate the average, given the number of data values and the sum of the data values.
- Read tables and graphs.
- Perform computations on data from tables and graphs.

- Use the relationship between the probability of an event and the probability of its complement.
- Calculate the missing data value, given the average and all data values but one.
- Translate from one representation of data to another (e.g., a bar graph to a circle graph).
- Determine the probability of a simple event.
- Exhibit knowledge of simple counting techniques.*
- Calculate the average, given the frequency counts of all the data values.
- Manipulate data from tables and graphs.
- Compute straightforward probabilities for common situations.
- Use Venn diagrams in counting.*
- Calculate or use a weighted average.
- Interpret and use information from figures, tables, and graphs.
- Apply counting techniques.
- Compute a probability when the event and/or sample space is not given or obvious.
- Distinguish between mean, median, and mode for a list of numbers.
- Analyze and draw conclusions based on information from figures, tables, and graphs.
- Exhibit knowledge of conditional and joint probability.

M3 Numbers: Concepts and Properties

- Recognize equivalent fractions and fractions in lowest terms.
- Recognize one-digit factors of a number.
- Identify a digit's place value.
- Exhibit knowledge of elementary number concepts including rounding, the ordering of decimals, pattern identification, absolute value, primes, and greatest common factor.
- Find and use the least common multiple.
- Order fractions.
- Work with numerical factors.
- Work with scientific notation.
- Work with squares and square roots of numbers.
- Work problems involving positive integer exponents.*
- Work with cubes and cube roots of numbers.*
- Determine when an expression is undefined.*
- Exhibit some knowledge of the complex numbers.†
- Apply number properties involving prime factorization.
- Apply number properties involving even and odd numbers and factors and multiples.
- Apply number properties involving positive and negative numbers.
- Apply rules of exponents.
- Multiply two complex numbers.†
- Draw conclusions based on number concepts, algebraic properties, and/or relationships between expressions and numbers.
- Exhibit knowledge of logarithms and geometric sequences.
- Apply properties of complex numbers.

M4 Expressions, Equations, and Inequalities

- Exhibit knowledge of basic expressions (e.g., identify an expression for a total as $b + g$).
- Solve equations in the form $x + a = b$, where a and b are whole numbers or decimals.
- Substitute whole numbers for unknown quantities to evaluate expressions.
- Solve one-step equations having integer or decimal answers.
- Combine like terms (e.g., $2x + 5x$).
- Evaluate algebraic expressions by substituting integers for unknown quantities.
- Add and subtract simple algebraic expressions.
- Solve routine first-degree equations.

- Perform straightforward word-to-symbol translations.
- Multiply two binomials.*
- Solve real-world problems using first-degree equations.
- Write expressions, equations, or inequalities with a single variable for common pre-algebra settings (e.g., rate and distance problems and problems that can be solved by using proportions).
- Identify solutions to simple quadratic equations.
- Add, subtract, and multiply polynomials.*
- Factor simple quadratics (e.g., the difference of squares and perfect square trinomials).*
- Solve first-degree inequalities that do not require reversing the inequality sign.*
- Manipulate expressions and equations.
- Write expressions, equations, and inequalities for common algebra settings.
- Solve linear inequalities that require reversing the inequality sign.
- Solve absolute value equations.
- Solve quadratic equations.
- Find solutions to systems of linear equations.
- Write expressions that require planning and/or manipulating to accurately model a situation.
- Write equations and inequalities that require planning, manipulating, and/or solving.
- Solve simple absolute value inequalities.

M5 Graphical Representations

- Identify the location of a point with a positive coordinate on the number line.
- Locate points on the number line and in the first quadrant.
- Locate points in the coordinate plane.
- Comprehend the concept of length on the number line.*
- Exhibit knowledge of slope.*
- Identify the graph of a linear inequality on the number line.*
- Determine the slope of a line from points or equations.*
- Match linear graphs with their equations.*
- Find the midpoint of a line segment.*
- Interpret and use information from graphs in the coordinate plane.
- Match number line graphs with solution sets of linear inequalities.
- Use the distance formula.
- Use properties of parallel and perpendicular lines to determine an equation of a line or coordinates of a point.
- Recognize special characteristics of parabolas and circles (e.g., the vertex of a parabola and the center or radius of a circle).†
- Match number line graphs with solution sets of simple quadratic inequalities.
- Identify characteristics of graphs based on a set of conditions or on a general equation such as $y = ax^2 + c$.
- Solve problems integrating multiple algebraic and/or geometric concepts.
- Analyze and draw conclusions based on information from graphs in the coordinate plane.

M6 Properties of Plane Figures

- Exhibit some knowledge of the angles associated with parallel lines.
- Find the measure of an angle using properties of parallel lines.
- Exhibit knowledge of basic angle properties and special sums of angle measures (e.g., 90° , 180° , and 360°).
- Use several angle properties to find an unknown angle measure.
- Recognize Pythagorean triples.*
- Use properties of isosceles triangles.*
- Apply properties of 30° - 60° - 90° , 45° - 45° - 90° , similar, and congruent triangles.
- Use the Pythagorean theorem.
- Draw conclusions based on a set of conditions.

- Solve multistep geometry problems that involve integrating concepts, planning, visualization, and/or making connections with other content areas.
- Use relationships among angles, arcs, and distances in a circle.

M7 Measurement

- Estimate or calculate the length of a line segment based on other lengths given on a geometric figure.
- Compute the perimeter of polygons when all side lengths are given.
- Compute the area of rectangles when whole number dimensions are given.
- Compute the area and perimeter of triangles and rectangles in simple problems.
- Use geometric formulas when all necessary information is given.
- Compute the area of triangles and rectangles when one or more additional simple steps are required.
- Compute the area and circumference of circles after identifying necessary information.
- Compute the perimeter of simple composite geometric figures with unknown side lengths.*
- Use relationships involving area, perimeter, and volume of geometric figures to compute another measure.
- Use scale factors to determine the magnitude of a size change.
- Compute the area of composite geometric figures when planning or visualization is required.

M8 Functions

- Evaluate quadratic functions, expressed in function notation, at integer values.
- Evaluate polynomial functions, expressed in function notation, at integer values.†
- Express the sine, cosine, and tangent of an angle in a right triangle as a ratio of given side lengths.†
- Evaluate composite functions at integer values.†
- Apply basic trigonometric ratios to solve right-triangle problems.†
- Write an expression for the composite of two simple functions.†
- Use trigonometric concepts and basic identities to solve problems.†
- Exhibit knowledge of unit circle trigonometry.†
- Match graphs of basic trigonometric functions with their equations.

Notes

- Students who score in the 1–12 range are most likely beginning to develop the knowledge and skills assessed in the other ranges.
- Standards followed by an asterisk (*) apply to the PLAN and ACT Mathematics tests only.
- Standards followed by a dagger (†) apply to the ACT Mathematics test only.

Reading

R1 Main Ideas and Author's Approach

- Recognize a clear intent of an author or narrator in uncomplicated literary narratives.
- Identify a clear main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.
- Infer the main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.
- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in uncomplicated passages.
- Identify a clear main idea or purpose of any paragraph or paragraphs in uncomplicated passages.
- Infer the main idea or purpose of straightforward paragraphs in more challenging passages.
- Summarize basic events and ideas in more challenging passages.
- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in more challenging passages.
- Infer the main idea or purpose of more challenging passages or their paragraphs.
- Summarize events and ideas in virtually any passage.

- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in virtually any passage.
- Identify clear main ideas or purposes of complex passages or their paragraphs.

R2 Supporting Details

- Locate basic facts (e.g., names, dates, events) clearly stated in a passage.
- Locate simple details at the sentence and paragraph level in uncomplicated passages.
- Recognize a clear function of a part of an uncomplicated passage.
- Locate important details in uncomplicated passages.
- Make simple inferences about how details are used in passages.
- Locate important details in more challenging passages.
- Locate and interpret minor or subtly stated details in uncomplicated passages.
- Discern which details, though they may appear in different sections throughout a passage, support important points in more challenging passages.
- Locate and interpret minor or subtly stated details in more challenging passages.
- Use details from different sections of some complex informational passages to support a specific point or argument.
- Locate and interpret details in complex passages.
- Understand the function of a part of a passage when the function is subtle or complex.

R3 Sequential, Comparative, and Cause–Effect Relationships

- Determine when (e.g., first, last, before, after) or if an event occurred in uncomplicated passages.
- Recognize clear cause–effect relationships described within a single sentence in a passage.
- Identify relationships between main characters in uncomplicated literary narratives.
- Recognize clear cause–effect relationships within a single paragraph in uncomplicated literary narratives.
- Order simple sequences of events in uncomplicated literary narratives.
- Identify clear relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear cause–effect relationships in uncomplicated passages.
- Order sequences of events in uncomplicated passages.
- Understand relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear relationships between characters, ideas, and so forth in more challenging literary narratives.
- Understand implied or subtly stated cause–effect relationships in uncomplicated passages.
- Identify clear cause–effect relationships in more challenging passages.
- Order sequences of events in more challenging passages.
- Understand the dynamics between people, ideas, and so forth in more challenging passages.
- Understand implied or subtly stated cause–effect relationships in more challenging passages.
- Order sequences of events in complex passages.
- Understand the subtleties in relationships between people, ideas, and so forth in virtually any passage.
- Understand implied, subtle, or complex cause–effect relationships in virtually any passage.

R4 Meaning of Words

- Understand the implication of a familiar word or phrase and of simple descriptive language.
- Use context to understand basic figurative language.
- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in uncomplicated passages.
- Use context to determine the appropriate meaning of virtually any word, phrase, or statement in uncomplicated passages.
- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in more challenging passages.

- Determine the appropriate meaning of words, phrases, or statements from figurative or somewhat technical contexts.
- Determine, even when the language is richly figurative and the vocabulary is difficult, the appropriate meaning of context-dependent words, phrases, or statements in virtually any passage.

R5 Generalizations and Conclusions

- Draw simple generalizations and conclusions about the main characters in uncomplicated literary narratives.
- Draw simple generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.
- Draw generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.
- Draw simple generalizations and conclusions using details that support the main points of more challenging passages.
- Draw subtle generalizations and conclusions about characters, ideas, and so forth in uncomplicated literary narratives.
- Draw generalizations and conclusions about people, ideas, and so forth in more challenging passages.
- Use information from one or more sections of a more challenging passage to draw generalizations and conclusions about people, ideas, and so forth.
- Draw complex or subtle generalizations and conclusions about people, ideas, and so forth, often by synthesizing information from different portions of the passage.
- Understand and generalize about portions of a complex literary narrative.

Science

S1 Interpretation of Data

- Select a single piece of data (numerical or non-numerical) from a simple data presentation (e.g., a table or graph with two or three variables, a food web diagram).
- Identify basic features of a table, graph, or diagram (e.g., headings, units of measurement, axis labels).
- Select two or more pieces of data from a simple data presentation.
- Understand basic scientific terminology.
- Find basic information in a brief body of text.
- Determine how the value of one variable changes as the value of another variable changes in a simple data presentation.
- Select data from a complex data presentation (e.g., a table or graph with more than three variables, a phase diagram).
- Compare or combine data from a simple data presentation (e.g., order or sum data from a table).
- Translate information into a table, graph, or diagram.
- Compare or combine data from two or more simple data presentations (e.g., categorize data from a table using a scale from another table).
- Compare or combine data from a complex data presentation.
- Interpolate between data points in a table or graph.
- Determine how the value of one variable changes as the value of another variable changes in a complex data presentation.
- Identify and/or use a simple (e.g., linear) mathematical relationship between data.
- Analyze given information when presented with new, simple information.
- Compare or combine data from a simple data presentation with data from a complex data presentation.
- Identify and/or use a complex (e.g., nonlinear) mathematical relationship between data.
- Extrapolate from data points in a table or graph.
- Compare or combine data from two or more complex data presentations.
- Analyze given information when presented with new, complex information.

S2 Scientific Investigation

- Understand the methods and tools used in a simple experiment.
- Understand the methods and tools used in a moderately complex experiment.
- Understand a simple experimental design.
- Identify a control in an experiment.
- Identify similarities and differences between experiments.
- Understand the methods and tools used in a complex experiment.
- Understand a complex experimental design.
- Predict the results of an additional trial or measurement in an experiment.
- Determine the experimental conditions that would produce specified results.
- Determine the hypothesis for an experiment.
- Identify an alternate method for testing a hypothesis.
- Understand precision and accuracy issues.
- Predict how modifying the design or methods of an experiment will affect results.
- Identify an additional trial or experiment that could be performed to enhance or evaluate experimental results.

S3 Evaluation of Models, Inferences, and Experimental Results

- Select a simple hypothesis, prediction, or conclusion that is supported by a data presentation or a model.
- Identify key issues or assumptions in a model.
- Select a simple hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.
- Determine whether given information supports or contradicts a simple hypothesis or conclusion and why.
- Identify strengths and weaknesses in one or more models.
- Identify similarities and differences between models.
- Determine which model(s) is/are supported or weakened by new information.
- Select a data presentation or a model that supports or contradicts a hypothesis, prediction, or conclusion.
- Select a complex hypothesis, prediction, or conclusion that is supported by a data presentation or model.
- Determine whether new information supports or weakens a model and why.
- Use new information to make a prediction based on a model.
- Select a complex hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.
- Determine whether given information supports or contradicts a complex hypothesis or conclusion and why.

Writing

W1 Expressing Judgments

- Show a little understanding of the persuasive purpose of the task, but neglect to take or to maintain a position on the issue in the prompt.
- Show limited recognition of the complexity of the issue in the prompt.
- Show a basic understanding of the persuasive purpose of the task by taking a position on the issue in the prompt but may not maintain that position.
- Show a little recognition of the complexity of the issue in the prompt by acknowledging, but only briefly describing, a counterargument to the writer's position.
- Show understanding of the persuasive purpose of the task by taking a position on the issue in the prompt.
- Show some recognition of the complexity of the issue in the prompt by doing the following:
 - Acknowledging counterarguments to the writer's position
 - Providing some response to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a broad context for discussion.

- Show recognition of the complexity of the issue in the prompt by doing the following:
 - Partially evaluating implications and/or complications of the issue
 - Posing and partially responding to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a critical context for discussion.
- Show understanding of the complexity of the issue in the prompt by doing the following:
 - Examining different perspectives
 - Evaluating implications or complications of the issue
 - Posing and fully discussing counterarguments to the writer's position

W2 Focusing on the Topic

- Maintain a focus on the general topic in the prompt through most of the essay.
- Maintain a focus on the general topic in the prompt throughout the essay.
- Maintain a focus on the general topic in the prompt throughout the essay, and attempt a focus on the specific issue in the prompt.
- Present a thesis that establishes focus on the topic.
- Maintain a focus on discussion of the specific topic and issue in the prompt throughout the essay.
- Present a thesis that establishes a focus on the writer's position on the issue.
- Maintain a clear focus on discussion of the specific topic and issue in the prompt throughout the essay.
- Present a critical thesis that clearly establishes the focus on the writer's position on the issue.

W3 Developing a Position

- Offer a little development, with one or two ideas; if examples are given, they are general and may not be clearly relevant; resort often to merely repeating ideas.
- Show little or no movement between general and specific ideas and examples.
- Offer limited development of ideas using a few general examples; resort sometimes to merely repeating ideas.
- Show little movement between general and specific ideas and examples.
- Develop ideas by using some specific reasons, details, and examples.
- Show some movement between general and specific ideas and examples.
- Develop most ideas fully, using some specific and relevant reasons, details, and examples.
- Show clear movement between general and specific ideas and examples.
- Develop several ideas fully, using specific and relevant reasons, details, and examples.
- Show effective movement between general and specific ideas and examples.

W4 Organizing Ideas

- Provide a discernible organization with some logical grouping of ideas in parts of the essay.
- Use a few simple and obvious transitions.
- Present a discernible, though minimally developed, introduction and conclusion.
- Provide a simple organization with logical grouping of ideas in parts of the essay.
- Use some simple and obvious transitional words, though they may at times be inappropriate or misleading.
- Present a discernible, though underdeveloped, introduction and conclusion.
- Provide an adequate but simple organization with logical grouping of ideas in parts of the essay but with little evidence of logical progression of ideas.
- Use some simple and obvious, but appropriate, transitional words and phrases.
- Present a discernible introduction and conclusion with a little development.
- Provide unity and coherence throughout the essay, sometimes with a logical progression of ideas.
- Use relevant, though at times simple and obvious, transitional words and phrases to convey logical relationships between ideas.
- Present a somewhat developed introduction and conclusion.

- Provide unity and coherence throughout the essay, often with a logical progression of ideas.
- Use relevant transitional words, phrases, and sentences to convey logical relationships between ideas.
- Present a well-developed introduction and conclusion.

W5 Using Language

- Show limited control of language by doing the following:
 - Correctly employing some of the conventions of standard English grammar, usage, and mechanics but with distracting errors that sometimes significantly impede understanding
 - Using simple vocabulary
 - Using simple sentence structure
 - Correctly employing some of the conventions of standard English grammar, usage, and mechanics but with distracting errors that sometimes impede understanding
 - Using simple but appropriate vocabulary
 - Using a little sentence variety, though most sentences are simple in structure
 - Correctly employing many of the conventions of standard English grammar, usage, and mechanics but with some distracting errors that may occasionally impede understanding
 - Using appropriate vocabulary
 - Using some varied kinds of sentence structures to vary pace
 - Correctly employing most conventions of standard English grammar, usage, and mechanics with a few distracting errors but none that impede understanding
 - Using some precise and varied vocabulary
 - Using several kinds of sentence structures to vary pace and to support meaning
 - Correctly employing most conventions of standard English grammar, usage, and mechanics with just a few, if any, errors
 - Using precise and varied vocabulary
 - Using a variety of kinds of sentence structures to vary pace and to support meaning

Appendix E: Pathway Content Standards

AGRICULTURE, FOOD, AND NATURAL RESOURCES (AFNR) PATHWAY CONTENT STANDARDS AND PERFORMANCE ELEMENTS

The AFNR Pathway Content Standards and Performance Elements are adapted from *National Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards*. Reprinted with permission from the National Council for Agricultural Education, 1410 King Street, Suite 400, Alexandria, VA 22314. (800) 772-0939. Copyright © 2009. A complete copy of the National Standards can be downloaded from the Team Ag Ed Learning Center at <https://aged.learn.com>.

AGRIBUSINESS SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of principles and techniques for the development and management of agribusiness systems.

- ABS.01. Utilize economic principles to establish and manage an AFNR enterprise.**
 - ABS.01.01. Apply principles of capitalism in the business environment.
 - ABS.01.02. Apply principles of entrepreneurship in businesses.
- ABS.02. Utilize appropriate management planning principles in AFNR business enterprises.**
 - ABS.02.01. Compose and analyze a business plan for an enterprise.
 - ABS.02.02. Read, interpret, evaluate, and write a mission statement to guide business goals, objectives, and resource allocation.
 - ABS.02.03. Apply appropriate management skills to organize a business.
 - ABS.02.04. Recruit, train, and retain appropriate and productive human resources for business.
- ABS.03. Utilize record keeping to accomplish AFNR business objectives while complying with laws and regulations.**
 - ABS.03.01. Prepare and maintain all files needed to accomplish effective record keeping.
 - ABS.03.02. Implement appropriate inventory management practices.
- ABS.04. Apply generally accepted accounting principles and skills to manage cash budgets, credit budgets, and credit for AFNR businesses.**
 - ABS.04.01. Use accounting fundamentals to accomplish dependable bookkeeping and fiscal management.
- ABS.05. Assess accomplishment of goals and objectives by an AFNR business.**
 - ABS.05.01. Maintain and interpret financial information (income statements, balance sheets, inventory, purchase orders, accounts receivable, and cash-flow analyses) for businesses.
- ABS.06. Use industry-accepted marketing practices to accomplish AFNR business objectives.**
 - ABS.06.01. Conduct appropriate market and marketing research.
 - ABS.06.02. Develop a marketing plan.
 - ABS.06.03. Develop strategies for marketing plan implementation.
 - ABS.06.04. Develop specific tactics to market AFNR products and services.
- ABS.07. Create a production system plan.**
 - ABS.07.01. Prepare a step-by-step production plan that identifies needed resources.
 - ABS.07.02. Develop a production and operational plan.
 - ABS.07.03. Utilize appropriate techniques to determine the most likely strengths, weaknesses, and inconsistencies in a business plan, and relate these to risk management strategies.
 - ABS.07.04. Manage risk and uncertainty.

ANIMAL SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and practices to the production and management of animals.

- AS.01. Examine the components, historical development, global implications, and future trends of the animal systems industry.**
 - AS.01.01. Evaluate the development and implications of animal origin, domestication, and distribution.
- AS.02. Classify, evaluate, select, and manage animals based on anatomical and physiological characteristics.**
 - AS.02.01. Classify animals according to hierarchical taxonomy and agricultural use.
 - AS.02.02. Apply principles of comparative anatomy and physiology to uses within various animal systems.
 - AS.02.03. Select animals for specific purposes and maximum performance based on anatomy and physiology.
- AS.03. Provide for the proper health care of animals.**
 - AS.03.01. Prescribe and implement a prevention and treatment program for animal diseases, parasites, and other disorders.
 - AS.03.02. Provide for the biosecurity of agricultural animals and production facilities.
- AS.04. Apply principles of animal nutrition to ensure the proper growth, development, reproduction, and economic production of animals.**
 - AS.04.01. Formulate feed rations to provide for the nutritional needs of animals.
 - AS.04.02. Prescribe and administer animal feed additives and growth promotants in animal production.
- AS.05. Evaluate and select animals based on scientific principles of animal production.**
 - AS.05.01. Evaluate the male and female reproductive systems in selecting animals.
 - AS.05.02. Evaluate animals for breeding readiness and soundness.
 - AS.05.03. Apply scientific principles in the selection and breeding of animals.
- AS.06. Prepare and implement animal handling procedures for the safety of animals, producers and consumers of animal products.**
 - AS.06.01. Demonstrate safe animal handling and management techniques.
 - AS.06.02. Implement procedures to ensure that animal products are safe.
- AS.07. Select animal facilities and equipment that provide for the safe and efficient production, housing, and handling of animals.**
 - AS.07.01. Design animal housing, equipment, and handling facilities for the major systems of animal production.
 - AS.07.02. Comply with government regulations and safety standards for facilities used in animal production.
- AS.08. Analyze environmental factors associated with animal production.**
 - AS.08.01. Reduce the effects of animal production on the environment.
 - AS.08.02. Evaluate the effects of environmental conditions on animals.

BIOTECHNOLOGY

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and techniques to biotechnology in agriculture.

BS.01. Recognize the historical, social, cultural, and potential applications of biotechnology.

- BS.01.01. Distinguish major innovators, historical developments, and potential applications of biotechnology in agriculture.
- BS.01.02. Determine regulatory issues, and identify agencies associated with biotechnology.
- BS.01.03. Analyze the ethical, legal, social, and cultural issues relating to biotechnology.

BS.02 Demonstrate laboratory skills as applied to biotechnology.

- BS.02.01. Maintain and interpret biotechnology laboratory records.
- BS.02.02. Operate biotechnology laboratory equipment according to standard procedures.
- BS.02.03. Demonstrate proper laboratory procedures using biological materials.
- BS.02.04. Safely manage biological materials, chemicals, and wastes used in the laboratory.
- BS.02.05. Perform microbiology, molecular biology, enzymology, and immunology procedures.

BS.03. Demonstrate the application of biotechnology to Agriculture, Food, and Natural Resources (AFNR).

- BS.03.01. Evaluate the application of genetic engineering to improve products of AFNR systems.
- BS.03.02. Perform biotechnology processes used in AFNR systems.
- BS.03.03. Use biotechnology to monitor and evaluate procedures performed in AFNR systems.

ENVIRONMENTAL SERVICE SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and techniques to the management of environmental service systems.

ESS.01. Use analytical procedures to plan and evaluate environmental service systems.

- ESS.01.01. Analyze and interpret samples.

ESS.02. Assess the impact of policies and regulations on environmental service systems.

- ESS.02.01. Interpret laws affecting environmental service systems.

ESS.03. Apply scientific principles to environmental service systems.

- ESS.03.01. Apply meteorology principles to environmental service systems.
- ESS.03.02. Apply soil science principles to environmental service systems.
- ESS.03.03. Apply hydrology principles to environmental service systems.
- ESS.03.04. Apply best management techniques associated with the properties, classifications, and functions of wetlands.
- ESS.03.05. Apply chemistry principles to environmental service systems.
- ESS.03.06. Apply microbiology principles to environmental service systems.

ESS.04. Operate environmental service systems to manage a facility environment.

- ESS.04.01. Use pollution control measures to maintain a safe facility environment.
- ESS.04.02. Manage safe disposal of all categories of solid waste.
- ESS.04.03. Apply the principles of public drinking water treatment operations to ensure safe water at a facility.
- ESS.04.04. Apply principles of wastewater treatment to manage wastewater disposal in keeping with rules and regulations.
- ESS.04.05. Manage hazardous materials to assure a safe facility and to comply with applicable regulations.

ESS.05. Examine the relationships between energy sources and environmental service systems.

ESS.05.01. Compare and contrast the impact of conventional and alternative energy sources on the environment.

ESS.06. Use tools, equipment, machinery, and technology to accomplish tasks in environmental service systems.

ESS.06.01. Use technological and mathematical tools to map land, facilities, and infrastructure.

ESS.06.02. Maintain tools, equipment, and machinery in safe working order for tasks in environmental service systems.

FOOD PRODUCTS AND PROCESSING SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles, practices, and techniques in the processing, storage, and development of food products.

FPP.01. Examine components of the food industry and historical development of food products and processing.

FPP.01.01. Evaluate the significance and implications of changes and trends in the food products and processing industry.

FPP.01.02. Work effectively with industry organizations, groups, and regulatory agencies affecting the food products and processing industry.

FPP.02. Apply safety principles, recommended equipment, and facility management techniques to the food products and processing industry.

FPP.02.01. Manage operational procedures, and create equipment and facility maintenance plans.

FPP.02.02. Implement Hazard Analysis and Critical Control Point (HACCP) procedures to establish operating parameters.

FPP.02.03. Apply safety and sanitation procedures in the handling, processing, and storing of food products.

FPP.02.04. Demonstrate worker safety procedures with food product and processing equipment and facilities.

FPP.03. Apply principles of science to the food products and processing industry.

FPP.03.01. Apply principles of science to food processing to provide a safe, wholesome, and nutritious food supply.

FPP.04. Select and process food products for storage, distribution, and consumption.

FPP.04.01. Utilize harvesting, selection, and inspection techniques to obtain quality food products for processing.

FPP.04.02. Evaluate, grade, and classify processed food products.

FPP.04.03. Process, preserve, package, and present food and food products for sale and distribution.

NATURAL RESOURCE SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and techniques to the management of natural resources.

NRS.01. Explain interrelationships between natural resources and humans necessary to conduct management activities in natural environments.

NRS.01.01. Apply knowledge of natural resource components to the management of natural resource systems.

- NRS01.02. Classify natural resources.
- NRS.02. Apply scientific principles to natural resource management activities.**
 - NRS.02.01. Develop a safety plan for work with natural resources.
 - NRS.02.02. Demonstrate cartographic skills to aid in developing, implementing, and evaluating natural resource management plans.
 - NRS.02.03. Measure and survey natural resource status to obtain planning data.
 - NRS.02.04. Demonstrate natural resource enhancement techniques.
 - NRS.02.05. Interpret laws related to natural resource management and protection.
 - NRS.02.06. Apply ecological concepts and principles to natural resource systems.
- NRS.03. Apply knowledge of natural resources to production and processing industries.**
 - NRS.03.01. Produce, harvest, process, and use natural resource products.
- NRS.04. Demonstrate techniques used to protect natural resources.**
 - NRS.04.01. Manage fires in natural resource systems.
 - NRS.04.02. Diagnose plant and wildlife diseases, and follow protocol to prevent their spread.
 - NRS.04.03. Manage insect infestations of natural resources.
- NRS.05. Use effective methods and venues to communicate natural resource processes to the public.**
 - NRS.05.01. Communicate natural resource information to the public.

PLANT SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and techniques to the production and management of plants.

- PS.01. Apply knowledge of plant classification, plant anatomy, and plant physiology to the production and management of plants.**
 - PS.01.01. Classify agricultural plants according to taxonomy systems.
 - PS.01.02. Apply knowledge of plant anatomy and the functions of plant structures to activities associated with plant systems.
 - PS.01.03. Apply knowledge of plant physiology and energy conversion to plant systems.
- PS.02. Prepare and implement a plant management plan that addresses the influence of environmental factors, nutrients, and soil on plant growth.**
 - PS.02.01. Determine the influence of environmental factors on plant growth.
 - PS.02.02. Prepare growing media for use in plant systems.
 - PS.02.03. Develop and implement a fertilization plan for specific plants or crops.
- PS.03. Propagate, culture, and harvest plants.**
 - PS.03.01. Demonstrate plant propagation techniques.
 - PS.03.02. Develop and implement a plant management plan for crop production.
 - PS.03.03. Develop and implement a plan for integrated pest management.
 - PS.03.04. Apply principles and practices of sustainable agriculture to plant production.
 - PS.03.05. Harvest, handle, and store crops.
- PS.04. Employ elements of design to enhance an environment.**
 - PS.04.01. Create designs using plants.

POWER, STRUCTURAL AND TECHNICAL SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of principles and techniques for the development and management of power, structural, and technical systems.

PST.01. Use physical science principles and engineering applications with power, structural, and technical systems to solve problems and improve performance.

- PST.01.01. Select energy sources in power generation appropriate to the situation.
- PST.01.02. Apply physical science laws and principles to identify, classify, and use lubricants.
- PST.01.03. Identify and use hand and power tools and equipment for service, construction, and fabrication.

PST.02. Design, operate, and maintain mechanical equipment, structures, biological systems, land treatment, power, and technology.

- PST.02.01. Perform service routines to maintain power units and equipment.
- PST.02.02. Operate, service, and diagnose the condition of power units and equipment.

PST.03. Service and repair mechanical equipment and power systems.

- PST.03.01. Troubleshoot and repair internal combustion engines.
- PST.03.02. Utilize manufacturers' guidelines to service and repair the power transmission systems of equipment.
- PST.03.03. Service and repair hydraulic and pneumatic systems.
- PST.03.04. Troubleshoot and service electrical systems.
- PST.03.05. Service vehicle heating and air-conditioning systems.
- PST.03.06. Service and repair steering, suspension, traction, and vehicle performance systems.

PST.04. Plan, build and maintain agricultural structures.

- PST.04.01. Create sketches and plans of agricultural structures.
- PST.04.02. Apply structural plans, specifications, and building codes.
- PST.04.03. Examine structural requirements for materials and procedures, and estimate construction cost.
- PST.04.05. Follow architectural and mechanical plans to construct and/or repair equipment, buildings, and facilities.

PST.05. Apply technology principles in the use of agricultural technical systems.

- PST.05.01. Use instruments and meters to test and monitor electrical and electronic processes.
- PST.05.02. Prepare and/or use electrical drawings to design, install, and troubleshoot control systems.
- PST.05.03. Use geospatial technologies in agricultural applications.

Appendix F:

National Educational Technology Standards for Students

- T1** Creativity and Innovation
- T2** Communication and Collaboration
- T3** Research and Information Fluency
- T4** Critical Thinking, Problem Solving, and Decision Making
- T5** Digital Citizenship
- T6** Technology Operations and Concepts

T1 Creativity and Innovation

Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students do the following:

- a. Apply existing knowledge to generate new ideas, products, or processes.
- b. Create original works as a means of personal or group expression.
- c. Use models and simulations to explore complex systems and issues.
- d. Identify trends and forecast possibilities.

T2 Communication and Collaboration

Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students do the following:

- a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
- b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
- c. Develop cultural understanding and global awareness by engaging with learners of other cultures.
- d. Contribute to project teams to produce original works or solve problems.

T3 Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information. Students do the following:

- a. Plan strategies to guide inquiry.
- b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
- c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
- d. Process data and report results.

T4 Critical Thinking, Problem Solving, and Decision Making

Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students do the following:

- a. Identify and define authentic problems and significant questions for investigation.
- b. Plan and manage activities to develop a solution or complete a project.
- c. Collect and analyze data to identify solutions and/or make informed decisions.
- d. Use multiple processes and diverse perspectives to explore alternative solutions.

T5 Digital Citizenship

Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students do the following:

- a. Advocate and practice safe, legal, and responsible use of information and technology.
- b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
- c. Demonstrate personal responsibility for lifelong learning.

- d. Exhibit leadership for digital citizenship.

T6 Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations. Students do the following:

- a. Understand and use technology systems.
- b. Select and use applications effectively and productively.
- c. Troubleshoot systems and applications.
- d. Transfer current knowledge to learning of new technologies.