Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Common Power Tools
Lesson	Safe Use and Maintenance of Power Tools for Woodworking
Estimated Time	Two 50-minute blocks

Student Outcome

Analyze the uses and safety procedures of common power tools used in woodworking.

Learning Objectives

1. Identify basic procedures for shop safety.
2. Identify common sources of power for woodworking tools.
3. Identify some safeguards for the use of power tools.
4. List the uses and safeguards for a portable drill.
5. List the uses and safeguards for a portable circular saw.
6. List the uses and safeguards for a reciprocating saw.
7. List the uses and safeguards for a band saw.
8. List the uses and safeguards for a table saw.
9. List the uses and safeguards for a shaper.
10. List the uses and safeguards for a jointer.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Basic Procedures for Shop Safety
   - PPt 2 – Portable Drill
   - PPt 3 – Circular Saw
   - PPt 4 – Reciprocating Saw
   - PPt 5 – Band Saw
   - PPt 6 – Table Saw
   - PPt 7 – Use of a Push Stick With a Table Saw
   - PPt 8 – Shaper
   - PPt 9 – Jointer
2. Activity Sheet
   - AS 1 – Safety and Maintenance Procedures for Power Tools for Woodworking
3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit I – Common Power Tools." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Internet Sites
   - ❑ Cyr, D., and S. Johnson. "Power Tool Safety." National Ag Safety Database. Accessed October 1, 2007, from http://www.cdc.gov/nasd/docs/d000901-d001000/d000903/d000903.html.
   - ❑ The Free Plan and Project List. Buildeazy. Accessed September 12, 2007, from http://www.buildeazy.com/fp_start.html.
   - ❑ Hand and Power Tools. Occupational Safety and Health Administration. U. S. Department of Labor. Accessed September 12, 2007, from http://www.osha.gov/SLTC/handpowertools/index.html.
   - ❑ My Woodworking Expert. Accessed September 12, 2007, from http://www.mywoodworkingexpert.com/.
   - ❑ Recalls and Product Safety News. U. S. Consumer Product Safety Commission. Accessed September 12, 2007, from http://www.cpsc.gov/cpscpub/prerel/prerel.html.
   - ❑ Woodworking Online. Accessed September 12, 2007, from http://www.woodworkingonline.com/category/power-tools/.
2. Print
   - ❑ Burkybile, C., D. Johnson, J. Lee, and C. Shelhamer. Agricultural Power and Technology. Danville, IL: Interstate Publishers, 2005.
   - ❑ Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics*. Upper Saddle River, NJ: Prentice Hall Interstate, 2004.
3. Electronic Media
   - ❑ The Power Tool Institute offers a line of free videos on safety that can be found at http://www.powertoolinstitute.com/education.html. Accessed September 12, 2007.

Interest Approach

1. Have students discuss the advantages that power tools have over hand tools and the advantages or disadvantages that exist between portable power tools and stationary floor machines. Which tools are most likely to be used for certain jobs and why? What are the reasons for choosing specific tools for a particular job? For example, is it versitility or portability?

2. Have students discuss safety measures for use of power tools and why safety precautions are important. What could be the consequences of unsafe use of power tools?

Communicate the Learning Objectives

1. Identify basic procedures for shop safety.
2. Identify common sources of power for woodworking tools.
3. Identify some safeguards for the use of power tools.
4. List the uses and safeguards for a portable drill.
5. List the uses and safeguards for a portable circular saw.
6. List the uses and safeguards for a reciprocating saw.
7. List the uses and safeguards for a band saw.
8. List the uses and safeguards for a table saw.
9. List the uses and safeguards for a shaper.
10. List the uses and safeguards for a jointer.

Instructor Directions	Content Outline
Objective 1	**Identify basic procedures for shop safety.**
A number of basic safety procedures apply to almost any work situation. These basic safety procedures appeared in Agricultural Mechanics Unit for Agricultural Science I and can be reviewed here. Refer to PPt 1. Specific safety procedures for different types of tools are discussed in this lesson's sections on individual tools. PPt 1 – Basic Procedures for Shop Safety	Adhere to instructions from the following sources: 1. Labels and warnings on containers and tools 2. The manufacturer's recommendations for use and maintenance of specific power tools 3. Signs posted in the work area 4. Directions given by the instructor Wear safety glasses in the shop at all times. Wear protective gear such as gloves, earplugs, and safety shoes if appropriate. Do not wear loose-fitting clothing that could get caught in a moving part. Secure long hair to avoid getting it caught.

Instructor Directions	Content Outline
	Keep work areas clean and free of clutter. Inspect each tool before using it to make sure it is working properly. Tell the instructor about any damaged tool. Do not use a tool that does not function properly. Return each tool to its proper place of storage.
Objective 2 *Electricity and compressed air are common power sources for woodworking tools. In addition to the general safety precautions listed above, there are safety considerations specific to electric and air-driven (pneumatic) tools. These are discussed below.*	**Identify common sources of power for woodworking tools.** 1. Electricity, including battery packs 2. Compressed air (pneumatic tools)
Objective 3	**Identify some safeguards for the use of power tools.** Safety precautions for electric tools and battery-powered tools 1. Always unplug a tool or disconnect it from its battery before inspecting it and making adjustments. 2. Only use a tool that is double insulated or has a grounded plug. 3. Always plug a tool into a power source with a ground-fault circuit interrupter (GFCI or GFI), which will shut off the electricity if a short occurs. If GFCIs are not installed, portable GFCIs can be plugged into grounded outlets. 4. Do not stand on wet ground or a wet surface while operating an electric tool. 5. Make sure stationary power tools are securely anchored to the floor. 6. Make sure all guards and shields are in place and vents are free of debris before operating an electric tool. 7. Do not bend the power cord sharply or use the cord to pull the plug from the outlet or carry the tool. Such

Instructor Directions	Content Outline
	actions could break the cord, and a broken cord is an electrical hazard. 8. Use only the battery specified by the manufacturer for the tool being used. 9. Use only the type of recharger designed for the batteries being used. 10. Always store battery packs safely so that no metal can come in contact with the terminals. This can short-circuit the battery and cause sparks, fire, or burns. Safety precautions for pneumatic tools 1. Disconnect pneumatic tools for all inspections and adjustments. 2. Do not join or separate quick-disconnect couplings on high-pressure lines when bystanders are nearby. 3. Do not use compressed air for cleanup if the air pressure is 30 lb per sq in. (psi) or greater. 4. Do not point an air stream at anyone. High-pressure air can drive dust into the eyes, damage eardrums, and cause other types of injury. 5. Inspect couplings and air lines regularly for evidence of wear or damage. 6. Make sure air tanks and air lines are free of moisture and appropriate filters are in place. 7. Follow the manufacturer's recommendations for hose size and maximum air pressure. 8. Oil pneumatic tools regularly according to manufacturer recommendations.
Objective 4 *Refer to PPt 2 or display the actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.* PPt 2 – Portable Drill	**List the uses and safeguards for a portable drill.** Main parts 1. On/off switch 2. Power cord 3. Handle 4. Chuck 5. Chuck key Uses 1. Drilling and boring 2. Driving and removing screws 3. Sanding 4. Polishing

Instructor Directions	Content Outline
	5. Powering hole saws Additional features 1. Available in different sizes 2. Size of drill determined by the chuck capacity (e.g., a 1/4-in. drill holds a drill bit with a shank no larger than 1/4 in.) 3. Single or variable speed 4. Reversible Safety considerations 1. Choose the correct bit for the job. For example, do not use a square-shank bit in an electric drill. 2. Make sure the bit is tightly seated in the chuck, securing it by turning the chuck key in each hole. Remove the chuck key before starting the drill. 3. Make sure the work is held securely in place. Use a clamp or vise to hold small work. 4. Hold the drill perpendicular to the work to avoid binding the bit. 5. Remove the bit from the drill when work is completed. Maintenance considerations 1. Follow the manufacturer's instructions for regular lubrication of parts. 2. Sharpen or replace dulled bits.
Objective 5 *Refer to PPt 3 or display the actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.* PPt 3 – Circular Saw	**List the uses and safeguards for a portable circular saw.** Main parts 1. On/off switch 2. Power cord 3. Angle scale 4. Base 5. Angle adjustment lock 6. Handle 7. Blade guard 8. Blade Uses 1. Rip cuts 2. Crosscuts

Instructor Directions	Content Outline
	3. Bevel cuts 4. Mitering Additional features 1. Available in different sizes 2. Size of portable circular saw determined by the diameter of largest blade it will hold 3. Different types of blades for different kinds of cuts 4. Angle scale used to set the depth of the blade's cut 5. Upward rotation of the blade produces splintering on the topside of piece. Cut with the better side of the work face down. Safety considerations 1. Choose the correct blade for the job. 2. Make sure base and angle adjustments are correct and snug. 3. Back the saw slightly away from the work before turning it on. The saw should be at full speed before beginning the cut. 4. Cut only in a straight line to avoid binding the blade. 5. Wait until the blade stops moving before setting the saw down. Maintenance considerations 1. Make sure the blade guard moves freely and covers the blade completely when the saw is not in use. Small pieces of wood can become wedged in the guard and prevent it from closing over the blade. 2. Clean, sharpen, or replace dulled or gummy blades.
Objective 6 *Refer to PPt 4 or display the actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.* PPt 4 – Reciprocating Saw	**List the uses and safeguards for a reciprocating saw.** Main parts 1. On/off switch 2. Power cord 3. Handle 4. Shoe 5. Blade Uses 1. Relief cuts 2. Irregular cuts

Instructor Directions	Content Outline
	3. Crosscuts 4. Pocket cuts Additional features 1. Heavy duty yet compact in size, making it useful for work in a close area where it would be difficult to operate a circular saw 2. Because of maneuverability, particularly useful for making irregular and pocket cuts 3. Different kinds of blades for cutting different types of materials, such as wood, metal, plastic, and plaster 4. Shoe adjusts for cutting at different depths Safety considerations 1. Choose the correct blade for the cut. 2. Choose the appropriate speed for the cut. Dense materials are cut at a slower speed and soft materials are cut at a higher speed. 3. Make sure the saw is operating at full speed before beginning the cut. 4. Hold the shoe against the work at all times. Maintenance considerations 1. Follow the manufacturer's recommendations for regular service. 2. Clean, sharpen, or replace blades as needed.
Objective 7 *Refer to PPt 5 or display the actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.* PPt 5 – Band Saw	**List the uses and safeguards for a band saw.** Main parts 1. On/off switch 2. Upper and lower wheels and wheel guards 3. Table 4. Blade 5. Upper and lower blade guides 6. Arm Uses 1. Straight cuts 2. Irregular cuts 3. Curved cuts 4. Bevel cuts

Instructor Directions	Content Outline
	Additional features 1. Size of band saw determined by the diameter of its wheels (e.g., a 14-in. band saw has 14-in. wheels) 2. Thin blade forms a loop over the two wheels and through the two blade guides 3. Upper and lower blade guides for holding blade on wheels 4. Different types of blades for different cuts Safety considerations 1. Choose the correct blade for the cut and material. 2. Make sure the blade is held tightly in the saw and the guide is within 1/8 in. of the piece. The teeth should point downward. 3. Plan the cut so the work and the waste piece of wood can be controlled. Make sure the board cannot strike the arm of the saw. 4. Turn off the saw immediately if the blade breaks or "clicks" during cutting. A clicking noise could indicate that the blade is cracked. 5. Turn off the saw before backing out of a cut. Maintenance considerations 1. Maintain proper blade tension. 2. Maintain proper tracking of the blade. The blade should stay at the center of the wheels. 3. Repair or replace broken blades.
Objective 8 *Refer to PPts 6 and 7 or display the actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.* PPt 6 – Table Saw PPt 7 – Use of a Push Stick With a Table Saw	**List the uses and safeguards for a table saw.** Main parts 1. On/off switch 2. Blade-height adjustment wheel 3. Rip fence 4. Miter groove 5. Blade 6. Blade guard 7. Table 8. Blade-angle adjustment wheel Uses 1. Rip cuts 2. Crosscuts

Instructor Directions	Content Outline
	3. Mitering 4. Bevel cuts 5. Joint making Additional features 1. Similar to a portable circular saw but in a stationary setup 2. Size of table saw determined by the diameter of the largest blade it will hold 3. Different kinds of blades, such as rip and crosscut blades, for different kinds of cuts 4. Tilting arbor or tilting table allows saw to make angle cuts 5. Rip fence used for straight rip cuts Safety considerations 1. Choose the correct blade for the cut. 2. Adjust the angle and height of the blade to accommodate the cut. The teeth should point in the direction of the blade's rotation. 3. Stand to the side of the blade and do not reach across the table. 4. Keep hands at least 6 in. from the blade. 5. Use a push stick to guide smaller stock. Maintenance considerations 1. Check the blade to be sure it is not warped. 2. Remove any accumulation of sawdust. A collection of sawdust could cause the motor to overheat. 3. Use silicone or powdered graphite, not oil, to keep screw threads working freely. With oil, screw threads could become gummed up with sawdust. 4. Remove rust on unpainted parts with oiled steel wool. Remove excess oil after cleaning with steel wool and coat the area with paste wax.
Objective 9 *Refer to PPt 8 or display the actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.*	**List the uses and safeguards for a shaper.** Main parts 1. On/off switch 2. Spindle-height adjustment wheel 3. Miter gauge groove 4. Spindle

Instructor Directions	Content Outline
PPt 8 – Shaper	5. Cutter 6. Cutter guard 7. Fence Uses 1. Cutting decorative edges 2. Cutting moldings 3. Cutting joints Additional features 1. Size of a shaper determined by the diameter of the spindle 2. Cutters available in a variety of shapes and sizes for making different patterns 3. Fence adjustable, used as a guide for straight cuts Safety considerations 1. Check all adjustments and locking nuts before using the machine. 2. Check the rotation of the cutter. Work must always be fed into the cutter opposite the direction of rotation. 3. Make sure the piece has no warps or cracks that could cause material to be thrown. 4. Always use proper guards and clamps. 5. Use a holder or a push stick when the piece less than 1 ft in length. Maintenance considerations 1. Follow the manufacturer's recommendations for proper lubrication. Oil is generally a good lubricant for locations not exposed to sawdust. Silicone can be used in areas where sawdust collects. 2. Inspect belts and follow the manufacturer's specifications for proper tension.
Objective 10 *Refer to PPt 9 or display the actual tool when explaining the main parts and features. Discuss safety and maintenance considerations. Have students complete AS 1 to answer*	**List the uses and safeguards for a jointer.** Main parts 1. On/off switch 2. Table adjustment levers or wheels 3. Infeed table 4. Tilting fence 5. Cutterhead

Instructor Directions	Content Outline
questions about safety and maintenance procedures in the shop. PPt 9 – Jointer AS 1 – Safety and Maintenance Procedures for Power Tools for Woodworking	6. Cutter guard 7. Outfeed table Uses 1. Planing edges 2. Planing surfaces 3. Cutting bevels and chamfers Additional features 1. Does similar work to the hand plane 2. Infeed table, fence, and outfeed table are adjustable 3. Main adjustable parts: infeed table, tilting fence, and outfeed table 4. Length of cutterhead blades determines the size of the jointer and the maximum width of the board it will cut Safety considerations 1. Make the correct adjustments for the infeed and outfeed tables and tilting fence. Do not exceed recommended maximum cuts. 2. Make sure the outfeed table is set at the same height as the cutter edges at the highest point of their rotation to avoid tapering or biting stock. 3. Perform cuts on stock that is at least 1 ft in length. 4. Only plane surfaces that are at least 3/8 in. thick. 5. Cut with the grain of the wood. 6. Make sure stock is free of knots and splits. 7. Keep hands at least 6 in. from the cutterhead. 8. Use a push stick and feather board when necessary. Maintenance considerations 1. Make sure knives are sharp. Dull knives can cause kickback. 2. Follow the manufacturer's recommendations for lubricating the machine. Some disassembly may be needed to reach all parts that require lubrication. 3. Replace sealed bearings if they are worn.

Instructor Directions	Content Outline
Application: AS 1 – Safety and Maintenance Procedures for Power Tools for Woodworking	Answers to AS 1 Answers will vary. Other activities 1. Accompany or follow the lesson with instructor demonstrations of each tool students will be using and procedures they will be expected to perform. Discuss any specific safety features relevant to the tools and machines in the shop that were not covered in the lesson outline above, and supplement the lesson with discussion of any equipment not covered. Begin or end demonstrations by having students review major parts of the tool and basic use and safety considerations.
Closure/Summary	Power tools can shorten the time it takes to complete woodworking jobs, but they must be used safely to prevent injuries. Using these tools safely requires choosing the right tool for the job, knowing how the tool works, and making the correct tool adjustments. Safe use also requires regular maintenance to be sure the tool is working properly.
Evaluation: Quiz	Answers: 1. b 2. d 3. b 4. a 5. c 6. d 7. d 8. b 9. d 10. Students should provide five of the following: a. Follow instructions from labels and warnings on containers and tools, from the manufacturer's recommendations for use and maintenance, on signs posted in the work area, and from directions given by the instructor.

Instructor Directions	Content Outline
	b. Wear safety glasses in the shop at all times. c. Wear protective gear such as gloves, earplugs, and safety shoes if appropriate. d. Do not wear loose-fitting clothing that could get caught in a moving part. e. Secure long hair to avoid getting it caught. f. Keep work areas clean and free of clutter. g. Inspect each tool before using it to make sure it is working properly. h. Tell the instructor about any damaged tool. i. Do not use a tool that does not function properly. j. Return each tool to its proper place of storage. 11. Students should provide three of the following: a. Unplug a tool or disconnect if from its battery before inspecting it and making adjustments. b. Use tools that are double insulated or that have grounded plugs. c. Always plug a tool into a power source with a ground-fault circuit interrupter (GFCI or GFI), which will shut off power if a short occurs. If a GFCI is not installed in an outlet, a portable GFCI can be plugged into a grounded outlet. d. Do not stand on wet ground or a wet surface while operating an electric tool. e. Make sure stationary power tools are anchored to the floor. f. Make sure all guards and shields are in place and vents are clear of debris. g. Do not bend the cord sharply or use the cord to pull it from an outlet or carry the tool. These actions could break a power cord and a broken power cord is an electrical hazard. h. Use only the battery specified by the manufacturer for the tool being used. i. Use only the recharger designed for the batteries being used. j. Always store battery packs safely so that no metal can come in contact with the terminals. This can short-circuit the battery and cause sparks, fire, or burns.

Instructor Directions	Content Outline
	12. Students should provide three of the following: a. Disconnect pneumatic tools for all inspections and adjustments. b. Do not join or separate quick-disconnect couplings on high-pressure lines when bystanders are nearby. c. Do not use compressed air for cleanup if the pressure is 30 lb per sq in. (psi) or greater. d. Do not point an air stream at anyone. High-pressure air can drive dust into the eyes, damage eardrums, and cause other types of injury. e. Inspect couplings and air lines regularly for evidence of wear and damage. f. Make sure tanks and air lines are free of moisture and air filters are in place. g. Follow the manufacturer's recommendations for hose size and maximum air pressure. h. Oil pneumatic tools regularly according to the manufacturer's recommendations.

Lesson 1: Safe Use and Maintenance of Power Tools for Woodworking

Name__________________________

Safety and Maintenance Procedures for Power Tools for Woodworking

Objective: Students will describe woodworking safety and maintenance procedures.

Directions: Answer the following questions regarding safety and maintenance procedures in woodworking.

Key Questions:

1. Where is the safety equipment kept in the shop?

2. What safety equipment is necessary for woodworking in your shop?

3. What type of protective eyewear is used in your woodworking shop?

4. What are the safety procedures for the use of stationary power tools?

5. Are there many battery pack tools in your woodworking shop? How are they stored? Are the batteries stored separately? Where are the batteries stored?

6. How are portable power tools stored? Where?

7. Where are saw blades stored when not in use? How are they stored?

8. How are pneumatic tools stored?

9. Is any special ventilation used for woodworking projects?

Unit I - Common Power Tools

Name___________________________

Lesson 1: Safe Use and Maintenance of Power Tools for Woodworking

Date___________________________

Assessment

Read the following statements from Workers A and B. Indicate which answer is correct by selecting from the four listed choices.

1. Worker A says that you should wear long hair loose when working in the shop.

   Worker B says that you should secure long hair to keep it from getting caught in equipment.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

2. Worker A says that you should keep pneumatic tanks and air lines moist for safe operation.

   Worker B says that you can safely clean the work area using compressed air at 40 psi.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

3. Worker A says that you can use square-shank bits in an electric drill.

   Worker B says that you can use round-shank bits in an electric drill.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

4. Worker A says that the size of a circular power saw is determined by the diameter of the largest blade that fits in the saw.

   Worker B says to cut with the better side of the work up when using a circular saw because of the upward rotation of the blade.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

5. Worker A says that the shoe on a reciprocating saw can be adjusted to control the depth of the cut.

   Worker B says that a reciprocating saw is useful for making irregular cuts.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

6. Worker A says that you should use a wider blade with coarse teeth to cut a sharp curve with a band saw.

   Worker B says that the blade tension for a band saw should be slack and the teeth should be pointing upward.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

7. Worker A says that you should use the rip fence to make accurate curved cuts on a table saw.

   Worker B says that you should install the blade in a table saw with its teeth pointing in the opposite direction to the blade's rotation.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

8. Worker A says that a push stick must be used with a shaper if the stock is longer than 2 ft.

   Worker B says that a shaper is useful for cutting a pattern in wood used for moldings.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

9. Worker A says that a jointer has a blade that is similar to the one used in a circular power saw.

   Worker B says that cuts with a jointer should be made against the grain of the piece.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

Complete the following short-answer questions.

10. Provide five general safety precautions to follow in an agricultural mechanics shop.

    a.

    b.

    c.

    d.

    e.

11. Provide three safety precautions for using electric or battery-powered tools.

    a.

    b.

    c.

12. Provide three safety precautions for using pneumatic power tools.

    a.

    b.

    c.

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Common Power Tools
Lesson	Safe Use and Maintenance of Power Tools for Metalworking
Estimated Time	Three 50-minute blocks

Student Outcome

Analyze the uses and safety procedures of common power tools used in metalworking.

Learning Objectives

1. Identify basic procedures for shop safety.
2. Identify common sources of power for metalworking tools.
3. Identify some safeguards for the use of power tools.
4. List the uses and safeguards for a portable drill.
5. List the uses and safeguards for a portable power nibbler.
6. List the uses and safeguards for a cold circular cutoff saw.
7. List the uses and safeguards for a portable grinder.
8. List the uses and safeguards for a bench grinder.
9. List the uses and safeguards for a sheet metal brake.
10. List the uses and safeguards for a drill press.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Basic Procedures for Shop Safety
   - PPt 2 – Portable Drill
   - PPt 3 – Using a Nibbler to Make an Interior Cut
   - PPt 4 – Cold Circular Cutoff Saw
   - PPt 5 – Portable Grinder
   - PPt 6 – Bench Grinder
   - PPt 7 – Sheet Metal Brake
   - PPt 8 – Drill Press
2. Activity Sheet
   - AS 1 – Safety and Maintenance Procedures for Power Tools for Metalworking
3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, “Unit I – Common Power Tools.” University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Internet Sites
   - ❑ Drill Presses. OSH Answers. Canadian Centre for Occupational Health and Safety. Accessed October 1, 2007, from http://www.ccohs.ca/oshanswers/safety_haz/metalworking/drillpresses.html.
   - ❑ Fabricating and Metalworking. Accessed September 12, 2007, from http://www.fandmmag.com/.
   - ❑ Hand and Power Tools. Occupational Safety and Health Administration. U. S. Department of Labor. Accessed September 12, 2007, from http://www.osha.gov/SLTC/handpowertools/index.html.
   - ❑ Safety Information. Power Tool Institute, Inc. Accessed September 12, 2007, from http://www.powertoolinstitute.com/safety.html.
2. Print
   - ❑ Burkybile, C., D. Johnson, J. Lee, and C. Shelhamer. *Agricultural Power and Technology*. Danville, IL: Interstate Publishers, 2005.
   - ❑ Phipps, L. *Mechanics in Agriculture*. 4th ed. Danville, IL: Interstate Publishers, 1992.
   - ❑ Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics*. Upper Saddle River, NJ: Prentice Hall Interstate, 2004.
3. Electronic Media
   - ❑ Smartflix offers a line of videos related to metalworking that can be rented from their Web site. Accessed September 12, 2007, from http://smartflix.com/store/category/115/Metalworking.
   - ❑ The Power Tool Institute offers a line of free videos on safety that can be found at http://www.powertoolinstitute.com/education.html. Accessed September 12, 2007.

Interest Approach

1. Have students discuss the advantages of using power tools for metalworking. What tools would be used for certain jobs and why? What are the reasons for choosing a specific tool for a particular job?

2. Have students discuss safety measures for the use of power tools and why safety precautions are important. What could be the consequences of unsafe use of power tools?

Communicate the Learning Objectives

1. Identify basic procedures for shop safety.
2. Identify common sources of power for metalworking tools.
3. Identify some safeguards for the use of power tools.
4. List the uses and safeguards for a portable drill.
5. List the uses and safeguards for a portable power nibbler.
6. List the uses and safeguards for a cold circular cutoff saw.
7. List the uses and safeguards for a portable grinder.
8. List the uses and safeguards for a bench grinder.
9. List the uses and safeguards for a sheet metal brake.
10. List the uses and safeguards for a drill press.

Instructor Directions	Content Outline
Objective 1 *The list of basic shop safety procedures that appears in the previous lesson is repeated here in case the lessons are not presented in sequence. Refer to PPt 1.* PPt 1 – Basic Procedures for Shop Safety	**Identify basic procedures for shop safety.** Adhere to instructions from the following sources. 1. Labels and warnings on containers and tools 2. The manufacturer's recommendations for use and maintenance of specific power tools 3. Signs posted in the work area 4. Directions given by the instructor Wear safety glasses in the shop at all times. Wear protective gear such as gloves, earplugs, and safety shoes if appropriate. Do not wear loose-fitting clothing that could get caught in a moving part. Secure long hair to avoid getting it caught. Keep work areas clean and free of clutter.

Instructor Directions	Content Outline
	Check each tool before using it to make sure it is working properly. Tell the instructor about any damaged tool. Do not use a tool that does not function properly. Return each tool to its proper storage place.
Objective 2 *Electricity and compressed air are common power sources for metalworking tools. In addition to the general safety precautions listed above, there are safety considerations specific to electric and air-driven (pneumatic) tools. These are discussed below.*	**Identify common sources of power for metalworking tools.** 1. Electricity, including battery packs 2. Compressed air (pneumatic tools)
Objective 3	**Identify some safeguards for the use of power tools.** Safety precautions for electric tools and battery-powered tools 1. Always unplug a tool or disconnect it from its battery before inspecting it and making adjustments. 2. Only use a tool that is double insulated or has a grounded plug. 3. Always plug a tool into a power source with a ground-fault circuit interrupter (GFCI or GFI), which will shut off the electricity if a short occurs. If GFCIs are not installed, portable GFCIs can be plugged into grounded outlets. 4. Do not stand on wet ground or a wet surface while operating an electric tool. 5. Make sure stationary power tools are securely anchored to the floor. 6. Make sure all guards and shields are in place and vents are free of debris before operating an electric tool. 7. Do not bend the power cord sharply or use the cord to pull the plug from the outlet or carry the tool. Such actions could break the cord, and a broken cord is an electrical hazard.

Instructor Directions	Content Outline
	8. Use only the battery specified by the manufacturer for the tool being used. 9. Use only the type of recharger designed for the batteries being used. 10. Always store battery packs safely so that no metal can come in contact with the terminals. This can short-circuit the battery and cause sparks, fire, or burns. Safety precautions for pneumatic tools 1. Disconnect pneumatic tools for all inspections and adjustments. 2. Do not join or separate quick-disconnect couplings on high-pressure lines when bystanders are nearby. 3. Do not use compressed air for cleanup if the air pressure is 30 lb per sq in. (psi) or greater. 4. Do not point an air stream at anyone. High-pressure air can drive dust into the eyes, damage eardrums, and cause other types of injury. 5. Inspect couplings and air lines regularly for evidence of wear or damage. 6. Make sure air tanks and air lines are free of moisture and appropriate filters are in place. 7. Follow the manufacturer's recommendations for hose size and maximum air pressure. 8. Oil pneumatic tools regularly according to manufacturer recommendations.
Objective 4 *Refer to PPt 2 or display the actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.* PPt 2 – Portable Drill	**List the uses and safeguards for a portable drill.** Main parts 1. On/off switch 2. Power cord 3. Handle 4. Chuck 5. Chuck key Uses 1. Drilling and boring 2. Driving and removing screws 3. Sanding 4. Polishing 5. Powering hole saws

Instructor Directions	Content Outline
	Additional features 1. Available in different sizes 2. Size of drill determined by the chuck capacity (e.g., a 1/4-in. drill holds a drill bit with a shank no larger than 1/4 in.) 3. Single or variable speed 4. Reversible 5. Different kinds of drill bits for different types of jobs 6. Drill bits commonly made of carbon steel, high-speed steel, and cemented carbide a. Carbon steel - not as strong as high-speed steel and cemented carbide b. High-speed steel - stronger than carbon steel; withstands higher speeds and lasts for a longer period c. Cemented carbide - outlasts carbon steel and high-speed steel and withstands higher speeds Safety considerations 1. Choose the right bit for the job. 2. Make sure the bit is tightly seated in the chuck, securing it by turning the chuck key in each hole. Remove the key before starting the drill. 3. Make sure the work is held securely in place. Use a clamp or vise to hold small work. 4. Use a center punch to mark the location of the hole. The indentation made with the center punch helps guide the bit. 5. Hold the drill perpendicular to the metal to avoid binding the bit. 6. Remove the bit from the drill when the work is completed. Maintenance considerations 1. Follow the manufacturer's instructions for regular lubrication of parts. 2. Sharpen or replace dulled bits.
Objective 5 *Refer to PPt 3 or display the actual tool when explaining the main parts and features. Discuss*	**List the uses and safeguards for a portable power nibbler.** Main parts 1. On/off switch 2. Gear cover

Instructor Directions	Content Outline
safety and maintenance considerations. PPt 3 – Using a Nibbler to Make an Interior Cut	3. Punch 4. Die 5. Die holder Uses 1. Straight cuts 2. Curved cuts 3. Interior cuts 4. Cuts on thin metal that is bent or formed Additional features 1. Nibblers do similar work to hand shears or snips 2. Designed so cuttings are ejected down and away from operator Safety considerations 1. Wear eye protection. 2. Wear gloves when handling metal with sharp, cut edges. 3. Do not use compressed air or the hands to remove metal chips and cuttings. Maintenance considerations 1. Make sure chip-ejection hole is clear of debris. 2. Follow the manufacturer's recommendations for regular service.
Objective 6 *Refer to PPt 4 or display the actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.* PPt 4 – Cold Circular Cutoff Saw	**List the uses and safeguards for a cold circular cutoff saw.** Main parts 1. On/off switch 2. Table 3. Blade 4. Guard 5. Handle 6. Motor 7. Fence Uses 1. Straight cuts 2. Miter cuts

Instructor Directions	Content Outline
	Additional features 1. Features similar to a circular saw or table saw used in woodworking 2. Used for making accurate cuts on soft or unhardened metals Safety considerations 1. Wear eye protection. 2. Wear heavy gloves to protect the hands from cuts. 3. Do not use compressed air or your hand to remove metal chips and cuttings. Maintenance considerations 1. Follow the manufacturer's recommendations for regular service. 2. Clean, sharpen, or replace blades when they become dull.
Objective 7 *Refer to PPt 5 or display actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.* PPt 5 – Portable Grinder	**List the uses and safeguards for a portable grinder.** Main parts 1. On/off switch 2. Grinding wheel 3. Safety guard 4. Handle 5. Power cord Uses 1. Grinding 2. Shaping 3. Cleaning 4. Sanding (some models) Additional features 1. Lightweight 2. Grinding wheels available in different abrasives and different grits (coarseness) for different jobs 3. Flexible sanding discs can be used with some grinders for sanding wood and metal 4. Can be used with a wire brush for removing rust Safety considerations 1. Wear appropriate eye and face protection.

Instructor Directions	Content Outline
	2. Wear additional protective clothing, such as a dust mask or respirator, if needed. 3. Choose the right wheel or disc for the job. It should be rated to turn at speeds higher than the machine will produce. 4. Secure small pieces in a clamp or vise. 5. Examine the work area to identify areas where sparks might fall and make sure there is no fire hazard. Do not grind metal near combustibles. Maintenance considerations 1. Inspect grinding wheels regularly. Do not use wheels that are damaged or out of round. 2. Do not use wheels that are less than half of their original diameter. 3. Remove the wheel or disc after use. 4. Store the grinder and accessories in their proper place.
Objective 8 *Refer to PPt 6 or display actual tool when explaining the main parts and features. Discuss safety and maintenance considerations.* PPt 6 – Bench Grinder	**List the uses and safeguards for a bench grinder.** Main parts 1. On/off switch 2. Grinding wheels 3. Safety shields 4. Adjustable tool rest Uses 1. Sharpening and reconditioning tools 2. Shaping metal 3. Cleaning metal surfaces Additional features 1. Stationary, mounted on a bench; pedestal grinder is similar to bench grinder but is larger and mounted on the floor 2. Double-shafted motor, allowing a wheel to be mounted on each side 3. One wheel usually coarser, for removing material quickly; other wheel usually finer, for finishing work Safety considerations 1. Wear appropriate face and eye protection.

Instructor Directions	Content Outline
	2. Wear additional protective clothing, such as a leather apron or an appropriate filter or respirator, if needed. 3. Adjust the tool rest. 4. Stand to the side of the wheel when starting the grinder and let the wheel run for a short period before using it. Wheels that are going to break generally do so within the first minute of use. 5. Move the work slowly back and forth across the face of the wheel to avoid overheating the metal. 6. Do not force work into the grinding wheel. Allow the speed and grit of the wheel to do the work. Maintenance considerations 1. Do not use the wheel to grind soft metals, such as copper and aluminum. They quickly clog the grinding wheel. For soft metals, use an abrasive belt grinder instead. 2. Inspect wheels frequently. Replace wheels that have been damaged or dropped or are too worn to be reconditioned. 3. Wheels should be reconditioned to restore their abrasive work surface and bring them back into round. This is called dressing. Receive proper instruction and permission before dressing a wheel.
Objective 9 *Refer to PPt 7 or display the actual tool to explain the main parts and features of a sheet metal brake. Discuss safety and maintenance considerations.* PPt 7 – Sheet Metal Brake	**List the uses and safeguards for a sheet metal brake.** Main parts 1. Radius adjustment bolts 2. Bending lever 3. Elevation levers 4. Shoes Uses 1. Angle bends 2. Radius bends 3. Seaming 4. Flattening 5. Punching

Instructor Directions	Content Outline
	Additional features 1. Hand-operated brakes available in different sizes, from small bench-mounted models to industrial-size machines 2. Brake can exert thousands of pounds of pressure Safety considerations 1. Keep fingers clear of the working mechanism. 2. Leave bending machines closed when not in use. Maintenance considerations 1. Follow the manufacturer's recommendations for regular service.
Objective 10 *Refer to PPt 8 or display actual tool when explaining main parts and features. Discuss safety and maintenance considerations. Have students complete AS 1 to answer questions about safety and maintenance in the shop.* PPt 8 – Drill Press AS 1 – Safety and Maintenance Procedures for Power Tools for Metalworking	**List the uses and safeguards for a drill press.** Main parts 1. On/off switch 2. Column 3. Table clamp 4. Hand-feed lever 5. Chuck 6. Table 7. Base Uses 1. Drilling 2. Boring 3. Countersinking Additional features 1. Performs functions similar to portable drill but capable of heavier work; useful when more precision is needed 2. Size determined by doubling the distance from front edge of the column to the center of the drill bit 3. Available in bench and floor models Safety considerations 1. Secure stock before beginning to drill. Clamp piece on the left side of the table to keep it from rotating. 2. Use a center punch to mark and start the hole when drilling in metal.

<table>
<tr><th>Instructor Directions</th><th>Content Outline</th></tr>
<tr><td></td><td>3. Choose the right bit for the material and the drill - straight-shank bits should be used with geared chucks and taper-shank bits with taper chucks.
4. Make sure the table is properly aligned before turning on the drill press to avoid drilling into the table.
5. Reduce pressure as drill breaks through the work.

Maintenance considerations
1. Inspect bits regularly. Sharp bits cut better and are less likely to break.
2. Follow the manufacturer’s recommendations for regular care. Light grease on the spindle spline provides lubrication and reduces noise.</td></tr>
<tr><td>Application:

AS 1 – Safety and Maintenance Procedures for Power Tools for Metalworking</td><td>Answers to AS 1
Answers will vary.

Other activities
1. Show students a video on shop safety. Topics could include general shop safety or particular safety considerations for the equipment in the shop.
2. Accompany or follow the lesson with instructor demonstrations of each tool students will be using and procedures they will be expected to perform. Discuss any specific safety features relevant to the tools and machines in the shop that were not covered in the lesson outline above, and supplement the lesson with discussion of any equipment not covered. Begin or end demonstrations by having students review major parts of the tool and basic use and safety considerations.</td></tr>
<tr><td>Closure/Summary</td><td>Power tools can shorten the time it takes to complete metalworking jobs, but they must be used safely to prevent injuries. Using these tools safely requires choosing the right tool for the job, knowing how the tool works, and making the correct tool adjustments. Safe use also requires regular maintenance to be sure the tool is working properly.</td></tr>
</table>

Instructor Directions	Content Outline
Evaluation: Quiz	Answers: 1. c 2. b 3. a 4. c 5. c 6. b 7. c 8. a 9. d 10. b

Lesson 2: Safe Use and Maintenance of Power Tools for Metalworking

Name____________________________

Safety and Maintenance Procedures for Power Tools for Metalworking

Objective: Students will describe metalworking safety and maintenance procedures.

Directions: Answer the following questions regarding safety and maintenance procedures in metalworking.

Key Questions:

1. Where is the safety equipment kept in the shop?

2. What safety equipment is necessary for metalworking in your shop?

3. What is the importance of protective eyewear in metalworking? Is the eyewear used for metalworking different from that used for woodworking?

4. Does the shop have GFCIs? Where? What equipment uses them?

5. What types of batteries are used for power pack tools? How are the batteries disposed of after being drained?

6. Where is the fire extinguisher?

7. If an electric tool has a frayed cord, what should be done? Are there any frayed cords in your shop?

8. What are the signs that a pneumatic tool is damaged?

Unit I - Common Power Tools

Name_______________________

Lesson 2: Safe Use and Maintenance of Power Tools for Metalworking

Date_______________________

Assessment

Read the following statements from Workers A and B. Indicate the correct answer by selecting from the four listed choices.

1. Worker A says that for safe operation of a portable power drill you should remove the chuck key after using it to tighten the chuck.

   Worker B says that you should use a center punch to mark metal for drilling.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

2. Worker A says that a portable power nibbler is most similar in function to a file.

   Worker B says that you should not use compressed air to remove power nibbler cuttings.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

3. Worker A says that a cold circular cutoff saw can be used to make miter cuts on metals such as aluminum, copper, and stainless steel.

   Worker B says that a cold circular cutoff saw can be used to make irregular cuts in hardened metal.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

4. Worker A says that a portable grinder with a wire brush attached to it is useful for removing rust or chipped paint.

   Worker B says that a grinding wheel for a portable grinder should be rated to turn at speeds higher than the machine will produce.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

5. Worker A says that it is unsafe to use a grinding wheel that is out of round.

   Worker B says that a grinding wheel of coarse texture is best for shaping metal.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

6. Worker A says that a bench grinder usually has mountings for three grinding wheels.

   Worker B says that a bench grinder has an adjustable tool rest for supporting a small object while grinding.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

7. Worker A says that the tool or object should be moved slowly back and forth on the face of the grinding wheel.

   Worker B says that hard pressure should not be applied on the work against the grinding wheel.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

8. Worker A says that a sheet metal brake can exert thousands of pounds of pressure.

   Worker B says that a sheet metal brake is useful for making interior cuts in metal.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

9. Worker A says that a drill press is convenient for taking to various job sites.

   Worker B says that a drill press is commonly used for installing and removing screws.

   a. Worker A is correct.
   b. Worker B is correct.
   c. Both are correct.
   d. Neither is correct.

10. Worker A says that when using a drill press you should increase the pressure as the bit breaks through the work.

    Worker B says when using a drill press you should use the hand feed lever to lower or raise the chuck to allow drilling.

    a. Worker A is correct.
    b. Worker B is correct.
    c. Both are correct.
    d. Neither is correct.

Agricultural Science II

Curriculum Guide: *Agricultural Mechanics Unit for Agricultural Science II*

Unit: I. Common Power Tools

Unit Objective:

Students will demonstrate an understanding of the correct use of power tools by devising and giving a safety presentation for a power tool found in their class shop.

Show-Me Standards: 2.1, HP5

References:

Agricultural Mechanics Unit for Agricultural Science II. University of Missouri-Columbia, Instructional Materials Laboratory, 2002.

Cyr, D. L., & Johnson, S. B. *Power Tool Safety*. University of Maine Cooperative Extension. Accessed November 25, 2003, from http://www.umext.maine.edu/onlinepubs/htmpubs/2329.htm.

Hobar Publications. Finney-Hobar. Accessed November 10, 2003, from http://www.finney-hobar.com/hobar.html.

Machinery Safety. National Ag Safety Database. Accessed November 10, 2003, from http://www.cdc.gov/nasd/menu/topic/machinery_safety.html.

Tritt, S. W. *Hand and Power Tool Safety*. Safety Information Resources on the Internet. University of Vermont. Accessed November 25, 2003, from http://www.esf.uvm.edu/sirippt/handsafe/.

University of Missouri Outreach and Extension Rural Safety and Health Program. Accessed November 10, 2003, from http://www.fse.missouri.edu/ruralsafety/index1.html.

Students may use additional outside sources to complete this activity.

Instructional Strategies/Activities:

- Students will engage in study questions in lessons 1 and 2.
- Students will complete AS 1.1, Safety and Maintenance Procedures for Power Tools for Woodworking; and AS 2.1, Safety and Maintenance Procedures for Power Tools for Metalworking.
- Additional activities that relate to the unit objective can be found under the heading “Other Activities” in the following location: p. I-10 (2).

Performance-Based Assessment:

Students will work in groups to develop a safety presentation that summarizes the main parts, uses, and safety and maintenance considerations for a power tool found in their class shop. Students will give the presentation to the class.

Assessment will be based on the overall thoroughness and accuracy of the presentation. Delivery of the presentation and use of supporting material, such as illustrations, also will be factors in the assessment.

Agricultural Mechanics Unit for Agricultural Science II
Unit I—Common Power Tools
Instructor Guide

The instructor should assign the performance-based assessment activity at the beginning of the unit. Students will work toward completing the activity as they progress through the unit lessons. The assessment activity will be due at the completion of the unit.

1. Divide the class into groups and assign each group a power tool in the class shop that is used for woodworking, metalworking, or both.

2. Have each group develop a safety presentation for its assigned tool. Presentations should address the following topics:
   - ❑ Main parts
   - ❑ Uses
   - ❑ Safety features of the tool and safe operating procedures, including wearing appropriate personal protective equipment and proper setup, shutdown, and cleanup procedures
   - ❑ Basic care and maintenance

3. **NOTE: This activity is designed as an informational presentation only; it is not a hands-on demonstration. This activity is *not* a substitute for instructor training and demonstrations, shop safety tests and safety agreements, or any other safety procedures. Students should not demonstrate or operate any equipment unless they have completed all required safety tests and agreements, mastered all relevant competencies, and have the instructor's permission.**

4. Have students incorporate appropriate supporting materials into their report, such as a poster or handout outlining safety practices, examples of personal protective equipment that should be worn when using the tool, a slide show using presentation software, or a combination of elements. Indicate to students what supporting elements are acceptable or preferred.

5. Students may use material found in the unit or discussed in class as well as additional outside material to complete their presentation.

6. Students may not use the source material word for word and must provide a complete bibliography of their sources following their presentation.

7. Review and approve each presentation before the students make their presentations to the class. Guide and correct the students' presentations as needed.

8. Have students give their safety presentations to the class.

9. Students should be prepared to answer questions about their presentations.

10. Guide and correct the students' presentations as needed.

11. The final assessment score will be based on the overall thoroughness and accuracy of the presentation. Delivery of the presentation and use of supporting material also will be factors in the assessment.

Agricultural Mechanics Unit for Agricultural Science II
Unit I—Common Power Tools
Student Handout

1. The instructor will divide the class into groups and assign each group a power tool found in the class shop.

2. Develop a safety presentation for your assigned tool. Your presentation should address the following topics:
   - ❑ Main parts
   - ❑ Uses
   - ❑ Safety features of the tool and safe operating procedures, including wearing appropriate personal protective equipment and proper setup, shutdown, and cleanup procedures
   - ❑ Basic care and maintenance

3. Include appropriate supporting materials in your report, such as a poster or handout outlining safety practices, examples of personal protective equipment that should be worn when using the tool, a slide show using presentation software, or a combination of these or other elements as indicated by your instructor.

4. You may use material found in the unit or discussed in class as well as additional outside material to complete your presentation.

5. You may not use the source material word for word and must provide the instructor with a complete bibliography of your sources following your presentation.

6. The instructor must review and approve your presentation.

7. Give your presentation to the class.

8. Be prepared to answer questions about your presentation.

9. Your final assessment score will be based on the overall thoroughness and accuracy of your presentation. Delivery of the presentation and use of supporting material also will be factors in the assessment.

Agricultural Science II

Agricultural Mechanics Unit for Agricultural Science II
Unit I—Common Power Tools
Scoring Guide **Name** ____________________

Assessment Area	Criteria	0 Points	1 Point	2 Points	3 Points	4 Points	Weight	Total
Information and Content of Safety Presentation	❑ Presentation addresses main parts, uses, safety, and maintenance of the tool ❑ Information is complete ❑ Facts are accurate ❑ Good use of supporting materials	0 criteria met	1 criterion met	2 criteria met	3 criteria met	4 criteria met	X 20	
Delivery of Safety Presentation	❑ Well organized ❑ Holds audience interest ❑ Speaks clearly and uses correct grammar ❑ Maintains good posture ❑ Needs little or no prompting from the instructor	0 criteria met	1–2 criteria met	3 criteria met	4 criteria met	5 criteria met	X 5	
TOTAL								

Final Assessment Total ________/100 pts.

Comments:

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Arc Welding
Lesson	Safety and Maintenance Procedures for Arc Welding
Estimated Time	50 minutes

Student Outcome

Identify basic safety and maintenance procedures for arc welding.

Learning Objectives

1. Identify the safety and health risks associated with arc welding.
2. Explain how electric shock can be avoided when welding.
3. Explain how burns and fire can be avoided when welding.
4. Explain how hazards from arc rays can be avoided when welding.
5. Explain how breathing hazards can be avoided when welding.
6. Describe the care and maintenance required for the arc welding equipment.

Grade Level Expectations

SC/ME/1/H/09-11/d

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Protective Clothing for Welding
   - PPt 2 – Protective Eyewear
   - PPt 3 – Respirators Used for Welding
2. Activity Sheet
   - AS 1 – Arc Welding Safety
3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit II – Arc Welding." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Internet Sites
   - Arc Welding Safety Resources. Lincoln Electric. Accessed November 12, 2007, from http://www.lincolnelectric.com/community/safety/.
   - Hexavalent Chromium. Safety and Health Topics. Occupational Safety and Health Administration. U. S. Department of Labor. Accessed October 2, 2007, from http://www.osha.gov/SLTC/hexavalentchromium/index.html.
   - Safety and Health Fact Sheets. American Welding Society. Accessed October 2, 2007, from http://www.aws.org/technical/facts/.

- ❑ Welding Calculators. Miller Electric Manufacturing Co. Accessed October 2, 2007, from http://www.millerwelds.com/education/calculators/.

2. Print
   - ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding*. Tinley Park, IL: Goodheart-Willcox, 2000.
   - ❑ Jeffus, L. *Welding Principles and Applications.* 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
   - ❑ Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics.* Upper Saddle River, NJ: Prentice Hall Interstate, 2004.
3. Electronic Media
   - ❑ Smartflix offers a line of videos related to metalworking that can be rented from their Web site. Accessed September 12, 2007, from http://smartflix.com/store/category/115/Metalworking.

Interest Approach

Have students discuss shop safety procedures they are already familiar with and how these might apply specifically to welding. Then discuss what additional safety procedures they would anticipate needing to take. One example would be protective eye wear. Clear safety glasses are needed when cleaning slag from welds, but shaded lenses are also needed for the actual welding process.

Communicate the Learning Objectives

1. Identify the safety and health risks associated with arc welding.
2. Explain how electric shock can be avoided when welding.
3. Explain how burns and fire can be avoided when welding.
4. Explain how hazards from arc rays can be avoided when welding.
5. Explain how breathing hazards can be avoided when welding.
6. Describe the care and maintenance required for the arc welding equipment.

Instructor Directions	Content Outline
Objective 1 *Safety and health risks associated with arc welding are discussed at right.*	**Identify the safety and health risks associated with arc welding.** 1. Electric shock – Arc welders produce relatively low voltage, but they can produce enough to kill a person by electric shock. 2. Burns and fire – The arc produced by an arc welder can reach temperatures in excess of 9,000°F. 3. Burns from arc rays – The welding arc emits rays that can cause first- and second-degree burns of skin within minutes and flash burns of the eyes within seconds. These rays cannot be seen, and their effects are not felt until after exposure has occurred. Reflected light from welding is as dangerous as direct light. 4. Breathing hazards from oxygen displacement and from toxic fumes and gases – The arc, flame, fumes, or gases can reduce or replace oxygen if the area is not adequately ventilated. Toxic fumes and gases given off in the welding process can also pose a hazard.
Objective 2 *Although welding can be done with relatively low voltage, it nevertheless poses the danger of electric shock. Discuss ways to avoid shock hazards.*	**Explain how electric shock can be avoided when welding.** Make sure the welder is installed and hooked up properly. 1. Make sure the welder is properly grounded. Do not confuse the grounding device with the ground clamp that attaches to the work.

Instructor Directions	Content Outline
	2. Make sure the power disconnect switch is within close reach of the operator. 3. Make sure the welder is on its own circuit with a fuse or breaker of the appropriate size. Inspect equipment for damage or a defect. 1. Keep connections tight and clean. Bad connections can heat up and cause dangerous arcs or melting. 2. Do not use electrode holders that are damaged or display poor insulation. Disconnect the welder from the power source before making any repairs. Do not change the polarity switch or the current setting while the machine is under a load, that is, when there is an arc between the electrode and the work. Keep clothing, gloves, and equipment dry and do not stand on a wet surface or on a conductive material. 1. Stand on a dry board or a rubber mat if work must be done in a wet area or if standing must be done on a conductive material, such as steel. 2. Wear rubber gloves under the welding gloves if the area is wet or the operator is perspiring. Do not change the electrode while wearing wet gloves or standing on a wet surface. Do not put the electrode holder in water to cool it. Do not use water to extinguish an electrical fire or any fire near the welder. Remove the electrode from the holder when work is finished.
Objective 3 *The welding arc and the high temperatures it produces can cause burns or fires. Discuss measures to prevent burns and fires. Refer to PPt 1.*	**Explain how burns and fire can be avoided when welding.** Make the work area as fire resistant as possible. 1. Construct the welding booth of fireproof or fire-resistant materials, such as metal sheeting or concrete blocks.

Instructor Directions	Content Outline
PPt 1 – Protective Clothing for Welding	2. Keep the work area clean and free of trash, grease, oil, and other flammable materials. 3. Keep a fire extinguisher, first-aid kit, and safety equipment within easy reach. Take precautions when handling hot work pieces. 1. Use tongs or pliers, not hands, to pick up hot metal. 2. Use caution to avoid steam burns when cooling metal pieces in water. 3. Write the word "HOT" with soapstone or chalk on the work if a piece of hot metal must be left where others could be in contact with it. 4. Do not walk around the shop holding hot metal. Wear appropriate clothing and safety gear. 1. Wear leather gauntlet-style gloves and high-top leather shoes to protect the hands and feet. 2. Wear only wool or cotton clothing that is dark and tightly woven to help protect the skin from fire and to help block arc rays. 3. Do not wear synthetic materials, which can burn readily and give off poisonous gases. 4. Wear only long-sleeved shirts that button at the sleeves and collar. Keep the sleeves and shirt buttoned, including the top button at the collar. 5. Wear pants that come down over the top of the boots and do not have cuffs. Sparks could get caught in the cuffs. 6. Long-sleeved fire-resistant coveralls are recommended. Other types of protective clothing, such as leather aprons and leather sleeves, are also available and should be worn as needed. 7. Do not wear clothing with torn or frayed areas that could leave the skin exposed or could easily catch fire from sparks. 8. Wear safety glasses or goggles when chipping hot slag from welds. Wear additional head and eye protection, such as a flameproof skullcap or face shield, as needed to avoid burns from sparks or hot metal spatter. 9. Do not have items in pockets that could catch fire or explode, such as matches or butane lighters.

Instructor Directions	Content Outline
	Do not attempt to heat, cut, or weld containers such as tanks, drums, and barrels.
Objective 4 *Light from the welding arc can burn the eyes within seconds. Discuss procedures for avoiding light burns of the eyes. Refer to PPt 2.* PPt 2 – Protective Eyewear	**Explain how hazards from arc rays can be avoided when welding.** Wear a welding helmet with a filter lens classified as no. 10 or higher, depending on the work being done. Consult the manufacturer's recommendations for appropriate lens. 1. Wear safety glasses if the helmet does not have a lens made of safety glass. Welding helmets are available in different types, including some that have a flip-up or fixed shaded lens. A flip-up lens allows work such as chipping to be done without removing the helmet. If a flip-up lens helmet is not used, safety glasses must be worn under the helmet. 2. Inspect the helmet and lens assembly to make sure they are undamaged and gaskets fit properly. A damaged helmet or loose gaskets could allow light leaks. Warn others in the area that you are going to begin welding by saying "Cover up!" Make sure all persons in the welding area are wearing eye protection, such as flash glasses, to avoid eye injury from the reflected light.
Objective 5 *Discuss the hazards of inadequate ventilation and exposure to gases and fumes. Refer to PPt 3. After discussing the various safety hazards in welding, assign AS 1 to have students do a safety inspection of the shop.* PPt 3 – Respirators Used for Welding AS 1 – Arc Welding Safety	**Explain how breathing hazards can be avoided when welding.** 1. Work in an adequately ventilated area. 2. Use forced ventilation if natural ventilation is not sufficient. 3. Supplement ventilation as needed with an appropriate respirator. 4. Clean the metal before welding. Cleaning the metal helps remove any chemicals that might mix with the fumes produced by welding. It also is safer and easier to establish an arc on a clean surface. 5. Operate engine-powered welders only in well-ventilated areas or with the exhaust vented directly outdoors.

Instructor Directions	Content Outline
Objective 6	**Describe the care and maintenance required for the arc welding equipment.** 1. Inspect the electrode holder frequently to be sure it is not damaged or in need of repair. 2. Keep cables free of oil and grease. 3. Run cables so that they will not be damaged or cause a tripping hazard. In temporary work sites, cables can be protected with C-channel. 4. To avoid damaging the welder, do not shut off or start the welder with the electrode or electrode holder in contact with the work or the welding table. Hang the holder from an insulated hanger when not in use. 5. Keep the welder and electrodes dry. 6. Do not allow dust to accumulate on the transformer coils.
Application: AS 1 – Arc Welding Safety	Answers to AS 1 Answers will vary, depending on the procedures assigned by the instructor and on the setup of the individual shop. Other activities 1. Obtain safety lenses of different shade numbers and show students the difference in the darkness of each shade. Show them how they can identify the shade number. Instruct students on the safe and proper use of safety lenses. 2. Have students collect additional information about arc welding and arc welding safety and present it to the class. Encourage them to consult a variety of sources. Possible sources include other agricultural mechanics textbooks, the Internet, safety information from manufacturers, and conversations with individuals who weld, either for personal use or professionally. Discuss their findings. If some of the information varies or seems to contradict other information, discuss possible causes for these differences and then identify the safest course of action.

Instructor Directions	Content Outline
Closure/Summary	Arc welding demands strict attention and adherence to safe practices. Specific dangers include electric shock, burns and fire, arc rays, and breathing hazards. Avoid these dangers by properly installing and maintaining equipment, promoting and maintaining a fire-resistant work area, wearing appropriate clothing and safety gear, and ventilating the work area.
Evaluation: Quiz	Answers: 1. d 2. b 3. b 4. a 5. d 6. a 7. c 8. b 9. b 10. a. Electric shock Instructor should use discretion. Some possible answers are the following: 1. Ensure proper installation and hookup of the welder. 2. Inspect equipment for damage or defects. 3. Disconnect the welder from the power source before making any repairs. 4. Do not change the current setting while the machine is under a load. 5. Keep clothing, gloves, floor, and equipment dry. 6. Do not put the electrode holder in water to cool it. 7. Do not use water to put out electrical fires or any fire near the welder. 8. Remove the electrode from the holder when the work is finished and disconnect the welder from the power source. b. Burns and fire 1. Make the work area as fire resistant as possible. 2. Be careful with hot work pieces. 3. Wear appropriate clothing and safety gear.

Instructor Directions	Content Outline
	4. Do not attempt to heat, cut, or weld containers such as tanks, drums, and barrels. c. Burns from arc rays 1. Wear a welding helmet with a filter lens classified as no. 10 or higher, depending on the work being done. 2. Wear dark, tightly woven clothing that covers the body. 3. Warn others in the area to cover up before you begin to weld. 4. Persons in the welding area should also wear eye protection. d. Breathing hazards 1. Work in an area with adequate ventilation. 2. Use forced ventilation if natural ventilation is not sufficient. 3. Supplement ventilation as needed with an appropriate respirator. 4. Clean metal before welding. 5 Operate engine-powered welders in well-ventilated areas or with the exhaust vented directly outdoors.

Lesson 1: Safety and Maintenance Procedures for Arc Welding

Name___________________________

Arc Welding Safety

Objective: Students will describe safety procedures required for arc welding.

Directions: Apply what you have learned about arc welding safety to do a safety inspection of the arc welding facilities in the classroom shop. Answer the following questions.

Key Questions:

1. What assigned safety procedures must be followed in the shop to avoid exposure to arc rays?

2. What assigned procedures must be followed to avoid burn injuries and to prevent fires?

3. How is ventilation provided?

4. Is a respirator required for any welding operations done in the shop? If so, when, and what kind of respirator is required?

5. What procedures exist to prevent electric shock?

6. Where is the fire extinguisher located?

Unit II – Arc Welding

Name__________________________

Lesson 1: Safety and Maintenance Procedures for Arc Welding

Date__________________________

Assessment

Read the following statements from Welders A and B. Indicate which is correct by selecting from the four listed choices.

1. Welder A says that putting out an electrical fire with water does not cause a hazard for electrical shock.

   Welder B says that changing the current while the welder is under load does not cause a hazard for electrical shock.

   a. Welder A is correct.
   b. Welder B is correct.
   c. Both are correct.
   d. Neither is correct.

2. Welder A says standing on steel while welding is not an electrical hazard.

   Welder B says that the electrode should be removed from the holder when welding is completed to avoid a shock hazard.

   a. Welder A is correct.
   b. Welder B is correct.
   c. Both are correct.
   d. Neither is correct.

3. Welder A says that the walls of the welding booth should be made of wood to avoid a fire hazard.

   Welder B says that the floor should be free of cracks to avoid a fire hazard.

   a. Welder A is correct.
   b. Welder B is correct.
   c. Both are correct.
   d. Neither is correct.

4. Welder A says that hot metal pieces should be handled with tongs rather than gloved hands.

   Welder B says that rubber gloves should be worn while welding to protect the hands from burns.

   a. Welder A is correct.
   b. Welder B is correct.
   c. Both are correct.
   d. Neither is correct.

5. Welder A says that a light-colored short-sleeved shirt should be worn for welding.

   Welder B says that polyester pants with cuffs should be worn for welding.

   a. Welder A is correct.
   b. Welder B is correct.
   c. Both are correct.
   d. Neither is correct.

6. Welder A says that dark, tightly woven clothing should be worn to protect the skin from harmful arc rays.

   Welder B says that safety lenses with filter lens of no. 10 or higher should be worn for chipping slag from a weld.

   a. Welder A is correct.
   b. Welder B is correct.
   c. Both are correct.
   d. Neither is correct.

7. Welder A says that good ventilation is essential for safe welding.

   Welder B says that a respirator is sometimes required to avoid exposure to harmful fumes from some metals.

   a. Welder A is correct.
   b. Welder B is correct.
   c. Both are correct.
   d. Neither is correct.

8. Welder A says that grease should be applied to the cables to prevent them from drying out.

   Welder B says that the welder should not be turned on while the electrode holder is in contact with the work.

   a. Welder A is correct.
   b. Welder B is correct.
   c. Both are correct.
   d. Neither is correct.

9. Welder A says that people in the work area do not need to wear protective eyewear if the welding booth has a curtain.

   Welder B says that it is necessary to warn others in the area that welding is about to begin so they can protect themselves.

   a. Welder A is correct.
   b. Welder B is correct.
   c. Both are correct.
   d. Neither is correct.

Complete the following short-answer question.

10. List ways to avoid the safety hazards listed below.

    a. Electric shock

    1)

    2)

    3)

b. Burns and fire

1)

2)

3)

c. Burns from arc rays

1)

2)

d. Breathing hazards

1)

2)

3)

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Arc Welding
Lesson	Controlling Distortion in Arc Welding
Estimated Time	50 minutes

Student Outcome

Describe the procedures used to control distortion during arc welding.

Learning Objectives

1. Describe the effects of temperature change on metal.
2. Explain the causes and examples of distortion in arc welding.
3. Describe what techniques can be used to control and correct distortion.
4. Explain what residual stress is and how can it be controlled and corrected.

Grade Level Expectations

SC/ME/1/D/09-11/a   SC/ME/1/D/09-11/b

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Distortion in Welding
   - PPt 2 – Welding Techniques to Control Distortion
   - PPt 3 – Distortion and Residual Stress
2. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
3. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit II – Arc Welding." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Internet Sites
   - American Welding Society. Accessed October 2, 2007, from http://www.aws.org.
   - Welding Calculators. Accessed October 2, 2007, from http://www.millerwelds.com/education/calculators/.
2. Print
   - Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding*. Tinley Park, IL: Goodheart-Willcox, 2000.
   - Jeffus, L. *Welding Principles and Applications*. 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
   - Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics*. Upper Saddle River, NJ: Prentice Hall Interstate, 2004.

Interest Approach

Show students examples of well-made and distorted joints that they should be familiar with from Agricultural Mechanics I. Have students discuss their experiences making these joints. Did they have trouble with distortion? What do they think was the cause of the distortion? Were they able to straighten any distorted welds or improve their technique to avoid distortion on welds they made later? If so, how?

Communicate the Learning Objectives

1. Describe the effects of temperature change on metal.
2. Explain the causes and examples of distortion in arc welding.
3. Describe what techniques can be used to control and correct distortion.
4. Explain what residual stress is and how can it be controlled and corrected.

Instructor Directions	Content Outline
Objective 1 *Discuss factors that cause welded metal to warp. Refer to PPt 1.* PPt 1 – Distortion in Welding	**Describe the effects of temperature change on metal.** Metal expands when it is heated and contracts as it cools. If metal is heated evenly and is cooled evenly, it can return to its original shape. If metal does not heat and cool evenly, it may distort.
Objective 2	**Explain the causes and examples of distortion in arc welding.** The metal is not heated evenly. Metal is much hotter at the point being welded than at an area not being welded. The weld bead itself restricts movement. Examples of distortion – an upward curve in a previously flat piece, a bend in a previously straight piece, and a vertical piece pulling away from the weld.
Objective 3 *Distortion can be an obstacle to producing good welds, but steps can be taken before, during, and after the welding process to control it. Refer to PPt 2.*	**Describe what techniques can be used to control and correct distortion.** Before welding 1. Heat treating – The whole piece of metal can be heated before welding (preheating) and during welding (interpass heating). The process of raising and maintaining the temperature of the whole piece and allowing it to cool slowly promotes uniform expansion and contraction.

Instructor Directions	Content Outline
PPt 2 – Welding Techniques to Control Distortion	2. Positioning – By setting the pieces slightly out of alignment opposite the pull of contraction, the contraction force can be used to pull the pieces into position and eliminate distortion. 3. Tack welding – Small welds can be made along the seam to hold the pieces in place. The number of tack welds needed depends on the length of the weld. 4. Prebending – Pieces can be bent prior to welding so that the contraction force pulls them into position. 5. Using welding jigs and fixtures – Jigs and fixtures can be used to hold pieces in place. During welding 1. Limiting the number of passes to as few as possible and not adding excessive material – Additional passes and filler add more heat to the weld, increasing the potential for distortion. 2. Back-step welding – The joint as a whole is completed from left to right, but it is made up of smaller beads put down from right to left. 3. Alternating sides – By welding on both sides of the material, the contraction forces on one side offset those on the other. After welding 1. Shrinkage – The piece is alternately heated and cooled to counteract distortion. 2. Shrink welding – Beads are added to the opposite side of the distorted weld. This added weld and the contraction force it produces as it cools help to pull the original weld into alignment. The additional beads can then be ground off, if desired. 3. Peening – Hammering is used to offset distortion. While peening can be done by hand, use of a pneumatic hammer with a suitable tool fitted in it is preferred. Peening can be completed faster with a pneumatic hammer and the hammering is consistent and more easily controlled. Whatever method is used, care should be taken to not overpeen the piece, which can cause cracks or new stresses. Combining methods – Methods can be used together or in sequence to control distortion.

Instructor Directions	Content Outline
Objective 4 *Welds can also be distorted by residual stress. Refer to PPt 3.* PPt 3 – Distortion and Residual Stress	**Explain what residual stress is and how can it be controlled and corrected.** Residual stress is the force that remains after welding is completed. It can cause cracks or distortion at the weld as well as elsewhere on the piece. Residual stress may not be apparent. A joint may be distorted but have no residual stress, or it may seem sound but have a great deal of internal stress. This force can cause the metal to distort at some later time. Residual stress can be controlled and corrected by preheating, postheating, and peening.
Application:	Other activities 1. Arrange a field trip to a welding shop to give students firsthand knowledge of a commercial operation using arc welding. Have the students pay particular attention to safety procedures and devices used and available at the job site.
Closure/Summary	Welded metal may distort when it is unevenly heated or cooled. Examples of distortion are a curve in a flat piece, a bend in a straight piece, and weld separation. Use any of several techniques to avoid distortion. Heat treating, positioning, tack welding, and prebending can be used before welding. During welding, limit passes, alternate sides, or apply back-step welding. After welding, employ shrinkage, shrink welding, or peening. Residual stress, which causes cracks or distortion after welding, can be controlled or corrected by preheating, postheating, or peening.
Evaluation: Quiz	Answers: 1. a 2. c 3. Residual stress is the force remaining after welding is completed. It can cause cracks or distortion at the weld or elsewhere on the piece. 4. Answers should include six of the following or others at instructor's discretion if discussed in class. a. Heat treating (preheating, interpass heating) b. Positioning c. Tack welding d. Prebending

Instructor Directions	Content Outline
	e. Using clamps, jigs, or fixtures f. Using as few passes as possible g. Avoiding adding excessive material to the weld h. Back-step welding i. Alternating sides (welding on both sides of the piece) j. Shrinkage k. Shrink welding l. Peening 5. Answers will vary. 6. Contraction force can be used to pull pieces into alignment. Students might also give examples, such as positioning pieces out of alignment so the contraction force pulls them together, prebending pieces, welding on alternate sides, positioning work slightly out of alignment in clamps or fixtures, or shrink welding. 7. Overpeening can cause cracks or new stresses in the work.

Course	Ag Science II
Unit	Ag Mech II
Lesson	Arc Welding – Controlling distortion

Item to Change (specific location)	Description of Change	**Enhancements** Location	Description	Priority

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Arc Welding
Lesson	Selecting and Maintaining Electrodes and Safety Lenses
Estimated Time	50 minutes

Student Outcome

Describe the factors in selecting and maintaining electrodes and safety lenses.

Learning Objectives

1. Identify the two parts of an arc welding electrode and what the functions of each of them are.
2. Describe some of the factors to take into consideration when selecting an electrode.
3. Explain how electrodes are identified.
4. Explain what the letters and numbers in the AWS classification system mean.
5. Explain how electrodes should be stored and cared for.
6. Explain how the correct safety lenses are selected for arc welding.
7. Describe how filter lenses and welding helmets should be cared for.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
    - PPt 1 – Electrode Color Markings
    - PPt 2 – AWS Classification and Designators
    - PPt 3 – Electrode Classification
    - PPt 4 – Protective Eyewear
2. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
3. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit II – Arc Welding." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Internet Sites
    - ❑ Arc Welding. Division of Safety and Hygiene of the Ohio Industrial Commission. Vermont Safety Information Resources, Inc. Accessed October 8, 2007, from http://siri.org/library/ind/Welding/arc.html.
    - ❑ Fluegel, L., and B. Rein. "Arc Welding Safety." University of Arizona Cooperative Extension. National Ag Safety Database. Accessed October 8, 2007, from http://www.cdc.gov/nasd/docs/d000801-d000900/d000873/d000873.html.

- Harris, J. Commonly Asked Questions About Welding Helmets and Eye Protection. Lincoln Electric. Accessed on October 8, 2007 from http://www.lincolnelectric.com/knowledge/articles/content/weldinglenses.asp.
- Recommended Filter Lenses for Various Welding Operations. Integrated Publishing. Accessed October 8, 2007, from http://www.tpub.com/content/construction/14250/css/14250_71.htm.
- Welding, Cutting, and Brazing. Occupational Safety and Health Administration. U. S. Department of Labor. Accessed October 8, 2007, http://www.osha.gov/SLTC/weldingcuttingbrazing/index.html.

2. Print
   - Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding.* Tinley Park, IL: Goodheart-Willcox, 2000.
   - Jeffus, L. *Welding Principles and Applications.* 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
   - Phipps, L. *Mechanics in Agriculture*. 4th ed. Danville, IL: Interstate Publishers, 1992.
   - Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics*. Upper Saddle River, NJ: Prentice Hall Interstate, 2004.
3. Electronic Media
   - Smartflix offers a line of videos related to metalworking that can be rented from their Web site. Accessed September 12, 2007, from http://smartflix.com/store/category/115/Metalworking.

Interest Approach

Have students examine a number of electrodes to identify how they are different and similar. Are they different in diameter, length, and application? What features could be used for classifying electrodes? Are there any electrodes that are different in only one way—length, for example—but otherwise are the same? What are important factors for choosing the right electrode for the job?

Communicate the Learning Objectives

1. Identify the two parts of an arc welding electrode and what the functions of each of them are.
2. Describe some of the factors to take into consideration when selecting an electrode.
3. Explain how electrodes are identified.
4. Explain what the letters and numbers in the AWS classification system mean.
5. Explain how electrodes should be stored and cared for.
6. Explain how the correct safety lenses are selected for arc welding.
7. Describe how filter lenses and welding helmets should be cared for.

Instructor Directions	Content Outline
Objective 1	**Identify the two parts of an arc welding electrode and what the functions of each of them are.** A solid metal core – adds filler metal to the weld as it melts A flux coating – may do any or all of the following: 1. Adds filler metal to the weld 2. Stabilizes the arc 3. Produces a gas shield that protects the weld 4. Adds flux to the weld a. Flux removes impurities that rise to the surface of the weld. b. Flux promotes the formation of slag (a protective layer over the weld). 5. Adds alloying elements to improve the weld 6. Determines the polarity of the electrode
Objective 2	**Describe some of the factors to take into consideration when selecting an electrode.** Type of metal being welded and its tensile strength Thickness of the metal Condition of the base metal

Instructor Directions	Content Outline
	Welding position (i.e., flat, vertical, horizontal, and overhead) Experience of the welder Rate at which the filler metal should be added Design or alignment of the joint Properties of the alloying elements contained in the flux Type of electric current being used
Objective 3 *Refer to PPts 1 and 2.* PPt 1 – Electrode Color Markings PPt 2 – AWS Classification and Designators	**Explain how electrodes are identified.** National Electrical Manufacturers Association (NEMA) color coding 1. This system identifies electrodes by placing a code color on the end of the electrode (end marking), on the bare metal core (spot marking), and the flux coating (group marking). 2. Manufacturers who use the NEMA system use the same color markings. 3. The NEMA color code is not the same as the manufacturer's trademarks or coating colors. American Welding Society (AWS) classification 1. This is the standard classification system adopted by the welding industry. 2. A series of letters and numbers gives information about the properties of the electrode, such as tensile strength, weld position, coating, welding current, and polarity. 3. The AWS classification code is stamped on the side of the electrode.
Objective 4 *Refer to PPts 2 and 3. Main elements of the AWS system for electrode classification are*	**Explain what the letters and numbers in the AWS classification system mean.** Prefix letter or letters provide information about the filler (e.g., "E" indicates the electrode is used in arc welding).

Instructor Directions	Content Outline
summarized in the outline at right. Supplement this discussion with additional information as needed to cover materials or procedures used in the shop. PPt 2 – AWS Classification and Designators PPt 3 – Electrode Classification	First two digits of a four-digit number or first three digits of a five-digit number indicate the minimum tensile strength of the weld metal. 1. Minimum tensile strength is usually expressed in pounds per square inch (psi). Thus, a 60-series electrode has a minimum tensile strength of 60,000 psi. 2. Tensile strength can also be expressed in kilopounds per square inch (ksi). 3. Tensile strength may be given for welds that have undergone postheating treatment to remove stress (referred to as "stress-relieved") or those that have not been postheated (termed "as-welded"). The manufacturer's specifications identify which is the case. The second digit from the right indicates recommended welding position. 1. The number "1" indicates the electrode can be used in all positions – flat (F), vertical (V), overhead (OH), and horizontal (H). 2. The number "2" indicates the electrode can be used in flat and horizontal positions. 3. The number "3" formerly indicated that the electrode was used in the flat position. This code is no longer used but continues to appear in some textbooks and references. 4. The number "4" indicates the electrode can be used in flat, horizontal, overhead, and vertical-down positions. The last digit on the right provides information about operating characteristics, such as welding current and/or depth of penetration. 1. "DCEN" stands for "direct current electrode negative" and was formerly referred to as "direct current straight polarity" (DCSP). It means that the electrode is the negative pole and the work is positive. The preferred term is now DCEN, but some references to DCSP may still be encountered. 2. "DCEP" stands for "direct current electrode positive" and was formerly referred to as "direct current

Instructor Directions	Content Outline
	reverse polarity" (DCRP). In this situation, the electrode is positive and the work is negative. The preferred term is DCEP, but some references to DCRP may be encountered. The last two digits on the right together give additional information, such as coating composition and proper application. Some electrodes are labeled with suffixes after the numerical code. 1. These additional designators identify any alloying elements added to the weld. 2. The manufacturer's specifications should be consulted for the exact chemical composition of the coating.
Objective 5 *Introduce the topic of proper handling of electrodes by asking students to describe how electrodes are stored in the shop and any storage procedures that must be followed. Why do they believe electrodes are stored and handled in such ways?*	**Explain how electrodes should be stored and cared for.** Store electrodes in a dry, waterproof place. 1. Moisture can produce steam during welding, which can carry away the shielding gases that protect the weld. 2. Damp electrodes can cause such problems as increased spatter and poor slag removal. 3. Hydrogen from water can be added to welds and weaken them. 4. Welds made with damp electrodes may be porous and subsequently crack. 5. Repairing or replacing faulty welds made with damp electrodes costs time and money. 6. Failure to recognize faulty welds could pose a safety threat if the weld breaks down. Know the moisture-pickup time for electrodes being used. 1. The moisture-pickup time is defined as the time it takes an electrode to absorb moisture from the air. 2. Manufacturers designate moisture-pickup time period for all electrodes. 3. To avoid exceeding the moisture-pickup time, take only the number of electrodes needed for a job or

Instructor Directions	Content Outline
	only the number that can be used within the moisture-pickup time period. Make sure electrodes exposed to moisture are dried in an electrode-drying oven before they are used. Handle electrodes carefully to avoid damaging the flux coating. Electrodes with chipped coating often cannot be used.
Objective 6 *Refer to PPt 4. Review general information about the need for protection from arc rays in Unit II Lesson 1 or amend or supplement any information in the outline as needed for the equipment and procedures used in the shop.* PPt 4 – Protective Eyewear	**Explain how the correct safety lenses are selected for arc welding.** Good quality filter lenses should filter out about 99.5% of the infrared rays and 99.75% of the ultraviolet rays produced by the welding arc. 1. Arc rays can damage the retina and cause vision loss. 2. Arc rays can burn the whites of the eyes; such burns are painful and can easily become infected. 3. The shade strengths of filter lenses often used in welding are no. 10, no. 12, and no. 14. 4. The darker the filter lens, the greater the shade number. 5. The brighter the arc is, the darker the filter lens should be. Electrode size can be helpful in determining the correct shade of filter lens. 1. Electrode diameter of up to 5/32 in. – no. 10 filter shade 2. Electrode diameter of 3/16 in. to 1/4 in. – no. 12 filter shade 3. Electrode diameter of 5/16 in. to 3/8 in. – no. 14 filter shade Other filter shades should be used if necessary. Students should consult the instructor and the manufacturer's guidelines. Too dark of a lens can cause eyestrain. The view through the lens should be clear so the welder can see comfortably while welding.

Instructor Directions	Content Outline
	If the helmet does not incorporate a lens made out of safety glass, safety glasses must be worn under the helmet. Safety glasses or goggles should also be worn to protect the eyes while chipping slag and doing other work. Persons in the welding area should wear eye protection, such as flash glasses, to avoid eye injury from the reflected light.
Objective 7	**Describe how filter lenses and welding helmets should be cared for.** A clear outer lens of glass or plastic should be used to protect the filter lens from damage. An inner plastic lens is also recommended to protect the inner surface of the filter lens. Clear cover lenses should be inspected regularly and replaced if they are damaged. Filter lenses should be inspected regularly for cracks or other damage. Do not use a filter lens that is damaged. The filter shade number must be readily identifiable to be certain the correct filter lens is selected. The shade number should be on the lens or the lens should be kept in its properly labeled container. Make sure that the lens gasket is in good shape and all parts of the lens assembly are installed correctly to eliminate the risk of light leakage. Examine the helmet for signs of wear, cracks, and other damage. Damage must be repaired or the helmet must be replaced.
Application:	Other activities 1. Have students examine a selection of welding helmets, filter lenses, and safety glasses in good and bad condition. Which ones are acceptable for shop

Instructor Directions	Content Outline
	use and which ones are not? Why? Point out any inspection procedures they might miss. 2. Develop various welding scenarios involving metals of different types, thicknesses, and conditions, as well as requiring different welding positions. Ask students which electrode they would choose for each scenario and why.
Closure/Summary	When selecting electrodes for a welding job consider several factors, such as the type, thickness, and condition of the base metal; the weld position and design of the joint; properties of the alloying elements in the flux; and the type of electric current. Two methods of electrode classification are the NEMA color-coding system and the AWS letter-and-number system, the standard of the welding industry. Another key to creating a quality weld is proper storage and care of electrodes to avoid moisture. Electrode characteristics serve as a guide for the selection of a proper safety lens. The brighter the arc produced by the electrode, the darker the filter lens should be. As with electrodes, it is important to handle filter lenses and welding helmets with care.
Evaluation: Quiz	Answers: 1. Answers should include five of the following. a. Type of metal being welded and its tensile strength b. Thickness of the metal c. Condition of the base metal d. Weld position, such as flat, vertical, horizontal, and overhead e. Experience of the welder f. Rate at which the filler metal should be added g. The design or alignment of the joint h. Properties of the alloying elements contained in the flux i. Type of electric current being used 2. a. The letter "E" means that it is an electrode used in arc welding. b. 60,000 pounds per square inch, or 60,000 psi, or 60 ksi

Instructor Directions	Content Outline
	c. The electrode can be used in all positions. Student could also list flat, vertical, overhead, and horizontal. 3. Answers should include three of the following. a. Moisture can produce steam, which can carry away the shielding gases that protect the weld. b. Damp electrodes can cause such problems as increased spatter and poor slag removal. c. Hydrogen from the water can be added to welds and weaken them. d. Welds made with damp electrodes may be porous and crack. e. Time and money are lost repairing and replacing these faulty welds. f. If faulty welds are not undetected, they are at risk of failing and posing a safety threat. 4. Answers should include three of the following. a. Use a clear outer lens of glass or plastic to protect the filter lens from damage. b. Use an inner plastic lens to protect the inner side of the filter lens. c. Inspect and replace cover lenses regularly. d. Inspect filter lenses regularly for cracks and other damage. e. Be sure the shade number of a filter lens is readily identifiable. f. Be sure the lens gasket is in good shape and all parts of the lens assembly are installed correctly to avoid any light leakage. g. Examine the helmet for signs of wear, cracks, and other damage. This damage must be repaired or the helmet replaced. 5. c 6. b

Unit II – Arc Welding

Name____________________________

Lesson 3: Selecting and Maintaining Electrodes and Safety Lenses

Date____________________________

Assessment

Complete the following short-answer questions.

1. List five factors to consider when choosing an electrode.

    a.

    b.

    c.

    d.

    e.

2. Answer the following questions regarding an E6011 electrode.

    a. What information does the "E" provide?

    b. What is the minimum tensile strength of the weld metal? Include the unit of measurement for tensile strength.

    c. In what position or positions can the electrode be used?

3. List three reasons why electrodes must be kept dry.

   a.

   b.

   c.

4. List three procedures for caring for filter lenses or the welding helmet.

   a.

   b.

   c.

Circle the letter that corresponds to the correct answer.

5. The last digit in an AWS classification number indicates:

   a. electrode diameter.
   b. tensile strength.
   c. welding current.
   d. welding position.

6. In which welding positions can an E6020 electrode be used?

   a. All positions
   b. Flat and horizontal
   c. Overhead and vertical down
   d. Designator no longer used

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Arc Welding
Lesson	Identifying Metals
Estimated Time	Two 50-minute blocks

Student Outcome

Analyze the characteristics of different metals, including their ability to be welded.

Learning Objectives

1. Explain why it is important to be able to identify metals.
2. Explain what ferrous and nonferrous metals are.
3. Explain some common methods of identifying metals.
4. Identify common ferrous metals, their characteristics, and their uses.
5. Identify common nonferrous metals, their characteristics, and their uses.

Grade Level Expectations

SC/ME/1/A/09-11/b SC/ME/1/A/09-11/c SC/ME/1/F/09-11/b

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. Activity Sheets
   - AS 1 – Identifying Ferrous Metals Using Spark Testing (Instructor)
   - AS 1 – Identifying Ferrous Metals Using Spark Testing (Student)
2. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
3. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit II – Arc Welding." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplies & Equipment

- ❑ See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ Brain, M. How Iron and Steel Work. HowStuffWorks. Accessed October 8, 2007, from http://science.howstuffworks.com/iron.htm.
   - ❑ Martin, T. The Spark Test of Steel. Shopswarf. Accessed October 8, 2007, from http://shopswarf.orcon.net.nz/spark.html.
2. Print
   - ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding*. Tinley Park, IL: Goodheart-Willcox, 2000.
   - ❑ Brandt, D., and J. Warner. *Metallurgy Fundamentals*. Tinley Park, IL: Goodheart-Willcox, 1999.

- ❑ Camp, W., and T. Daugherty. *Managing our Natural Resources*. Albany, NY: Delmar Publishers, 1988.
- ❑ Jeffus, L. *Welding Principles and Applications.* 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
- ❑ Phipps, L. *Mechanics in Agriculture*. 4th ed. Danville, IL: Interstate Publishers, 1992.
- ❑ Walker, J. *Modern Metalworking*. Tinley Park, IL: Goodheart-Willcox, 2000.

3. Electronic Media
   - ❑ *It All Starts With Dirt.* A three-minute video on how aluminum is made. Alcoa, Inc. Accessed October 8, 2007, from http://www.alcoa.com/global/en/about_alcoa/dirt_video.asp.

Interest Approach

Show students an assortment of common items made of various metals, such as a piece of copper tubing, a brass screw, and objects made of different types of steel. Ask them to identify the metal and explain how they identified it or how they might test it to determine the type of metal. Examples of ways to identify metals might be by color or whether or not the metal is magnetic. Write the characteristics on the board. Are there any metals that do not totally fit their tests or expectations? An example would be stainless steel, which is not always magnetic. Ask whether they think it would be necessary to further identify the steel items. Why? How would they go about identifying these?

Communicate the Learning Objectives

1. Explain why it is important to be able to identify metals.
2. Explain what ferrous and nonferrous metals are.
3. Explain some common methods of identifying metals.
4. Identify common ferrous metals, their characteristics, and their uses.
5. Identify common nonferrous metals, their characteristics, and their uses.

<table>
<tr><th>Instructor Directions</th><th>Content Outline</th></tr>
<tr><td>Objective 1

Introduce the lesson by discussing why it is important to be able to identify metals from the point of view of welding.</td><td>Explain why it is important to be able to identify metals.

There are over 1,000 different metals with industrial applications.

Not all welding procedures can be used on all metals with acceptable results.

It is important to know what kind of metal is being worked with in order to determine which welding procedure or procedures are required to produce strong, functional joints.</td></tr>
<tr><td>Objective 2</td><td>Explain what ferrous and nonferrous metals are.

There are two basic categories of metal - ferrous and nonferrous.
1. Ferrous refers to iron and metals with a high iron content.
a. “Ferrous” comes from the Latin word ferrum, which means iron.
b. Common ferrous metals include wrought iron, all steels, and cast iron.
2. Nonferrous refers to metals that contain little or no iron.</td></tr>
</table>

Instructor Directions	Content Outline
	a. Common nonferrous metals include aluminum, copper, brass, and bronze.
Objective 3 *Discuss ways in which metals can be identified. If the earlier motivation or a similar introduction to the material was used, this question could be introduced by reviewing procedures the students suggested for identifying metals. In many cases, such as doing repairs, a welder will not know exactly what kind of metal he or she is working with. Some common ways of identifying unmarked metals are presented at right. Supplement with other means of identifying unmarked metals or a discussion of standardized systems, such as the American Iron and Steel Institute (AISI) system, as needed. The instructor version of AS 1 can be used to demonstrate spark testing on known and unknown metals. The student version of AS 1 can be assigned to evaluate student competency.* AS 1 – Identifying Ferrous Metals Using Spark Testing	**Explain some common methods of identifying metals.** Magnetic testing 1. A magnet can be used to separate most ferrous metals from nonferrous ones. 2. Most ferrous metals are magnetic; nonferrous metals are not. 3. An exception is stainless steel. Not all stainless steel is magnetic. Color 1. Color is another general way in which ferrous metals can be distinguished from nonferrous ones. 2. Ferrous metals (irons and steels) tend to be gray, gray-white, bright silver, or black in appearance. 3. Nonferrous metals tend to be white, yellow, or reddish in color. Oxyacetylene torch testing 1. A neutral flame can be used to heat metal. This can be used to determine the melting point of the metal. Information about the metal can also be gained by observing it as it is heated and after it cools. 2. Torch testing can be used to determine whether or not steel and steel alloys have good welding properties. a. The melted metal should not produce excessive sparks or boil. b. When it has solidified, the metal should be smooth and shiny, not rough, dull, or porous. c. Boiling generally indicates the presence of significant amounts of an alloy or alloys. d. Special fluxes may be needed to weld alloy steels. Spark testing of ferrous metals 1. The metal is held lightly against a grinding wheel. Small heated particles of metal oxidize or burn as they are thrown off by the wheel. 2. Because ferrous metals and their alloys produce distinctive spark patterns, these patterns can be used to identify the metals.

Instructor Directions	Content Outline
	3. By comparing sparks made by an unknown type of metal to those from a known metal, the beginning welder can learn to identify ferrous metals by spark testing. 4. Sparks are observed for the following characteristics. a. Color b. Length c. Explosions along the length of the spark d. Shape of the explosions 5. Spark testing is used to identify ferrous metals. 6. In general, as carbon content of steel increases, the number of explosions increases and the length of the spark decreases. 7. Nonferrous metals do not produce sparks. a. If a nonferrous metal or a metal suspected of being nonferrous is to be spark tested, consult the instructor before proceeding. b. Grinding is not recommended for nonferrous metals because they can frequently clog the grinding wheel and some nonferrous metals produce toxic oxides. c. The operator must wear approved breathing apparatus and the grinding wheel must be equipped with an exhaust system.
Objective 4 *The characteristics and uses of some common ferrous metals are discussed below.*	**Identify common ferrous metals, their characteristics, and their uses.** Wrought iron 1. Wrought iron is almost pure iron and contains very little carbon. 2. Low carbon means wrought iron has low strength and hardness, but it also means it is very ductile (easy to shape without fracturing). 3. It rusts slowly. 4. It is easily welded. 5. Once an important structural metal, it is now used mostly for ornamental work. Carbon steel 1. This is the most common type of steel (about 90% of manufactured steel). 2. Generally, as carbon increases, so do hardness, tensile strength, resistance to wear, and cost.

Instructor Directions	Content Outline
	3. As carbon increases, ductility is lost and the melting point is lowered. 4. It is cheaper than alloy steel. 5. There are three basic types. a. Low-carbon steel – Low-carbon steel cannot be hardened. – It is easy to machine, can be used with all welding processes, and produces high-quality welds. – Applications include wire, pipe, auto bodies, and storage tanks. b. Medium-carbon steel – Medium-carbon steel can be strengthened and hardened with heat treating. – Heat treatment before and after welding generally produces the best results. – Applications are similar to those of low-carbon steel, but it can withstand greater stress. Medium-carbon steel is used in crankshafts, gears, and hammer heads. c. High-carbon steel – High-carbon steel can be heat treated to produce high strength and hardness. – It is more difficult to weld than low- or medium-carbon steel. – Heat treatment before and after welding is used to reduce brittleness. – It is used in making tools, dies, and railroad wheels. Alloy steel 1. Alloy steel refers to steels to which other elements besides carbon have been added in large enough amounts to produce qualities not found in carbon steel. 2. Common alloying elements include the following. a. Manganese – strengthens steel, increases resistance to shock b. Nickel – adds strength and corrosion resistance c. Tungsten – makes steel self-hardening and able to withstand high temperature 3. As alloying elements increase, welding difficulty generally increases.

Instructor Directions	Content Outline
	Stainless steel 1. Stainless steel refers to steels with enough chromium to resist corrosion. 2. There are over 100 different kinds. 3. It is more difficult to weld than carbon steel. Cast iron 1. Cast iron contains more carbon than steel does. 2. High-carbon content helps cast iron withstand high-compression loads. 3. The carbon content also lowers the melting point, making it good for casting. 4. High carbon can also mean the cast iron is more brittle. 5. Most cast iron can be welded, though white cast iron in considered almost unweldable. 6. Oxyacetylene and shielded metal arc welding generally produce the most favorable results. 7. Uses include brake drums, engine blocks, and furnace grates.
Objective 5 *The characteristics and uses of some common nonferrous metals are discussed below.*	**Identify common nonferrous metals, their characteristics, and their uses.** Aluminum 1. In its pure state, aluminum is much weaker than steel. 2. The addition of alloys, heat treatment, and cold working can make aluminum, pound for pound, stronger than structural steel. 3. Aluminum alloys are lighter than most metals and resistant to corrosion. 4. Aluminum oxide must be removed to ensure the quality of the weld. 5. Aluminum does not change color before reaching its melting point. The surface of the metal can be scratched as it is heated to determine if it is softening. 6. Uses include wheels, airplane parts, cans, and castings. Copper 1. Pure copper is very soft, but processes such as alloying and cold working can increase its ductility

Instructor Directions	Content Outline
	and malleability (ability to be forged, hammered, or rolled). 2. It is second only to silver as an electrical conductor. 3. Most copper and copper alloys can be joined by common welding methods, brazing, and soldering. 4. Like many other nonferrous metals, copper has a tendency toward "hot shortness" (easily distorting when heated to its melting point). Because of this property, it must be firmly clamped when heated to this temperature. 5. Uses include wire, pipe, and radiator parts. Brass 1. Brass is an alloy of copper and zinc. 2. It has working characteristics similar to copper. 3. It is resistant to acids and has high formability. 4. It is a good brazing alloy. 5. Uses include plumbing parts, castings, and ornamental work. Bronze 1. Bronze is an alloy of copper and tin. 2. It resists corrosion like copper, but is stronger and easier to cast. 3. It behaves similarly to brass when welded. 4. Uses include gears, castings, and decorative parts.
Application: 🖹 AS 1 – Identifying Ferrous Metals Using Spark Testing	AS 1 Results will vary. Other activities 1. Create an identification board that displays different types of metals and their characteristics and uses. In addition, have students bring metal samples from home and discuss the type, characteristics, and purpose of each sample.
Closure/Summary	Metal selection governs the welding technique that can be applied, so it is important to properly identify the metal used in each job. The more than 1,000 available metals come in two categories: ferrous, which has high iron content, and nonferrous, which contains little or no iron.

Instructor Directions	Content Outline
	Common methods of identifying metals include magnetic testing, color, oxyacetylene torch testing, and spark testing. Common types of ferrous metals are wrought iron, carbon steel (low, medium, high), alloy steel (which combine iron with such elements as manganese, nickel, or tungsten), stainless steel, and cast iron. Common nonferrous metals are aluminum, copper, brass, and bronze.
Evaluation: Quiz	Answers: 1. a 2. d 3. c 4. b 5. a 6. d 7. b 8. d 9. c 10. a. Ferrous metals – A group of metals with high iron content. Students should list two of the following: wrought iron, carbon steel, alloy steel, stainless steel, and cast iron. b. Nonferrous metals – A group of metals with little or no iron. Students should list two of the following: aluminum, copper, brass, and bronze.

Lesson 4: Identifying Metals

Identifying Ferrous Metals Using Spark Testing

Objective: Students will identify different types of ferrous metals by the characteristics of their sparks.

Directions: Use a grinding wheel and known samples of different ferrous metals to explain how spark testing can be used to identify metals. Then test unidentified samples so that students can apply what they have just learned to identify the new samples.

Materials and Equipment:

Bench grinder
Grinding wheel
Four "known" ferrous metal samples of different types, labeled "A," "B," "C," and "D"
Three different "unknown" ferrous metal samples, labeled "1," "2," and "3"
Safety glasses or goggles or a face shield*
Leather apron or other protective clothing recommended by the instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

CAUTION: This activity is designed as a demonstration. Students should only perform these or similar procedures themselves if they have successfully completed all competencies relevant to operating the grinder and have the instructor's permission to perform the procedure.

Procedure:

1. Hand out AS 1 (Student).
2. Before beginning the procedure, review safety procedures for use of the grinder as needed.
3. If needed, begin by reviewing the theory behind spark testing, which is that different ferrous metals oxidize in different and predictable ways and produce characteristic spark patterns. By knowing what these sparks should look like, the welder can identify an unknown ferrous metal.
4. Inspect equipment, materials, and work area to ensure safe and correct operation.
5. Use the spark test on known samples of different ferrous metals.
   a. Explain what each metal is before testing it.

b. After testing the first example, have the students as a class identify characteristics of the sparks produced and fill in the information on AS 1 (Student).
c. Mention any significant characteristics they may not notice.
d. Continue performing spark tests on each sample and have students classify the characteristics.
e. To help students become familiar with the composition of different metals, it would probably be useful to present the samples in an ordered way (e.g., from less carbon content to more) and point out to students this ordering system and any corresponding changes in spark pattern.
f. Students should be able to examine the samples before and after testing, provided the samples are cool and it does not interfere with their observation of the procedure.

6. Now test the unknown samples one at a time.
   a. Students should individually apply what they have learned and discussed as a group to fill out the information about samples 1, 2, and 3 on their own.
   b. Students should be able to examine these samples as well, before and after testing, provided the metal is cool and it does not interfere with their observation of the procedure or completion of the questions.
   c. The "unknown" samples should be of metals that the students have seen tested or have a composition that would allow the students to deduce the type of metal from information presented during the demonstration. If a completely new sample is presented, indicate to students that "new sample" is a valid answer, but that they must explain in what way the sample seemed unique.
7. The instructor can repeat any or all of the samples as many times as he or she feels is appropriate.
8. This is only an outline for a suggested activity. The instructor should adapt it to the particular needs of the class as he or she feels is appropriate.
9. Observe safety and cleanup procedures.
10. Collect AS 1 (Student) sheets.

Lesson 4: Identifying Metals Name________________________

Identifying Ferrous Metals Using Spark Testing

Objective: Students will identify different types of ferrous metals by the characteristics of their sparks.

Directions: Fill in the following information about the known metal samples.

Sample A

Type of metal:

Surface characteristics or other distinguishing features:

Spark characteristics
Color:

Length:

Number of explosions:

Shape of explosions:

Sketch of spark pattern:

Sample B

Type of metal:

Surface characteristics or other distinguishing features:

Spark characteristics
Color:

Length:

Number of explosions:

Shape of explosions:

Sketch of spark pattern:

Sample C

Type of metal:

Surface characteristics or other distinguishing features:

Spark characteristics
Color:

Length:

Number of explosions:

Shape of explosions:

Sketch of spark pattern:

Sample D

Type of metal:

Surface characteristics or other distinguishing features:

Spark characteristics
Color:

Length:

Number of explosions:

Shape of explosions:

Sketch of spark pattern:

Fill in the information about the unknown metal samples as they are presented. Using this information and what you have learned about spark testing, indicate what you think each metal is likely to be.

Sample 1

Surface characteristics or other distinguishing features:

Spark characteristics
Color:

Length:

Number of explosions:

Shape of explosions:

Sketch of spark pattern:

Possible metal type:

Sample 2

Surface characteristics or other distinguishing features:

Spark characteristics
Color:

Length:

Number of explosions:

Shape of explosions:

Sketch of spark pattern:

Possible metal type:

Sample 3

Surface characteristics or other distinguishing features:

Spark characteristics
Color:

Length:

Number of explosions:

Shape of explosions:

Sketch of spark pattern:

Possible metal type:

Unit II – Arc Welding Name___________________________

Lesson 4: Identifying Metals Date___________________________

Assessment

Circle the letter that corresponds to the correct answer.

1. Which of the following is a nonferrous metal?

   a. Aluminum
   b. Carbon steel
   c. Cast iron
   d. Stainless steel

2. A characteristic of most ferrous metals is that they are:

   a. spark-free when ground.
   b. a reddish color.
   c. a yellow color.
   d. magnetic.

3. Spark testing is commonly used to identify:

   a. nonferrous metals by the pattern of the sparks they produce.
   b. nonferrous metals by the temperature of the sparks they produce.
   c. ferrous metals by the pattern of the sparks they produce.
   d. ferrous metals by the temperature of the sparks they produce.

4. Which is a characteristic of wrought iron?

   a. Almost all carbon
   b. Almost all iron
   c. High strength
   d. Extremely brittle

5. What generally happens as the carbon content increases in a metal?

   a. Hardness increases
   b. Melting point increases
   c. Brittleness decreases
   d. Strength decreases

6. Which element is added to steel to make stainless steel?

    a. Zinc
    b. Manganese
    c. Copper
    d. Chromium

7. One way that pure aluminum differs from steel is that it is:

    a. harder.
    b. lighter.
    c. easier to weld.
    d. more prone to rust.

8. A correct statement about brass is that it is a:

    a. ferrous metal made from iron and nickel.
    b. ferrous metal made from copper and zinc.
    c. nonferrous metal made from iron and nickel.
    d. nonferrous metal made from copper and zinc.

9. A correct statement about carbon steel is that it is:

    a. more expensive than alloy steel.
    b. mainly used for ornamental work.
    c. the most common type of steel made.
    d. more difficult to weld than stainless steel.

Complete the following short-answer question.

10. Define the terms below and provide two examples of each.

    a. Ferrous metals

    b. Nonferrous metals

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Arc Welding
Lesson	Welding Out of Position
Estimated Time	Seven 50-minute blocks

Student Outcome

Demonstrate the procedures for making out-of-position welds using a shielded metal arc welder.

Learning Objectives

1. Identify the basic types of weld joints.
2. Explain the positions used in arc welding.
3. Demonstrate what techniques can be used to improve results in out-of-position welds.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Types of Joints
   - PPt 2 – Welding Positions
   - PPt 3 – Basic Joint Types in Different Positions
   - PPt 4 – Angles for Horizontal Welding
   - PPt 5 – Angles for Vertical Welding
   - PPt 6 – Angles for Overhead Welding
2. Activity Sheets
   - AS 1 – Welding a Butt Joint in the Horizontal Position (Instructor)
   - AS 1 – Welding a Butt Joint in the Horizontal Position (Student)
   - AS 2 – Making a Downhill Fillet Weld (Instructor)
   - AS 2 – Making a Downhill Fillet Weld (Student)
   - AS 3 – Making an Uphill Fillet Weld (Instructor)
   - AS 3 – Making an Uphill Fillet Weld (Student)
   - AS 4 – Welding a Butt Joint in the Overhead Position (Instructor)
   - AS 4 – Welding a Butt Joint in the Overhead Position (Student)
3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit II – Arc Welding." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplies & Equipment

- ❑ See AS 1 through AS 4 for materials and equipment needed to complete the Activity Sheets.

Supplemental Information

1. Print
   - ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding.* Tinley Park, IL: Goodheart-Willcox, 2000.
   - ❑ Jeffus, L. *Welding Principles and Applications.* 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
   - ❑ Phipps, L. *Mechanics in Agriculture*. 4th ed. Danville, IL: Interstate Publishers, 1992.
   - ❑ Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics*. Upper Saddle River, NJ: Prentice Hall Interstate, 2004.

Interest Approach

Identify or have students identify various types of welded joints in the shop. Ask them if they think the joints were made in a flat, vertical, or overhead position. Why? Ask them what they think would change for each type of weld should the position change.

Communicate the Learning Objectives

1. Identify the basic types of weld joints.
2. Explain the positions used in arc welding.
3. Demonstrate what techniques can be used to improve results in out-of-position welds.

Instructor Directions	Content Outline
Objective 1 *Introduce the lesson by discussing the different types of joints made in welding. Refer to PPt 1.* PPt 1 – Types of Joints	**Identify the basic types of weld joints.** Butt joint – Pieces are joined edge to edge in the same plane. Lap joint – One piece overlaps another. Corner joint – Pieces are joined at the edges at an angle, usually a right angle. Tee joint – Pieces are joined at an angle to form a "T" shape. Edge joint – Pieces are positioned parallel or nearly parallel to each other and joined edge to edge.
Objective 2 PPt 2 – Welding Positions PPt 3 – Basic Joint Types in Different Positions	**Explain the positions used in arc welding.** Flat – The weld axis (imaginary line through the center of the weld) and weld face (surface of the weld on the welding side) are both approximately horizontal (flat) in front of the welder. Horizontal – The weld axis is horizontal and the weld face and base metal are approximately vertical (up and down). Vertical – The weld axis and weld face are both approximately vertical. 1. Uphill or vertical up – The weld is performed from the bottom of the joint to the top. 2. Downhill or vertical down – The weld is performed from the top of the joint to the bottom.

<table>
<tr><th>Instructor Directions</th><th>Content Outline</th></tr>
<tr><td></td><td>Overhead – The weld is performed from the underside of the joint, with the weld axis and face approximately horizontal.

Welding in positions other than flat is called welding out of position.

Whenever possible, welds should be made in the flat position.

In positions other than flat, the welder is working against the force of gravity.

When welds cannot be made in the flat position, the welder must be able to make welds out of position that are as strong as those made in the flat position.

All of the joint types can be made in all four positions.</td></tr>
<tr><td>Objective 3

General techniques for welding out of position are discussed in the outline. Refer to PPts 4-6. When students have reviewed and discussed these and any other arc welding safety and use procedures recommended by the instructor, the instructor versions of AS 1-4 can be used to demonstrate the correct way to make out-of-position welds using the arc welder. The student versions of AS 1-4 can be assigned to evaluate student competency.

PPt 4 – Angles for Horizontal Welding

PPt 5 – Angles for Vertical Welding</td><td>Demonstrate what techniques can be used to improve results in out-of-position welds.

Use a smaller diameter electrode.
1. Allows lower amperage to be used
2. Makes a smaller weld pool
3. Creates a weld pool that is more easily managed

Use a fast-setting electrode to keep the weld from sagging (e.g., E6010, E6011, and E7018).

Adjust the electrode in the holder to a convenient angle. Do not bend the electrode into position. This can cause the flux to break off, resulting in a loss of shielding gas and in substandard welds.

For horizontal welds
1. For butt welds, hold the electrode roughly 5 to 10 degrees below perpendicular, so that the electrode is pointed up at the weld. This is the work angle.
2. Lean the electrode approximately 20 degrees in the direction of travel. This is the lead angle.
3. For different joints, reposition the electrode as needed.</td></tr>
</table>

Instructor Directions	Content Outline
PPt 6 – Angles for Overhead Welding AS 1 – Welding a Butt Joint in the Horizontal Position AS 2 – Making a Downhill Fillet Weld AS 3 – Making an Uphill Fillet Weld AS 4 – Welding a Butt Joint in the Overhead Position	4. Maintain a shorter arc length to ensure better transfer of filler material. For vertical welds 1. For butt welds, hold the electrode at a right angle to the base metal and inclined down approximately 10 to 15 degrees, so that the electrode is pointed up in relation to the base metal. 2. For different joints, reposition the electrode as needed. 3. To keep the weld pool from getting too hot, use a flipping or whipping motion. To do this, move the electrode forward, lift it slightly, and bring it back to the weld pool without breaking the arc. 4. Hold a shorter arc length to ensure better transfer of filler. 5. Downhill or vertical down welding generally works best on thinner material. For overhead welds 1. For overhead butt welds, the electrode is approximately perpendicular to the base metal and tilted 15 to 20 degrees in the direction of travel. 2. For different joints, reposition the electrode as needed. 3. A flipping motion can be used to control the weld pool and keep the filler from dropping out. In addition to the usual welding safety procedures, the welder must be sure to take extra steps to protect against falling molten metal, particularly when welding overhead. The welder should wear a cap, be sure that pant legs cover the tops of the shoes, and follow any other guidelines from the instructor.
Application: AS 1 – Welding a Butt Joint in the Horizontal Position AS 2 – Making a Downhill Fillet Weld	AS 1 – AS 4 Results will vary.

Instructor Directions	Content Outline
🖹 AS 3 – Making an Uphill Fillet Weld 🖹 AS 4 – Welding a Butt Joint in the Overhead Position	Other activities 1. After students have completed the activity sheets, demonstrate how to safely and correctly perform destructive testing on the joints they have made. Show them examples of well-made welds and welds with flaws, such as inclusions and porosity. Discuss ways to improve these defects. Have students examine their welds and write down their observations. Include aspects that are well done, as well as any changes they would make. The instructor's comments should give the students feedback both on their welds and their assessment of the welds. 2. Ask a professional welder in the community to visit the class and provide information about welding out of position. The presenter could demonstrate the techniques he or she uses to produce sound welds. Have the students prepare questions for the presenter before the visit. 4. Create a display board that has examples of good out-of-position welds produced by students. It can be a "wall of fame" that gives recognition to students for a job well done.
Closure/Summary	Flat is the preferred position in arc welding, because the weld axis and the weld face are both approximately horizontal in front of the welder. Horizontal, vertical, and overhead approaches are called out of position welds, and the welder must work against gravity to make them. All of the basic types of weld joints (butt, lap, corner, tee, and edge) can be made in all four positions. To improve results in out-of-position welds, use a smaller diameter electrode, use a fast-setting electrode, or adjust the electrode in the holder to a convenient angle. When making out-of-position welds, the welder should follow all the usual welding safety procedures and take any additional steps necessary to protect against falling molten metal, particularly when welding overhead.

Instructor Directions	Content Outline
Evaluation: Quiz	Answers: 1. c 2. a 3. b 4. d 5. c 6. Flat position is the only position in which the welder does not have to use special techniques to keep the force of gravity from pulling the molten metal out of place. 7. Students should list three of the following. a. Maintaining a shorter arc length b. Using a smaller diameter electrode c. Using an electrode with fast-setting filler d. Adjusting the electrode to specific work and lead angles e. Using a whipping motion for vertical and overhead welds

Lesson 5: Welding Out of Position

Welding a Butt Joint in the Horizontal Position

Objective: Students will observe how to weld a butt joint in the horizontal position using a shielded metal arc welder.

Directions: Use an arc welder to weld a butt joint in the horizontal position.

Materials and Equipment:

SMAW machine and accessories
Chipping hammer
Wire brush
Helmet*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
SMAW electrode(s), selected by instructor
Mild steel plates, selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. If needed for review, demonstrate welding in flat position before welding out of position. Possible exercises include striking and maintaining an arc, running beads, and welding butt and fillet joints. (See *Agricultural Mechanics Unit for Agricultural Science I,* Unit V Lesson 3, AS 1 through 5 for these demonstrations.)
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. If necessary, bevel plates to be welded and explain the beveling procedure for horizontal welds. For horizontal welds, if most or all of the beveling is done on the top piece, the bottom of the joint can act as a shelf for the weld material.
4. Wear appropriate face and eye protection and protective clothing.
5. Set up and turn on the machine. Explain any differences in setup, such as current setting or electrode diameter, for welding in horizontal position.
6. Cover up and remind those in the area to do so as well.
7. Tack weld the pieces together, leaving approximately a 1/16-in. gap between the pieces.
8. Clean slag from the tack welds.
9. Secure the pieces in the horizontal position. If beveling was necessary, the beveled or more beveled piece should be on top.
10. Strike an arc and demonstrate the correct procedure for welding the joint.

a. Hold the electrode 5 to 10 degrees below a right angle to the work and tilted approximately 20 degrees in the direction of travel.
b. Generally, the arc length used for horizontal welds is shorter than that used for flat welds.
c. A stringer bead is generally recommended for the initial (root) pass.

11. Remove the slag from the weld.
12. Run additional passes if needed to complete the weld, cleaning the weld between each pass. A weaving pattern can be used to distribute heat if needed.
13. Clean the final pass and inspect the weld. If desired, have students examine the weld when it is safe to do so and remind them that the weld should have the same qualities as those of flat-position welds. The completed weld should blend evenly with the base, should have uniform ripples for the length of the weld, should go through to the bottom of the base, and fill the groove completely from one edge to the other.
14. Remove the electrode from the holder and observe safety, shutdown, and cleanup procedures.
15. Assign the student version of AS 1 to be performed by the students.

Lesson 5: Welding Out of Position

Welding a Butt Joint in the Horizontal Position

Objective: Students will weld a butt joint in the horizontal position using a shielded metal arc welder.

Directions: Students will use an arc welder to weld a butt joint in the horizontal position.

Materials and Equipment:

SMAW machine and accessories
Chipping hammer
Wire brush
Helmet*

Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
SMAW electrode(s), selected by instructor
Mild steel plates, selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Before beginning to weld out of position, it may be useful to review procedures for welding in the flat position. If instructed to do so, practice running beads, weld butt or fillet joints in flat position, or review any material on arc welding safety and procedures as needed.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. If necessary, bevel plates to be welded.
4. Wear appropriate face and eye protection and protective clothing.
5. Set up and turn on the machine following assigned procedure.
6. Cover up and remind those in the area to do so as well.
7. Tack weld the pieces together, leaving approximately a 1/16-in. gap between them.
8. Clean slag from the tack welds.
9. Secure the pieces in the horizontal position. If beveling was necessary, the beveled or more beveled piece should be on top. Refer to Figure 1.

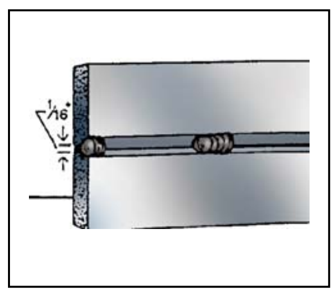

Figure 1

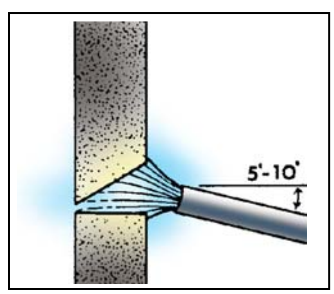

Figure 2

10. Strike an arc and weld the joint.
    a. Hold the electrode 5 to 10 degrees below a right angle to the work and tilted approximately 20 degrees in the direction of travel. Refer to Figures 2 and 3.
    b. Generally, the arc length used for horizontal welds is shorter than that used for flat welds.
    c. A stringer bead is generally recommended for the initial (root) pass.
    d. Remove the slag from the weld.
11. Run additional passes if needed to complete the weld, cleaning the weld between each pass. A weaving pattern can be used to distribute heat if needed.
12. Clean the final pass and inspect the weld.
13. Remove the electrode from the holder and observe safety, shutdown, and cleanup procedures.
14. Turn in work to be graded by the instructor.

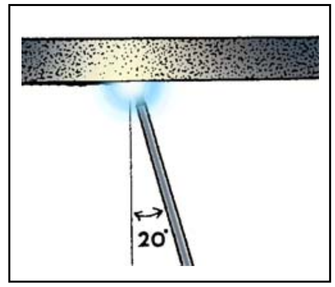

Figure 3

Lesson 5: Welding Out of Position

Making a Downhill Fillet Weld

Objective: Students will observe how to make a downhill fillet weld using a shielded metal arc welder.

Directions: Use an arc welder to make a downhill fillet weld in a tee joint.

Materials and Equipment:

SMAW machine and accessories	Safety glasses or goggles
Chipping hammer	Leather gloves and any other protective clothing recommended by instructor
Wire brush	SMAW electrode(s), selected by instructor
Helmet*	Mild steel plates, selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Inspect equipment, materials, and work area to ensure safe and correct operation.
2. Wear appropriate face and eye protection and protective clothing.
3. Set up and turn on the machine.
   a. Explain any differences in setup, such as current setting or electrode diameter, for welding in the vertical position.
   b. Explain that slag has a tendency to run into the weld pool when welding downhill. To prevent this, the welder must stay ahead of the slag, which requires a speed that generally produces welds with shallow penetration. For this reason, downhill welding is probably most effective on thin material.
4. Cover up and remind those in the area to do so as well.
5. Tack weld the pieces together at a 90-degree angle, leaving approximately a 1/16-in. gap between the pieces.
6. Clean slag from the tack welds.
7. Secure the pieces in the vertical position.
8. Strike an arc and demonstrate the correct procedure for welding the joint.
   a. Hold the electrode approximately 10 to 15 degrees below a right angle, so that it is pointed up at the work, and about 45 degrees from each side.
   b. Generally, the arc length used for vertical welds is shorter than that used for flat welds.

   c. A stringer bead is generally recommended for the root pass.
9. Remove the slag from the weld.
10. Run additional passes if needed to complete the weld, cleaning the weld between each pass. A weaving pattern can be used to distribute heat if needed.
11. Clean the final pass and inspect the weld.
12. Remove the electrode from the holder and observe safety, shutdown, and cleanup procedures.
13. Assign the student version of AS 2 to be performed by the students.

Making a Downhill Fillet Weld

Objective: Students will make a downhill fillet weld using a shielded metal arc welder.

Directions: Students will use an arc welder to make a downhill fillet weld in a tee joint.

Materials and Equipment:

SMAW machine and accessories
Chipping hammer
Wire brush
Helmet*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
SMAW electrode(s), selected by instructor
Mild steel plates, selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

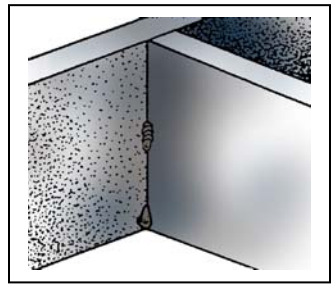

Figure 1

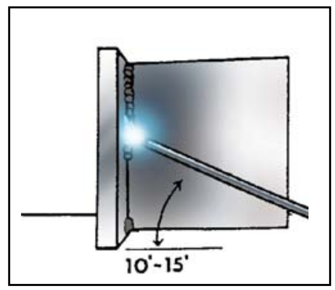

Figure 2

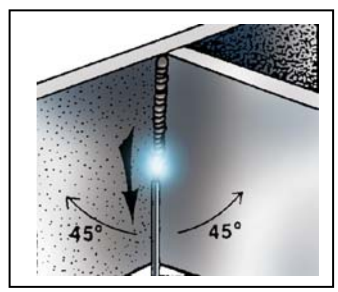

Figure 3

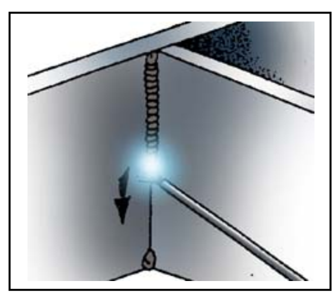

Figure 4

Procedure:

1. Inspect equipment, materials, and work area to ensure safe and correct operation.
2. Wear appropriate face and eye protection and protective clothing.
3. Set up and turn on the machine following assigned procedure.
4. Cover up and remind those in the area to do so as well.
5. Tack weld the pieces together at a 90-degree angle, leaving approximately a 1/16-in. gap between the pieces. Refer to Figure 1.
6. Clean slag from the tack welds.
7. Secure the pieces in the vertical position.
8. Strike an arc and weld the joint.
   a. Hold the electrode approximately 10 to 15 degrees below a right angle, so that it is pointed up at the work, and about 45 degrees from each side. Refer to Figures 2 and 3.
   b. Generally, the arc length used for vertical welds is shorter than that used for flat welds.

c. A stringer bead is generally recommended for the root pass.
   Refer to Figure 4.

9. Remove the slag from the weld.
10. Run additional passes if needed to complete the weld, cleaning the weld between each pass. A weaving pattern can be used to distribute heat if needed.
11. Clean the final pass and inspect the weld.
12. Remove the electrode from the holder and observe safety, shutdown, and cleanup procedures.
13. Turn in work to be graded by the instructor.

Lesson 5: Welding Out of Position

Making an Uphill Fillet Weld

Objective: Students will observe how to make an uphill fillet weld using a shielded metal arc welder.

Directions: Use an arc welder to make an uphill fillet weld in a tee joint.

Materials and Equipment:

SMAW machine and accessories	Safety glasses or goggles
Chipping hammer	Leather gloves and any other protective clothing recommended by instructor
Wire brush	SMAW electrode(s), selected by instructor
Helmet*	Mild steel plates, selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Inspect equipment, materials, and work area to ensure safe and correct operation.
2. Wear appropriate face and eye protection and protective clothing.
3. Set up and turn on the machine. Explain any differences in setup, such as current setting or electrode diameter, for welding in the vertical position.
4. Cover up and remind those in the area to do so as well.
5. Tack weld the pieces together at a 90-degree angle, leaving approximately a 1/16-in. gap between the pieces.
6. Clean slag from the tack welds.
7. Secure the pieces in the vertical position.
8. Strike an arc and demonstrate the correct procedure for welding the joint.
   a. Hold the electrode approximately 10 to 15 degrees below a right angle, so that it is pointed up at the work, and about 45 degrees from each side.
   b. Generally, the arc length used for vertical welds is shorter than that used for flat welds.
   c. The electrode can be moved ahead, out, and back to the weld pool to help control the temperature of the pool. The arc is not broken in this movement.
9. Remove the slag from the weld.
10. Run additional passes if needed to complete the weld, cleaning the weld between each pass. A weaving pattern can be used to distribute heat if needed.

11. Clean the final pass and inspect the weld.
12. Remove the electrode from the holder and observe safety, shutdown, and cleanup procedures.
13. Assign the student version of AS 3 to be performed by the students.

Lesson 5: Welding Out of Position

Making an Uphill Fillet Weld

Objective: Students will make an uphill fillet weld using a shielded metal arc welder.

Directions: Students will use an arc welder to make an uphill fillet weld in a tee joint.

Materials and Equipment:

SMAW machine and accessories
Chipping hammer
Wire brush
Helmet*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
SMAW electrode(s), selected by instructor
Mild steel plates, selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

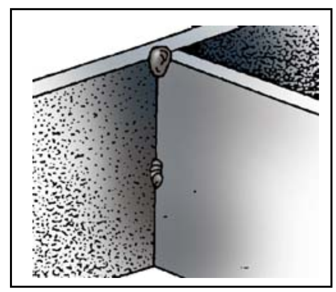
Figure 1

Procedure:

1. Inspect equipment, materials, and work area to ensure safe and correct operation.
2. Wear appropriate face and eye protection and protective clothing.
3. Set up and turn on the machine following assigned procedure.
4. Cover up and remind those in the area to do so as well.
5. Tack weld the pieces together at a 90-degree angle, leaving approximately a 1/16-in. gap between the pieces. Refer to Figure 1.
6. Clean slag from the tack welds.
7. Secure the pieces in the vertical position.
8. Strike an arc and weld the joint.
   a. Hold the electrode approximately 10 to 15 degrees below a right angle, so that it is pointed up at the work, and about 45 degrees from each side. Refer to Figures 2 and 3.
   b. Generally, the arc length used for vertical welds is shorter than that used for flat welds.

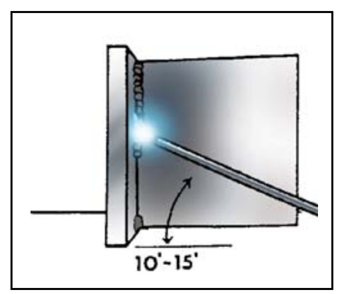

Figure 2

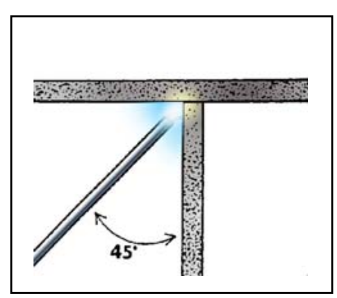

Figure 3

c. The electrode can be moved ahead, out, and back to the weld pool to help control the temperature of the pool. The arc is not broken in this movement. Refer to Figure 4.

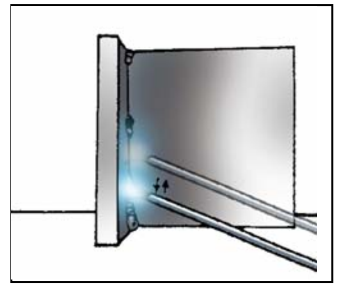

Figure 4

9. Remove the slag from the weld.
10. Run additional passes if needed to complete the weld, cleaning the weld between each pass. A weaving pattern can be used to distribute heat if needed.
11. Clean the final pass and inspect the weld.
12. Remove the electrode from the holder and observe safety, shutdown, and cleanup procedures.
13. Turn in work to be graded by the instructor.

Lesson 5: Welding Out of Position

Welding a Butt Joint in the Overhead Position

Objective: Students will observe how to weld a butt joint in the overhead position using a shielded metal arc welder.

Directions: Use an arc welder to make a butt joint in the overhead position.

Materials and Equipment:

SMAW machine and accessories	Safety glasses or goggles
Chipping hammer	Leather gloves and any other protective clothing recommended by instructor
Wire brush	SMAW electrode(s), selected by instructor
Helmet*	Mild steel plates, selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Inspect equipment, materials, and work area to ensure safe and correct operation.
2. Wear appropriate face and eye protection and protective clothing. Point out any additional protective clothing or procedures that may be required for overhead welding that have not been required when welding in other positions.
3. Set up and turn on the machine. Explain any differences in setup, such as current setting or electrode diameter, for welding in the overhead position.
4. Cover up and remind those in the area to do so as well.
5. Tack weld the pieces together, leaving approximately a 1/16-in. gap between the pieces.
6. Clean slag from the tack welds.
7. Secure the pieces in the overhead position.
8. Strike an arc and demonstrate the correct procedure for welding the joint.
   a. Hold the electrode approximately perpendicular to the base metal and tilted 15 to 20 degrees in the direction of travel.
   b. The electrode can be moved ahead, out, and back to the weld pool to help control the temperature of the pool. The arc is not broken in this movement.
9. Remove the slag from the weld.
10. Run additional passes if needed to complete the weld, cleaning the weld between each pass. A weaving pattern can be used to distribute heat if needed.

11. Clean the final pass and inspect the weld.
12. Remove the electrode from the holder and observe safety, shutdown, and cleanup procedures.
13. Assign the student version of AS 4 to be performed by the students.

Lesson 5: Welding Out of Position

Welding a Butt Joint in the Overhead Position

Objective: Students will weld a butt joint in the overhead position using a shielded metal arc welder.

Directions: Students will use an arc welder to make a butt joint in the overhead position.

Materials and Equipment:

SMAW machine and accessories	Safety glasses or goggles
Chipping hammer	Leather gloves and any other protective clothing recommended by instructor
Wire brush	SMAW electrode(s), selected by instructor
Helmet*	Mild steel plates, selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Inspect equipment, materials, and work area to ensure safe and correct operation.
2. Wear appropriate face and eye protection and protective clothing, including any additional protective clothing needed for welding in the overhead position.
3. Set up and turn on the machine following assigned procedures.
4. Cover up and remind those in the area to do so as well.
5. Tack weld the pieces together, leaving approximately a 1/16-in. gap between them.
6. Clean slag from the tack welds.
7. Secure the pieces in the overhead position.
8. Strike an arc and weld the joint.
   a. Hold the electrode approximately perpendicular to the base metal and tilted 15 to 20 degrees in the direction of travel. Refer to Figures 1 and 2.
   b. The electrode can be moved ahead, out, and back to the weld pool to help control the temperature of the pool. The arc is not broken in this movement. Refer to Figure 3.

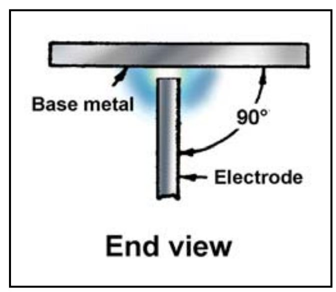

Figure 1

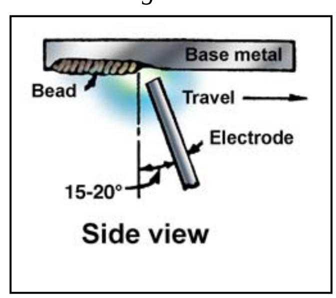

Figure 2

Figure 3

9. Remove the slag from the weld.
10. Run additional passes if needed to complete the weld, cleaning the weld between each pass. A weaving pattern can be used to distribute heat if needed.
11. Clean the final pass and inspect the weld.
12. Remove the electrode from the holder and observe safety, shutdown, and cleanup procedures.
13. Turn in work to be graded by the instructor.

Agricultural Science II

Curriculum Guide: *Agricultural Mechanics Unit for Agricultural Science II*

Unit: II. Arc Welding

Unit Objective:

Students will apply principles of shielded metal arc welding by making out-of-position welds as part of a welding contest.

Show-Me Standards: 2.5, CA3

References:

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Missouri FFA Agricultural Mechanics Career Development Event. Accessed November 19, 2003, from http://web.missouri.edu/~pavt0689/statecon.html.

Instructional Strategies/Activities:

- Students will engage in study questions in lessons 1 through 5.
- Students will complete AS 1.1, Arc Welding Safety; AS 4.1, Identifying Ferrous Metals Using Spark Testing; AS 5.1, Welding a Butt Joint in the Horizontal Position; AS 5.2, Making a Downhill Fillet Weld; AS 5.3, Making an Uphill Fillet Weld; and AS 5.4, Welding a Butt Joint in the Overhead Position.
- Additional activities that relate to the unit objective can be found under the heading "Other Activities" in the following locations: p. II-5 (2, 3), p. II-24 (2), p. II-42 (1, 2), p. II-60, and p. II-74 (1, 3, 4).

Performance-Based Assessment:

Students will be divided into groups. The groups will represent teams and will participate in a welding contest that is similar to the welding portion of the Agricultural Mechanics Career Development Event. Each student will use a shielded metal arc welder to make out-of-position welds presented in the unit and discussed in class.

Assessment will be based on the ability to safely and correctly make out-of-position welds using a shielded metal arc welder.

Agricultural Mechanics Unit for Agricultural Science II
Unit II—Arc Welding
Instructor Guide

The instructor should assign the performance-based assessment activity at the beginning of the unit. Students will work toward completing the activity as they progress through the unit lessons. The assessment activity will be due at the completion of the unit.

1. Use or adapt the activity sheets found in the unit to assess student competency at welding. Review or supplement these activities as needed, based on student mastery of the procedures and equipment the students will be using. **NOTE: Students should only complete this performance-based activity if they have mastered all the relevant competencies and have the instructor's permission to perform the activity.**

2. For the performance-based assessment activity, have students apply the skills and procedures discussed in the unit by participating in a welding contest.

3. Divide the class into groups and assign students a series of out-of-position welds to perform.
   a. Each student should perform all of the assigned procedures.
   b. Assign students welding procedures that they have mastered as part of the instructional activities for this unit.

4. This activity will help prepare students for the arc welding portion of the Agricultural Mechanics Career Development Event.
   a. Explain or review event guidelines as needed.
   b. Refer to the *Missouri CDE Handbook* for guidelines regarding the Agricultural Mechanics Career Development Event. The *Missouri CDE Handbook* is available from the Missouri Department of Elementary and Secondary Education at http://www.dese.mo.gov/divcareered/ag_cde_guidelines.htm.

5. Have students perform the assigned welding procedures.
   a. Performance in the welding contest will determine the student's individual score.
   b. Combine the individual scores of the group members to determine the team score for each group.

6. The final assessment score will be based on the ability to safely and correctly perform the assigned welding procedures.

7. Present an appropriate award to the high-scoring team and individual, if desired.

8. NOTE: If desired, this activity can be combined with the performance-based assessment activities from Unit III, Oxyacetylene Welding, and Unit IV, Tool Sharpening and Reconditioning, to form a mini Agricultural Mechanics Career Development Event. To conduct a mini Agricultural Mechanics Career Development Event, maintain the same student groups for all of the performance-based assessment activities. An expanded score sheet is included at the end of each of these units that can be used to track individual and group performance in the mini CDE.

9. ADDITIONAL ACTIVITIES:
   a. Create a display board using correctly made examples of each type of weld to be performed by the class. Have students compare their welds with the correctly made examples.
   b. Create a display board using the students' best welds. Possible display board themes include the following: each student's best weld, the best example of each type of weld performed by the class, and the best weld of the week.
   c. Perform destructive tests to check the strength and soundness of welds students have made.
   d. Create a display board that identifies different metals and their characteristics. Have students contribute samples.

Agricultural Mechanics Unit for Agricultural Science II
Unit II—Arc Welding
Student Handout

1. The instructor will divide the class into groups and give you a series of welds to perform in a welding contest.

2. Your group will compete in the contest as a team.

3. Perform the assigned welds.
   - ❑ Wear appropriate safety equipment at all times.
   - ❑ Follow all assigned safety procedures. You can lose points for not following safety precautions and other assigned procedures.
   - ❑ Inspect the equipment, materials, and work area to ensure safe and correct operation.
   - ❑ Perform the welds using the assigned procedure.
   - ❑ Inspect your work.
   - ❑ Follow shutdown and cleanup procedures and return all equipment and materials to their assigned places.
   - ❑ Turn in your work to the instructor.

4. Your final assessment score will be based on your ability to safely and correctly perform the assigned welding procedures.

Agricultural Science II

Agricultural Mechanics Unit for Agricultural Science II
Unit II—Arc Welding
Scoring Guide

Name ____________________

Assessment Area	Criteria	0 Points	1 Point	2 Points	3 Points	4 Points	Weight	Total
Positioning	Metal was properly positioned	Failed	Poor	Fair	Good	Excellent	X 5	
Electrode and Amperage Selection	Electrode was appropriate for the weld and amperage was correctly set	Failed	Poor	Fair	Good	Excellent	X 4	
Distortion	Welds are free of distortion	Failed	Poor	Fair	Good	Excellent	X 5	
Appearance	Weld appearance indicates correct speed of travel, amperage setting, and arc length	Failed	Poor	Fair	Good	Excellent	X 6	
Strength	Welds are strong and sound	Failed	Poor	Fair	Good	Excellent	X 5	
Safety and Work Habits	**Student followed all safety precautions**	**Passed**				**Failed**	**X (-25)**	Negative Points *
	Student followed all assigned procedures	**Excellent**	**Good**	**Fair**	**Poor**	**Failed**	**X (-10)**	Negative Points *
TOTAL								

Final Assessment Total ________/100 pts.
*** Overall combined score cannot be lower than 0.**

Comments:

Agricultural Mechanics II Score Sheet

Team Members	Arc Welding	Oxyacetylene Welding	Tool Sharpening/ Reconditioning	Score
Team A				
				Total:
Team B				
				Total:
Team C				
				Total:
Team D				
				Total:
Team E				
				Total:
Team F				
				Total:

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Oxyacetylene Welding
Lesson	Safety and Maintenance Procedures for Oxyacetylene Welding
Estimated Time	50 minutes

Student Outcome

Identify the basic safety and maintenance procedures for oxyacetylene welding.

Learning Objectives

1. Identify the protective clothing that should be worn for oxyacetylene welding.
2. Explain the safety procedures that should be observed in the work area.
3. Explain the safety procedures that should be observed when using the oxyacetylene outfit.
4. Identify some additional maintenance considerations for using the oxyacetylene outfit.

Grade Level Expectations

SC/ME/1/H/09-11/d

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Protective Gear and Clothing for Oxyacetylene Welding
   - PPt 2 – Storing and Moving Gas Cylinders
   - PPt 3 – Oxyacetylene Safety Procedures
2. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
3. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit III – Oxyacetylene Welding." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Internet Sites
   - ❑ Agricultural Engineering Safety Lesson Plan: Oxyacetylene Welding Safety. Kansas State University Cooperative Extension Service. National Ag Safety Database. Accessed October 15, 2007, from http://www.cdc.gov/nasd/docs/d000701-d000800/d000785/d000785.html.
   - ❑ Educators Library: Safety. American Welding Society. Accessed September 10, 2007, from http://www.aws.org/cgi-bin/educate/scan/dl=Safety/mp=guide?id=MKJbHy6P&mv_pc=7.

- Gailey, D. W. "Backfires, Flashbacks, and Flashback Arrestors." *Welding Magazine*, January 2004. Accessed September 26, 2007, from http://www.weldingmag.com/323/Issue/Article/False/11305/Issue.
- Gas Welding Safety. Ohio State University Extension. National Ag Safety Database. Accessed September 26, 2007, from http://www.cdc.gov/nasd/docs/d001601-d001700/d001691/d001691.html.
- National Fire Protection Association. Accessed September 24, 2007, from http://www.nfpa.org/.
- Welding, Cutting, and Brazing. Occupational Safety and Health Administration. U. S. Department of Labor. Accessed September 26, 2007, from http://www.osha.gov/SLTC/weldingcuttingbrazing/index.html.

2. Print
- Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding.* Tinley Park, IL: Goodheart-Willcox, 2000.
- Jeffus, L. *Welding Principles and Applications.* 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
- Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics.* Upper Saddle River, NJ: Prentice Hall Interstate, 2004.

Interest Approach

If students are familiar with the oxyacetylene outfit from previous lessons, introduce the topic of oxyacetylene welding by asking them to describe safety and maintenance and procedures for the process. Have them apply the information to the oxyacetylene setup in the shop as much as possible.

If this unit is the students' introduction to oxyacetylene, begin the topic of oxyacetylene safety by giving them a tour of the oxyacetylene station and storage area of the shop. Explain why the station is set up and maintained the way it is, how tanks should be stored, and other safety considerations.

Communicate the Learning Objectives

1. Identify the protective clothing that should be worn for oxyacetylene welding.
2. Explain the safety procedures that should be observed in the work area.
3. Explain the safety procedures that should be observed when using the oxyacetylene outfit.
4. Identify some additional maintenance considerations for using the oxyacetylene outfit.

Instructor Directions	Content Outline
Objective 1	**Identify the protective clothing that should be worn for oxyacetylene welding.**
Discuss protective clothing and equipment. Refer to PPt 1. PPt 1 – Protective Gear and Clothing for Oxyacetylene Welding	Wear leather gauntlet-style gloves and high-top leather shoes to protect the hands and feet. Wear wool or cotton clothing that is dark and tightly woven, which helps block light rays. Wear long-sleeved shirts and keep the sleeves and top button at the collar buttoned. Wear cuffless pants that come down over the tops of the boots. Sparks could get caught in pants with cuffs. Other protective clothing, such as leather aprons and leather sleeves, are also available and should be worn as needed. Do not wear clothing with tears or frayed areas that can leave skin exposed or easily catch fire by sparks. Do not wear synthetic materials, which can burn readily and give off poisonous gases.

Instructor Directions	Content Outline
	Wear welding goggles with filter lenses appropriate for the work being done. Lenses with a shade number from 4 to 8 are commonly used for oxyacetylene welding. Consult the manufacturer's recommendations. 1. Expensive filter lenses can be protected with clear cover plates. 2. Wear safety glasses under the welding goggles to protect eyes from flying debris. 3. Wear additional head and eye protection, such as a flameproof skullcap or face shield, as needed to avoid burns from sparks or hot metal spatter. Do not carry items in pockets that could potentially catch fire or explode, such as matches or butane lighters. Supplement ventilation as needed with an appropriate respirator. Do not allow clothing to become saturated with fuel gas or oxygen. This makes the clothing highly flammable and it must be aired out before it is safe to wear.
Objective 2 *Discuss safety procedures in the work area. Refer to PPt 2.* ☐ PPt 2 – Storing and Moving Gas Cylinders	**Explain the safety procedures that should be observed in the work area.** Make the work area as fire resistant as possible. 1. Use fireproof material to support work. 2. Keep work area clean and free of trash, grease, oil, and other flammable materials. 3. Keep a fire extinguisher, first-aid kit, and safety equipment within easy reach. Work with adequate ventilation. Use forced ventilation, if natural ventilation is not sufficient. Store cylinders correctly. 1. Fuel and oxygen cylinders must be stored separately. 2. Cylinders should be chained or otherwise prevented from being knocked over.

Instructor Directions	Content Outline
	3. Storage should be locked and labeled with appropriate warning signs. 4. Fuel storage should be adequately ventilated. 5. Valve protection caps should be in place when the cylinder is not in use. 6. A cylinder should be moved using a hand truck with a safety chain or by tilting it slightly and rolling it on its bottom edge with one hand on the safety cap. 7. A cylinder without proper labeling should not be used. Return it to the supplier. Do not attempt to heat, cut, or weld containers such as tanks, drums, and barrels.
Objective 3 *Discuss safety procedures for setting up and using an oxyacetylene outfit. Refer to PPt 3.* PPt 3 – Oxyacetylene Safety Procedures	**Explain the safety procedures that should be observed when using the oxyacetylene outfit.** Keep cylinders fastened to a wall, post, or approved cylinder truck so that they stay upright at all times. Follow the specific procedure for setting up the outfit to be used and use only parts designed for that particular setup. Parts such as tips and regulators can appear similar to those used with other fuel gases, but they cannot be used interchangeably without risk of explosion. Run hoses so that they will not be damaged or cause a tripping hazard. Check all connections with a leak-detecting solution. The solution bubbles if a leak is present. Do not use petroleum-based solutions to check for leaks or grease to lubricate parts. They can cause a fire hazard in the presence of oxygen. Use a spark lighter held at an angle to light the torch. Do not use a match or butane lighter. Always be sure the flame is off before setting the torch down. If work is suspended for some time, the outfit must be shut down.

Instructor Directions	Content Outline
	Follow correct shutdown procedure when finished. Close all points where oxygen or fuel gas can escape and bleed lines of any remaining gas. If equipment catches fire, turn off the gas at the tanks immediately. If the fire does not go out, leave the area and call for help.
Objective 4 *As with the other equipment in the shop, safety and maintenance procedures for the oxyacetylene outfit are related. A number of the safety procedures above involve the proper care and use of the equipment. Below are some additional maintenance and proper use considerations. They can be incorporated in the discussion above, or the instructor can use this question as a starting point for the maintenance procedures assigned in his or her own shop and add to it or adapt it as needed.*	**Identify some additional maintenance considerations for using the oxyacetylene outfit.** Hoses 1. Repair or replace hoses that show signs of damage. 2. Do not use tape to repair hoses. 3. When not in use, coil hoses and store them properly. Do not hang hoses over the regulators. This can break the regulators or cause a leak. Regulators 1. Release pressure from regulators when the equipment is not in use. Pressure can stretch internal parts, which makes regulators less accurate and reduces their life expectancy. 2. Do not oil the regulators. This can cause a fire or explosion. 3. Have repair work on regulators done by properly trained technicians. Torch tips 1. Avoid dropping the tip or knocking it against the work or other surface. This can damage the tip. 2. Inspect and clean tips frequently. Recondition or replace damaged tips as needed to ensure proper function of the equipment. Be sure to use the correct size of tip cleaner to avoid enlarging the tip orifices.
Application:	Other activities 1. When demonstrating the use of the acetylene cylinder, open the valve for a short time to allow some acetylene to escape. Have students smell the acetylene so they will be able to recognize its odor. Being able to recognize the odor of acetylene will aid them in detecting leaks.

Instructor Directions	Content Outline
	2. Ask a safety expert (e.g., professional oxyacetylene welder or a representative from an oxyacetylene equipment distributor) to visit the class and give a presentation about safe setup and use of an oxyacetylene outfit. Have students prepare questions before the visit.
Closure/Summary	Safety is a primary concern in oxyacetylene welding. Consistently monitor clothing, equipment, and work areas to ensure safe practices and conditions. Make the work area as fire resistant as possible. Properly maintain equipment and work areas and be sure all hoses, regulators, and torch tips are in good working order. Repair or replace any parts that are found to be deficient.
Evaluation: Quiz	Answers: 1. c 2. b 3. b 4. d 5. a 6. d 7. c 8. d 9. c 10. d 11. b 12. a 13. b 14. d

Unit III – Oxyacetylene Welding

Name__________________________

Lesson 1: Safety and Maintenance Procedures for Oxyacetylene Welding

Date__________________________

Assessment

Circle the letter that corresponds to the correct answer.

1. The welder should light an oxyacetylene torch with a:

   a. match.
   b. butane lighter.
   c. spark lighter.
   d. combustible object.

2. The welder should wear goggles with filter lenses with a shade of:

   a. 1 to 3.
   b. 4 to 8.
   c. 9 to 12.
   d. 13 to 16.

3. Which of the following is **not** a hazard to have in the work area?

   a. Grease
   b. Spark lighter
   c. Trash
   d. Oil

4. After setting up an oxyacetylene outfit, the welder should check for leaks using:

   a. an open flame.
   b. grease.
   c. a petroleum-based solution.
   d. soap and water.

5. Oxygen and acetylene cylinders should **not** be stored:

   a. together in the back of the shop.
   b. chained upright.
   c. in a ventilated area.
   d. with valve protection caps in place.

6. When not using oxyacetylene hoses, proper care and maintenance includes:

   a. applying grease to the rubber for lubrication.
   b. repairing a leak with a piece of electrical tape.
   c. hanging the hoses over the cylinder regulators.
   d. coiling the hoses and storing them in a safe place.

7. When not using oxyacetylene regulators, a welder should:

   a. oil the internal parts of the regulators.
   b. clean the internal parts of the regulators.
   c. relieve the pressure from the regulators.
   d. maintain the pressure at a moderate level.

8. Which is a proper maintenance procedure for a dirty and clogged torch tip?

   a. Tap the tip against a hard surface to dislodge the dirt.
   b. Discard the tip and replace it with a new or reconditioned tip.
   c. Use a tip cleaner that is larger than the tip openings to file away the dirt.
   d. Clean the tip with a tip cleaner that does not fit too tightly in the openings.

Circle the letter that corresponds to the safety risk in the following situation.

9. The welder wears filter lenses that are rated too low for the process.

   a. Explosion hazard
   b. Burn hazard
   c. Light ray hazard
   d. Breathing hazard

10. The shop has no forced ventilation system and the doors and windows are closed.

    a. Explosion hazard
    b. Burn hazard
    c. Light ray hazard
    d. Breathing hazard

11. The welder wears pants with cuffs.

    a. Explosion hazard
    b. Burn hazard
    c. Light ray hazard
    d. Breathing hazard

12. The welder welds on a gas tank for a small gas engine after purging the tank with oxygen.

    a. Explosion hazard
    b. Burn hazard
    c. Light ray hazard
    d. Breathing hazard

13. The welder's clothes have become saturated with oxygen.

    a. Explosion hazard
    b. Burn hazard
    c. Light ray hazard
    d. Breathing hazard

14. The welder welds on a piece of plated metal in a confined space.

    a. Explosion hazard
    b. Burn hazard
    c. Light ray hazard
    d. Breathing hazard

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Oxyacetylene Welding
Lesson	Welding With Oxyacetylene
Estimated Time	Five 50-minute blocks

Student Outcome

Weld with and without filler rods using an oxyacetylene outfit.

Learning Objectives

1. Describe the differences between the oxyacetylene welding outfit and the cutting outfit.
2. Explain when the welding rod is used for oxyacetylene welding.
3. Identify some characteristics of welding rods used for oxyacetylene welding.
4. List some factors that influence the quality of the weld.
5. Identify common problems to avoid when welding with oxyacetylene.

Grade Level Expectations

SC/ME/1/G/09-11/a

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Welding Torch
   - PPt 2 – Angles for Welding
   - PPt 3 – Torch Movement Patterns
2. Activity Sheets
   - AS 1 – Running a Continuous Weld Pool With and Without Welding Rod (Instructor)
   - AS 1 – Running a Continuous Weld Pool With and Without Welding Rod (Student)
   - AS 2 – Welding a Butt Joint in Flat Position Using Welding Rod (Instructor)
   - AS 2 – Welding a Butt Joint in Flat Position Using Welding Rod (Student)
   - AS 3 – Welding an Edge Weld in a Flanged Butt Joint Without Welding Rod (Instructor)
   - AS 3 – Welding an Edge Weld in a Flanged Butt Joint Without Welding Rod (Student)
   - AS 4 – Welding an Outside Corner Joint With and Without Welding Rod (Instructor)
   - AS 4 – Welding an Outside Corner Joint With and Without Welding Rod (Student)
3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit III – Oxyacetylene Welding." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplies & Equipment

- ❑ See AS 1 through AS 4 for materials and equipment needed to complete the Activity Sheets.

Supplemental Information

1. Print
   - ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding.* Tinley Park, IL: Goodheart-Willcox, 2000.
   - ❑ Jeffus, L. *Welding Principles and Applications*. 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
   - ❑ Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics.* Upper Saddle River, NJ: Prentice Hall Interstate, 2004.
2. Electronic Media
   - ❑ Smartflix offers a line of videos related to metalworking that can be rented from their Web site. Accessed September 12, 2007, from http://smartflix.com/store/category/115/Metalworking.

Interest Approach

Students should be familiar with much of the oxyacetylene outfit from *Agricultural Mechanics Unit for Agricultural Science I,* Unit VI Lesson 2. Have students identify parts of the outfit and review the setup, use, and shutdown procedures they should use for the equipment.

Communicate the Learning Objectives

1. Describe the differences between the oxyacetylene welding outfit and the cutting outfit.
2. Explain when the welding rod is used for oxyacetylene welding.
3. Identify some characteristics of welding rods used for oxyacetylene welding.
4. List some factors that influence the quality of the weld.
5. Identify common problems to avoid when welding with oxyacetylene.

Instructor Directions	Content Outline
Objective 1	**Describe the differences between the oxyacetylene welding outfit and the cutting outfit.**
Students should be familiar with oxyfuel cutting, which was covered in Agricultural Mechanics Unit for Agricultural Science I. Introduce oxyacetylene welding by discussing differences between the welding and cutting outfit. Refer to PPt 1. ☐ PPt 1 – Welding Torch	Torch design – The welding torch does not use an additional oxygen line to produce a cutting jet of oxygen. Regulators 1. The oxygen regulator used for the cutting outfit may be designed to work under greater pressure because of the volume of oxygen that can be used when cutting thicker pieces of metal. If different oxygen regulators are used in the shop for different applications, check with the instructor to be sure the regulator is designed for the work that is being done. 2. The same acetylene regulator used for cutting can be used for welding because the working pressure of acetylene should always be below 15 psi to avoid risk of fire and explosion.
Objective 2	**Explain when the welding rod is used for oxyacetylene welding.**
Oxyacetylene welding can be done with and without filler rods. Discuss reasons why filler rod would be used. Examples of welding rods can be given to students to examine. These filler rods can be compared to examples of electrodes used in shielded metal arc welding.	For some oxyacetylene procedures, a welding rod is needed to add metal and strengthen the weld. Other oxyacetylene welds can be made by welding one piece directly to another.

Instructor Directions	Content Outline
Objective 3	**Identify some characteristics of welding rods used for oxyacetylene welding.** Welding rods are metal rods similar to the material they will be used to weld. They are generally 36 in. long and are available in different diameters, from 1/16 to 3/8 in. Like arc welding electrodes, welding rods used for oxyacetylene welding are available in different tensile strengths. 1. Tensile strength is indicated in the AWS classification number. 2. For an RG-45 rod, the "R" indicates it is a welding rod, the "G" indicates it is used for gas welding, and "45" indicates it has a tensile strength of approximately 45,000 psi. Welding rods are designed to produce safe, strong welds when used in the procedures and for the conditions specified by their classification number. Substituting other types of wire for welding rod is not acceptable for the following reasons. 1. The composition of another type of wire can vary greatly. 2. It can produce porous, substandard welds. 3. It can include finishes or coatings that produce toxic fumes.
Objective 4 *The size of the torch tip and welding rod and the position of the torch are key elements in creating strong welds with the oxyacetylene outfit. Supplement with more detailed procedural information as needed. Refer to PPts 2 and 3.* PPt 2 – Angles for Welding	**List some factors that influence the quality of the weld.** Torch tip size 1. The right tip must be chosen for the job because tip size is a factor that controls the width of the weld bead, the penetration of the weld, and the speed of movement. 2. Torch tips are designed to work within a specific operating range. Do not adjust the torch flame to compensate for the wrong tip size. Use the correct tip instead.

Instructor Directions	Content Outline
PPt 3 – Torch Movement Patterns	Torch position 1. Torch position has a great effect on the speed of melting and the weld pool. Two key aspects of torch position are angle and distance from work. 2. Torch angle a. The torch is held at an angle to the work. The closer the torch is held at a right angle to the work, the more heat is transferred to the base metal. b. A typical angle is 45 degrees. 3. Distance from work a. As the torch is moved closer to the work, the heating rate increases. b. A typical operating range is 1/8 to 1/4 in. from the work. Torch movement 1. As the torch is moved along the centerline of the weld, it is also moved back and forth or in a circular motion. a. The cone of the flame should stay in the weld pool during this motion. b. The flame should be advanced a distance of about 1/16 in. each time it is moved along the centerline. 2. There are two general techniques for directing flame at the weld pool. a. Forehand welding – The flame is pointed in the direction of travel and preheats the work ahead of the weld pool. b. Backhand welding – The flame is pointed in the opposite direction of travel and post heats the metal behind the pool, which helps to relieve welding stress. Backhand welding is generally used for welding cast iron and thicker metal. Welding rod size 1. A welding rod of the correct diameter must be selected because the rod can influence the width of the bead and the buildup and penetration of the weld. Below are some factors the welder should consider. a. A small-diameter welding rod can be used on

Instructor Directions	Content Outline
	thick metal for better penetration, but rod that is too small will not add enough filler material. b. A thicker welding rod can be used with thin metal to avoid burn through, but a rod that is too large can remove too much heat from the weld pool too quickly. This causes the pool to freeze and trap the rod. c. The correct size of welding rod will form a good bead and allow the weld pool to stay fluid as filler is added.
Objective 5 *Discuss problems beginning welders can encounter using an oxyacetylene outfit. When students have reviewed and discussed oxyacetylene safety and procedures, AS 1-4 can be used to demonstrate the correct way to make basic welds using the oxyacetylene outfit. The student versions of these activities can be assigned to evaluate student competency.* 🖹 AS 1 – Running a Continuous Weld Pool With and Without Welding Rod 🖹 AS 2 – Welding a Butt Joint in Flat Position Using Welding Rod 🖹 AS 3 – Welding an Edge Weld in a Flanged Butt Joint Without Welding Rod 🖹 AS 4 – Welding an Outside Corner Joint With and Without Welding Rod	**Identify common problems to avoid when welding with oxyacetylene.** Backfire – The flame goes out with a loud pop or snapping sound. 1. Possible causes of backfire include the following. a. Overheating the tip – caused by overuse, getting too close to the work, or working in a hot corner b. Operating the torch at pressures that are too low for the tip being used c. Touching the tip to the work d. A loose or damaged tip e. Dirt in the tip 2. In case of a backfire, shut down the torch immediately and correct the cause before relighting the torch. Flashback – The flame burns back inside the tip, torch, hose, or regulator, usually accompanied by a squealing or hissing sound. 1. Possible causes of flashback include the following. a. Failure to purge the system prior to use b. Overheating the tip 2. If a flashback occurs, immediately close the torch oxygen valve and then the torch fuel valve. If fire is suspected in the hoses, close the acetylene valve, followed by the oxygen valve at the tank. The torch should be allowed to cool before the problem is investigated. 3. Flashback usually indicates a serious problem. An experienced operator must determine whether the outfit is safe to use or if parts must be repaired or replaced.

Instructor Directions	Content Outline
	Improper flame adjustment for the procedure 1. Carburizing (carbonizing) flame – low temperature; may add carbon to the cut or weld a. Excess acetylene present b. May be used for some brazing or welding procedures c. Causes the weld pool on steel to boil and be cloudy and produce brittle welds 2. Oxidizing flame – high temperature; may add oxygen to the cut or weld a. Excess oxygen present b. Inner cone is shortened and noisy c. Not recommended for most operations d. Forms oxides with many metals, which produces brittle, low-strength welds e. Causes foaming and sparking of the weld pool on steel and produces welds with low strength and ductility
Application: 🖹 AS 1 – Running a Continuous Weld Pool With and Without Welding Rod 🖹 AS 2 – Welding a Butt Joint in Flat Position Using Welding Rod 🖹 AS 3 – Welding an Edge Weld in a Flanged Butt Joint Without Welding Rod 🖹 AS 4 – Welding an Outside Corner Joint With and Without Welding Rod	AS 1 – AS 4 Results will vary.

Instructor Directions	Content Outline
Closure/Summary	An oxyacetylene welding outfit is similar to a cutting outfit, except the welding torch does not use an additional oxygen line to produce a cutting jet of oxygen. Welding can be performed with or without filler rods, which when used add metal and strength to the weld. Most rods are similar to the material being welded, are generally 36 in. long, vary from 1/16 to 3/8 in. in diameter, and come in different tensile strengths. Among factors determining weld quality are torch tip size, torch position (angle and distance), torch movement, and welding rod size. Common problems to avoid when welding are backfire, flashback, and improper flame adjustment.
Evaluation: Quiz	Answers: 1. d 2. c 3. a 4. a 5. a 6. d 7. b 8. a. The "R" indicates that it is a welding rod. b. The "G" indicates that it is used for gas welding. c. The "60" indicates that the filler metal has a tensile strength of 60,000 psi. 9. The student should list two of the following. a. The composition of other wire can vary greatly. b. Unclassified wire can produce poor-quality welds. c. Other wire can have coatings or finishes that produce toxic fumes. 10. a. Forehand welding – A welding technique in which the oxyacetylene flame is pointed in the direction of travel and preheats the work ahead of the weld pool. b. Back welding – A welding technique in which the oxyacetylene flame is pointed in the opposite direction of travel and post heats the metal behind the pool. 11. If a backfire occurs, the torch should be shut down immediately and all possible causes checked and eliminated before relighting the torch. 12. If a flashback occurs, the oxygen torch valve should be shut off immediately, followed by the acetylene

Instructor Directions	Content Outline
	torch valve. If fire is suspected in the hoses, the acetylene cylinder valve should quickly be shut off followed by the oxygen cylinder valve. An experienced operator or technician should inspect the equipment to determine whether it is safe to use or which parts must be repaired or replaced.

Lesson 2: Welding With Oxyacetylene

Running a Continuous Weld Pool With and Without Welding Rod

Objective: Students will observe how to run a continuous weld pool with and without welding rod using the oxyacetylene outfit.

Directions: Use an oxyacetylene outfit to run a continuous weld pool. If needed, demonstrate how to set up the oxyfuel outfit, adjust the flame, and shut down the outfit as a review or as new material if this has not already been covered in class.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Soapstone or chalk
Straightedge
Wire brush
Pliers
Steel plate(s), selected by instructor
Welding rod(s), selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

Demonstrate the proper procedure for running a continuous weld pool without welding rod.

1. Wear appropriate face protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Demonstrate the correct procedure for preparing the metal using a wire brush.
4. Position the plate on the worktable and mark a line using the soapstone and straightedge. More lines can be laid out for additional demonstrations, if desired.
5. Demonstrate or review proper setup procedures for the oxyacetylene outfit, including the following steps and others as needed. (In the student activity, these steps will be indicated by the instruction to “Set up the oxyacetylene outfit following assigned procedure.”)
   a. Crack the valves.
   b. Attach the regulators.
   c. Inspect and install the torch tip.

d. Purge the lines.
e. Check for leaks.

6. Demonstrate the correct method for lighting the torch using the spark lighter. If desired, set the torch to demonstrate a carburizing flame and oxidizing flame. Point out how the students can recognize them and remind them that these flames are not preferred for most cutting and welding work.
7. Demonstrate how to adjust the flame to a neutral flame.
8. Position the torch so that the flame is just inside the edge of the metal and turned toward the plate. If desired, explain that this is the forehand welding method, which means that the metal in front of the welding pool will be preheated by the flame.
9. Hold the torch at a 45-degree angle, with the inner cone approximately 1/8 in. from the work.
10. Move the torch in a small circular pattern to form a weld pool that is about 1/4 in. in diameter.
11. Continue moving the torch in the circular pattern and also move it forward at a speed that will keep the weld pool a uniform size and shape. Be sure to keep the tip of the inner flame cone inside the boundary of the weld pool but not touching the surface.
12. At the end of the weld, lift the tip slowly so that the weld pool solidifies before the flame is removed. Explain that this technique helps keep the weld pool from cracking.
13. If desired, other beads could be run to demonstrate the effects of varying factors such as speed of travel, position of torch, and type of flame.
14. Demonstrate the correct procedure for shutting off the outfit. Explain to students that the flame must be shut off before they set the torch down.
15. If desired, turn the metal over when it is safe to do so and have the students inspect the underside of the weld or welds. Explain that a properly run weld pool has the appearance of a continuous, uniform deformation on the underside of the metal with no holes burned through the piece.
16. Demonstrate the proper procedure for running a continuous weld pool using welding rod. If this portion of the activity is not demonstrated or assigned, skip to step 30 to demonstrate the proper procedure for shutting down the outfit. If the activity is performed at a different time, perform and review setup procedures as needed.

Demonstrate the proper procedure for running a continuous weld pool using welding rod.

17. Use pliers to bend one end of the welding rod into a hook. Explain that this is to distinguish the cool back end of the rod from the end that may be hot and also to avoid injuring anyone nearby with the end of the wire. Also explain that it is standard procedure to leave rods full-length rather than cut them down.

18. Demonstrate the correct way to hold, feed, and change hand position with the rod. Explain that to change hand positions the students should set the rod down with the hot end pointed away from the body and pick it up in the new position. Do not place the rod against the body and move the hand to a new position. The hot end of the rod can burn through clothes and burn the skin.
19. Prepare the metal to be welded.
20. Position the plate on the worktable and mark a line using the soapstone and straightedge. More lines can be laid out for additional demonstrations, if desired.
21. Set up the outfit, if needed, and light and adjust the torch.
22. Position the torch so that the flame is just inside the edge of the metal and turned toward the plate.
23. Hold the torch at a 45-degree angle, with the inner cone approximately 1/8 in. from the work.
24. Move the torch in a small circular pattern to form a weld pool that is about 1/4 in. in diameter.
25. At the same time, use the other hand to bring the welding rod close to the flame for preheating. The end of the rod should be approximately 3/8 in. from the flame and 1/16 to 1/8 in. from the pool surface. The rod is held at an angle to the work, usually about 45 degrees.
26. When the weld pool needs additional material, dip the end of the rod in the front edge of the weld pool. This melts the rod and fills the pool. When enough filler is added to make the desired bead, move forward.
27. Carry the bead forward by moving the torch and adding filler with a smooth, uniform motion.
    a. Keep the end of the welding rod inside the flame so that it stays preheated and does not become oxidized by contact with the air.
    b. If the welding rod becomes too cool, it can freeze the weld pool. If it is too hot, drops of filler can be blown around by the flame, resulting in an uneven bead and poor fusion.
28. Continue moving forward until the weld is complete.
29. Demonstrate the correct procedure for shutting off the outfit. Explain to students that the flame must be shut off before they set the torch down.
30. Demonstrate the correct procedure for shutting down the outfit, including the following steps and others as needed. (In the student activity, these steps will be indicated by the instruction to "Shut down the outfit following assigned procedure.")
    a. Turn off gas at the cylinders.
    b. Bleed the lines.
    c. Close the regulators.
    d. Hang up the hoses. Do not hang them over the regulators.
    e. If the outfit is portable, return it to its assigned place.
31. Assign the student version of AS 1 to be performed by students.

Lesson 2: Welding With Oxyacetylene

Running a Continuous Weld Pool With and Without Welding Rod

Objective: Students will run a continuous weld pool with and without welding rod using the oxyacetylene outfit.

Directions: Students will use an oxyacetylene outfit to run a continuous weld pool with and without welding rod.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Soapstone or chalk
Straightedge
Wire brush
Pliers
Steel plate(s), selected by instructor
Welding rod(s), selected by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

Run a continuous weld pool without welding rod.

1. Wear appropriate face protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Prepare the metal for welding using the wire brush.
4. Position the plate on the worktable and mark a line using the soapstone and straightedge. Lay out additional lines if instructed to do so.
5. Set up the oxyacetylene outfit following assigned procedure.
6. Light the torch using the spark lighter.
7. Adjust the flame to a neutral flame.
8. Position the torch so that the flame is just inside the edge of the metal and turned toward the plate.
9. Hold the torch at a 45-degree angle, with the inner cone approximately 1/8 in. from the work. Refer to Figures 1 and 2.

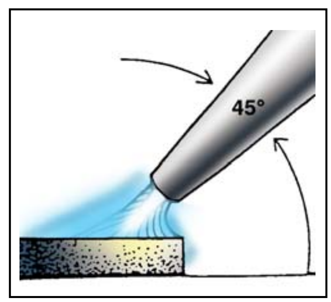


Figure 1

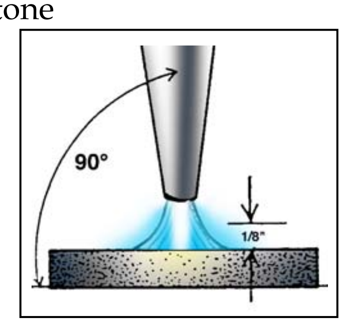


Figure 2

10. Move the torch in a small circular pattern to form a weld pool that is about 1/4 in. in diameter.
11. Continue moving the torch in the circular pattern and also move it forward at a speed that will keep the weld pool a uniform size and shape. Be sure to keep the tip of the inner flame cone inside the boundary of the weld pool but not touching the surface. Refer to Figure 3.
12. At the end of the weld, lift the tip slowly so that the weld pool solidifies before the flame is removed. This helps keep the weld pool from cracking.
13. Run other beads, if instructed to do so.
14. Shut off the outfit if the torch must be set down.
15. Turn the metal over when it is safe to do so and inspect the underside of the weld or welds. With a properly run weld pool, there is a continuous, uniform deformation on the underside of the metal and no holes burned through the piece.
16. Steps follow for running a continuous weld pool using welding rod. If this portion of the activity has not been demonstrated or assigned, shut down the outfit according to the assigned procedure, return equipment and materials to their proper places, and turn in work to be graded by the instructor. If the second part of the activity is performed at a different time, set up the outfit according to the instructor's directions before continuing with step 17.

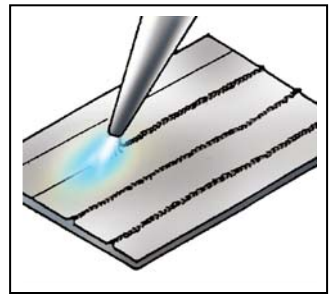


Figure 3

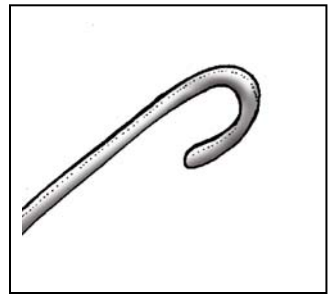


Figure 4

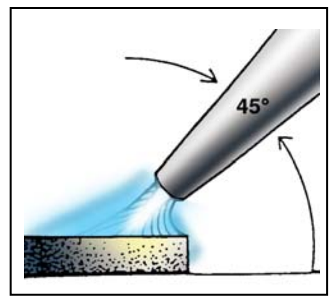


Figure 5

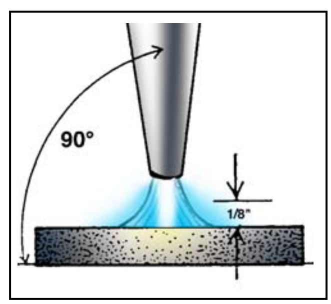


Figure 6

Run a continuous weld pool using welding rod.

17. Use pliers to bend one end of the welding rod into a hook. Refer to Figure 4. This is to distinguish the cool back end of the rod from the end that may be hot and also to avoid injuring anyone nearby with the end of the wire. It is standard procedure to leave rods full-length rather than cut them down.
18. Prepare the metal to be welded.
19. Position the plate on the worktable and mark a line using the soapstone and straightedge. Lay out additional lines if instructed to do so.
20. Set up the outfit, if needed, and light and adjust the torch.
21. Position the torch so that the flame is just inside the edge of the metal and turned toward the plate.
22. Hold the torch at a 45-degree angle, with the inner cone approximately 1/8 in. from the work. Refer to Figures 5 and 6.
23. Move the torch in a small circular pattern to form a weld pool that is about 1/4 in. in diameter.

24. At the same time, use the other hand to bring the welding rod close to the flame for preheating. The end of the rod should be approximately 3/8 in. from the flame and 1/16 to 1/8 in. from the pool surface. The rod is held at an angle to the work, usually about 45 degrees.

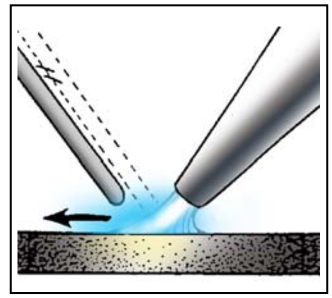


Figure 7

25. When the weld pool needs additional material, dip the end of the rod in the front edge of the weld pool. This melts the rod and fills the pool. When enough filler is added to make the desired bead, move forward. Refer to Figure 7.
26. Carry the bead forward by moving the torch and adding filler with a smooth, uniform motion. Refer to Figure 8.
    a. Keep the end of the welding rod inside the flame so that it stays preheated and does not become oxidized by contact with the air.
    b. If the welding rod becomes too cool, it can freeze the weld pool. If it is too hot, drops of filler can be blown around by the flame, resulting in an uneven bead and poor fusion.

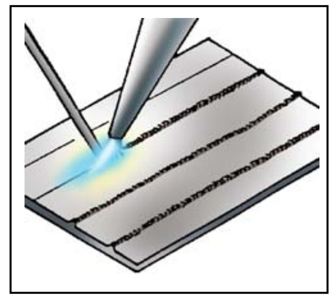


Figure 8

27. Continue moving forward until the weld is complete.
28. Run additional beads if instructed to do so.
29. Shut off the outfit if the torch must be set down.
30. Shut down the outfit according to the assigned procedure. Materials and equipment should be returned to their proper places.
31. Turn in work to be graded by the instructor.

Lesson 2: Welding With Oxyacetylene

Welding a Butt Joint in Flat Position Using Welding Rod

Objective: Students will observe how to weld a butt joint in flat position using the oxyacetylene outfit and welding rod.

Directions: Use an oxyacetylene outfit to weld a butt joint in flat position.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Pliers
Wire brush
Steel plates, selected by instructor
Welding rods, selected by instructor. Use the pliers to bend the back end of the rod into a hook to distinguish it from the end that could be hot.

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Wear appropriate face protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Prepare the metal to be welded.
4. Position the plates on the worktable.
5. Set up the welding outfit.
6. Light the torch using the spark lighter.
7. Adjust the flame to a neutral flame.
8. Use the torch and welding rod to tack weld the pieces together.
9. Start welding at one end, with the torch at a 45-degree angle and the inner flame cone approximately 1/8 in. from the work.
10. Hold this position until a weld pool forms. It should form equally over both pieces of metal.
11. At the same time, use the other hand to bring the welding rod close to the flame for preheating. The end of the rod should be approximately 3/8 in. from the flame and 1/16 to 1/8 in. from the pool surface. The rod is held at an angle to the work, usually about 45 degrees.

12. When the weld pool needs additional material, dip the end of the rod in the front edge of the weld pool. When enough filler is added to make the desired bead, move forward.
13. Carry the bead forward by moving the torch and adding filler with a smooth, uniform motion.
14. Continue moving forward until the weld is complete.
15. Shut off the outfit.
16. If work is to be suspended, shut down the outfit.
17. Assign the student version of AS 2 to be performed by students.

Lesson 2: Welding With Oxyacetylene

Welding a Butt Joint in Flat Position Using Welding Rod

Objective: Students will weld a butt joint in flat position using the oxyacetylene outfit and welding rod.

Directions: Students will use an oxyacetylene outfit to weld a butt joint in flat position.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Pliers
Wire brush
Steel plates, selected by instructor
Welding rods, selected by instructor. Use the pliers to bend the back end of the rod into a hook to distinguish it from the end that could be hot.

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Wear appropriate face protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Prepare the metal to be welded.
4. Position the plates on the worktable.
5. Set up the welding outfit following assigned procedure.
6. Light the torch using the spark lighter.
7. Adjust the flame to a neutral flame.
8. Use the torch and welding rod to tack weld the pieces together.
9. Start welding at one end, with the torch at a 45-degree angle and the inner flame cone approximately 1/8 in. from the work. Refer to Figure 1.
10. Hold this position until a weld pool forms. It should form equally over both pieces of metal. Refer to Figure 2.

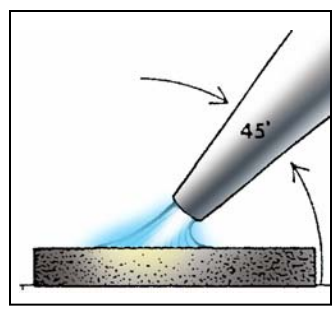


Figure 1

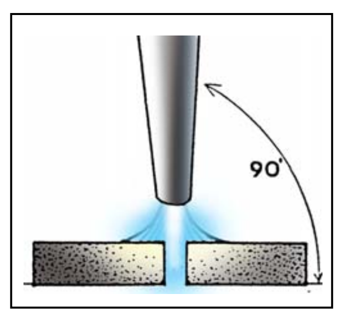


Figure 2

11. At the same time, use the other hand to bring the welding rod close to the flame for preheating. The end of the rod should be approximately 3/8 in. from the flame and 1/16 to 1/8 in. from the pool surface. The rod is held at an angle to the work, usually about 45 degrees. Refer to Figure 3.
12. When the weld pool needs additional material, dip the end of the rod in the front edge of the weld pool. This melts the rod and fills the pool. When enough filler is added to make the desired bead, move forward. Refer to Figure 4.
13. Carry the bead forward by moving the torch and adding filler with a smooth, uniform motion. Refer to Figure 5.
14. Continue moving forward until the weld is complete.
15. Shut off the outfit if the torch must be set down.
16. Shut down the outfit according to the assigned procedure. Materials and equipment should be returned to their proper places.
17. Turn in work to be graded by the instructor.

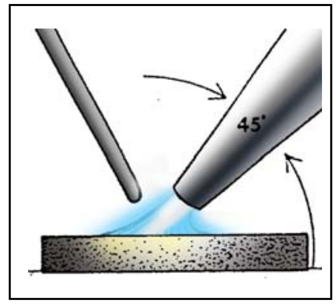


Figure 3

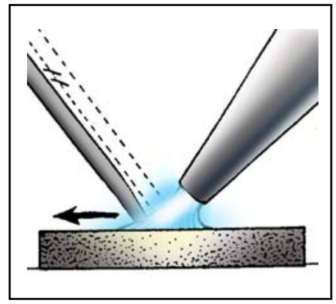


Figure 4

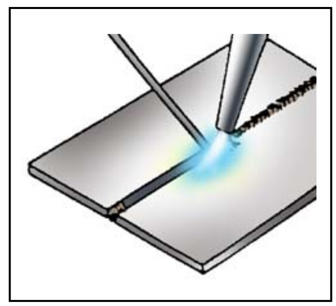


Figure 5

Lesson 2: Welding With Oxyacetylene

Welding an Edge Weld in a Flanged Butt Joint Without Welding Rod

Objective: Students will observe how to weld an edge weld in a flanged butt joint in flat position using the oxyacetylene outfit.

Directions: Use an oxyacetylene outfit to weld an edge weld in flat position.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Pliers
Wire brush
Steel plates, selected by instructor
Brake

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Wear appropriate face protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Demonstrate the correct procedure for using the brake to bend metal. Use the brake to make a flange approximately 1/4 in. long in the edges that are to be welded together. Be sure that both flanges are of equal length.
4. Prepare the metal to be welded.
5. Position the plates on the worktable with the flanges together.
6. Set up the welding outfit.
7. Light the torch using the spark lighter.
8. Adjust the flame to a neutral flame.
9. Use the torch to tack weld the pieces together.
10. Start welding at one end, with the torch at a 45-degree angle and the inner flame cone approximately 1/8 in. from the work.
11. Hold this position until a weld pool forms.

12. Carry the bead forward by moving the torch with a smooth, uniform motion. The flanges are used to add filler material to the weld.
13. Continue moving forward until the weld is complete.
14. Shut off the outfit.
15. If work is to be suspended, shut down the outfit.
16. Assign the student version of AS 3 to be performed by students.

Lesson 2: Welding With Oxyacetylene

Welding an Edge Weld in a Flanged Butt Joint Without Welding Rod

Objective: Students will weld an edge weld in a flanged butt joint in flat position using the oxyacetylene outfit.

Directions: Students will use an oxyacetylene outfit to weld an edge weld in flat position.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Pliers
Wire brush
Steel plates, selected by instructor
Brake

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Wear appropriate face protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Use the brake to make a flange approximately 1/4 in. long in the edges that are to be welded together. Be sure that both flanges are of equal length.
4. Prepare the metal to be welded.
5. Position the plates on the worktable with the flanges together.
6. Set up the welding outfit following the assigned procedure.
7. Light the torch using the spark lighter.
8. Adjust the flame to a neutral flame.
9. Use the torch to tack weld the pieces together.
10. Start welding at one end, with the torch at a 45-degree angle and the inner flame cone approximately 1/8 in. from the work.
11. Hold this position until a weld pool forms.
12. Carry the bead forward by moving the torch with a smooth, uniform motion. The flanges are used to add filler material to the weld. Refer to Figure 1.

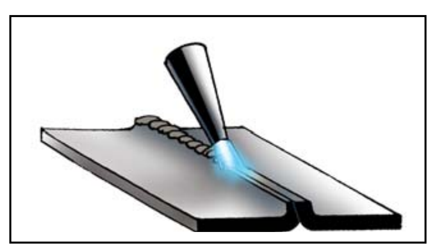


Figure 1

13. Continue moving forward until the weld is complete.
14. Shut off the outfit if the torch must be set down.
15. Shut down the outfit according to the assigned procedure. Materials and equipment should be returned to their proper places.
16. Turn in work to be graded by the instructor.

Welding an Outside Corner Joint With and Without Welding Rod

Objective: Students will observe how to use the oxyacetylene outfit to weld an outside corner joint in flat position with and without welding rod.

Directions: Use an oxyacetylene outfit to weld an outside corner joint in flat position.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Pliers
Wire brush
Firebrick or angle iron
Steel plates, selected by instructor
Welding rods, selected by instructor. Use the pliers to bend the back end of the rod into a hook to distinguish it from the end that could be hot.

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

Demonstrate the proper procedure for welding an outside corner joint without welding rod.

1. Wear appropriate face protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Prepare the metal to be welded.
4. Position the plates on the worktable. Demonstrate the correct procedure for using a firebrick or angle iron as a jig to hold the work.
5. Set up the welding outfit.
6. Light the torch using the spark lighter.
7. Adjust the flame to a neutral flame.
8. Use the torch to tack weld the pieces together.
9. Position the piece so that the outside corner is ready to be welded in the flat position. Use the pliers or tongs to move hot work.
10. Start welding at one end, with the torch at a 45-degree angle and the inner flame cone approximately 1/8 in. from the work.

11. Hold this position until a weld pool forms.
12. Carry the bead forward by moving the torch with a smooth, uniform motion.
13. Continue moving forward until the weld is complete.
14. Shut off the outfit.
15. Steps follow for demonstrating the proper procedure for welding an outside corner joint using welding rod. If this portion of the activity is not demonstrated or assigned, shut down the outfit. If the activity is performed at a different time, perform and review setup procedures as needed.

Demonstrate the proper procedure for welding an outside corner joint using welding rod.

16. Position the plates on the worktable. Use a firebrick or angle iron to support the work.
17. Set up the outfit, if needed, and light and adjust the torch.
18. Use the torch and welding rod to tack weld the pieces together.
19. Position the pieces so that the outside corner is ready to be welded in the flat position. Use pliers or tongs to move hot work.
20. Start welding at one end, with the torch at a 45-degree angle and the inner flame cone approximately 1/8 in. from the work.
21. Hold this position until a weld pool forms.
22. At the same time, use the other hand to bring the welding rod close to the flame for preheating. The end of the rod should be approximately 3/8 in. from the flame and 1/16 to 1/8 in. from the pool surface. The rod is held at an angle to the work, usually about 45 degrees.
23. When the weld pool needs additional material, dip the end of the rod in the front edge of the weld pool. When enough filler is added to make the desired bead, move forward.
24. Carry the bead forward by moving the torch and adding filler with a smooth, uniform motion.
25. Continue moving forward until the weld is complete.
26. If work is to be suspended, shut down the outfit.
27. Assign the student version of AS 4 to be performed by students.

Welding an Outside Corner Joint With and Without Welding Rod

Objective: Students will use the oxyacetylene outfit to weld an outside corner joint in flat position with and without welding rod.

Directions: Students will use an oxyacetylene outfit to weld an outside corner joint in flat position.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses or goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Pliers
Wire brush
Firebrick or angle iron
Steel plates, selected by instructor
Welding rods, selected by instructor. Use the pliers to bend the back end of the rod into a hook to distinguish it from the end that could be hot.

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

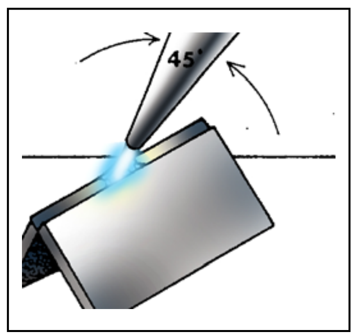


Figure 1

Weld an outside corner joint without welding rod.

1. Wear appropriate face protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Prepare the metal to be welded.
4. Position the plates on the worktable. Use a firebrick or angle iron as a jig to hold the work.
5. Set up the welding outfit.
6. Light the torch using the spark lighter.
7. Adjust the flame to a neutral flame.
8. Use the torch to tack weld the pieces together.
9. Position the piece so that the outside corner is ready to be welded in the flat position. Use pliers or tongs to move hot work.

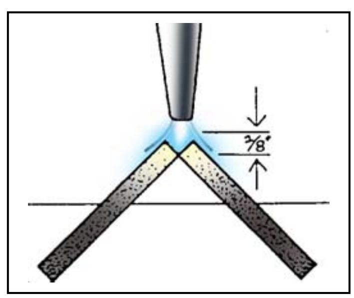


Figure 2

10. Start welding at one end, with the torch at a 45-degree angle and the inner flame cone approximately 1/8 in. from the work.
11. Hold this position until a weld pool forms.
12. Carry the bead forward by moving the torch with a smooth, uniform motion. Refer to Figures 1, 2, and 3.
13. Continue moving forward until the weld is complete.
14. Shut off the outfit.
15. Steps follow for welding an outside corner joint using welding rod. If this portion of the activity has not been demonstrated or assigned, shut down the outfit according to the assigned procedure, return equipment and materials to their proper places, and turn in work to be graded by the instructor. If the second part of the activity is performed at a different time, set up the outfit according to the instructor's directions before continuing with step 16.

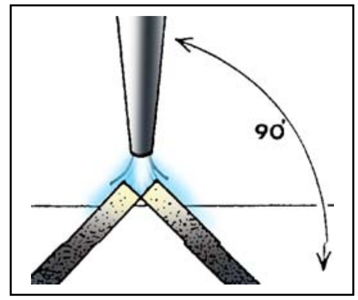


Figure 3

Weld an outside corner joint using welding rod.

16. Position the plates on the worktable. Use firebrick or angle iron to support the work.
17. Set up the outfit, if needed, and light and adjust the torch.
18. Use the torch and welding rod to tack weld the pieces together.
19. Position the pieces so that the outside corner is ready to be welded in the flat position. Use pliers or tongs to move hot work.
20. Start welding at one end, with the torch at a 45-degree angle and the inner flame cone approximately 1/8 in. from the work.
21. Hold this position until a weld pool forms.
22. At the same time, use the other hand to bring the welding rod close to the flame for preheating. The end of the rod should be approximately 3/8 in. from the flame and 1/16 to 1/8 in. from the pool surface. The rod is held at an angle to the work, usually about 45 degrees. Refer to Figure 4.
23. When the weld pool needs additional material, dip the end of the rod in the front edge of the weld pool. When enough filler is added to make the desired bead, move forward.
24. Carry the bead forward by moving the torch and adding filler with a smooth, uniform motion. Refer to Figure 5.
25. Continue moving forward until the weld is complete.
26. Shut off the outfit if the torch must be set down.
27. Shut down the outfit according to the assigned procedure. Materials and equipment should be returned to their proper places.
28. Turn in work to be graded by the instructor.

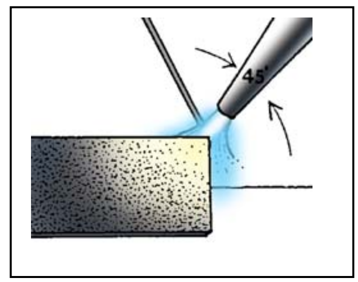


Figure 4

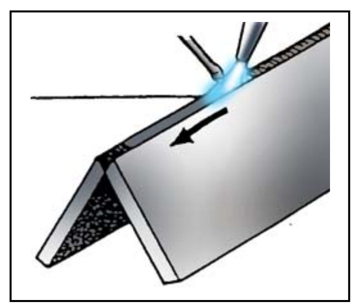


Figure 5

Unit III – Oxyacetylene Welding | Name________________________

Lesson 2: Welding With Oxyacetylene | Date________________________

Assessment

Circle the letter that corresponds to the correct answer.

1. Differences between an oxyacetylene cutting outfit and a welding outfit can be found in the:

   a. hoses and acetylene control valve.
   b. hoses and oxygen control valve.
   c. torch and acetylene regulator.
   d. torch and oxygen regulator.

2. If the torch has a tip that is the incorrect size for the work, what should the welder do?

   a. Adjust the flow of oxygen.
   b. Adjust the flow of acetylene.
   c. Replace the tip with the correct size.
   d. Recondition the tip on a grinding wheel.

3. In oxyacetylene welding, what is a usual torch angle and distance to hold the flame from the work?

   a. 45 degrees and 1/8 to 1/4 in.
   b. 45 degrees and 3/8 to 1/2 in.
   c. 60 degrees and 1/8 to 1/4 in.
   d. 60 degrees and 3/8 to 1/2 in.

4. A small diameter welding rod can be used on thick metal to:

   a. produce better penetration.
   b. avoid burnthrough.
   c. add more filler material than a larger rod.
   d. remove excess heat from the weld pool.

5. A common welding problem in which the oxyacetylene flame goes out with a snapping sound is called:

   a. backfire.
   b. carbonization.
   c. flashback.
   d. oxidation.

6. A correct statement about a carburizing flame is that it:

   a. has two distinct parts.
   b. has a high temperature.
   c. contains too much oxygen.
   d. may add carbon to the weld.

7. A correct statement about an oxidizing flame is that it:

   a. is low temperature.
   b. makes a lot of noise.
   c. has a longer inner cone.
   d. contains too much fuel.

Complete the following short-answer questions.

8. Answer the following questions regarding an RG-60 welding rod.

   a. What does the "R" indicate?

   b. What does the "G" indicate?

   c. What does the "60" indicate?

9. List two reasons why wire or rods that are not classified for oxyacetylene welding should not be used.

   a.

   b.

10. Define the following terms.

    a. Forehand welding -

    b. Backhand welding -

11. What should be done if a backfire occurs?

12. What should be done if a flashback occurs?

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Oxyacetylene Welding
Lesson	Brazing on Mild Steel
Estimated Time	Three 50-minute blocks

Student Outcome

Braze on mild steel using an oxyacetylene outfit.

Learning Objectives

1. List some safety considerations for using the oxyacetylene outfit to braze and braze weld.
2. Explain what brazing is and how is it different from fusion welding and soldering.
3. Identify the advantages and disadvantages of brazing.
4. Explain the functions of flux in brazing procedures.
5. List some factors to consider when choosing brazing flux and filler.
6. Identify flux and filler materials commonly used for brazing mild steel.
7. Demonstrate general techniques to use when brazing and braze welding.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Differences Between Brazing and Fusion Welding
2. Activity Sheets
   - AS 1 – Running a Bead With Brazing Rod (Instructor)
   - AS 1 – Running a Bead With Brazing Rod (Student)
   - AS 2 – Braze Welding an Outside Corner Joint in Mild Steel (Instructor)
   - AS 2 – Braze Welding an Outside Corner Joint in Mild Steel (Student)
3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, “Unit III – Oxyacetylene Welding.” University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplies & Equipment

- ❑ See AS 1 and AS 2 for materials and equipment needed to complete the Activity Sheets.

Supplemental Information

1. Internet Sites
   - ❑ Brazing Alloy Datasheets. Aufhauser Corporation. Accessed October 15, 2007, from http://www.brazing.com/products/Braze_Copper/.

2. Print
   - ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding*. Tinley Park, IL: Goodheart-Willcox, 2000.
   - ❑ Jeffus, L. *Welding Principles and Applications.* 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
   - ❑ Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics.* Upper Saddle River, NJ: Prentice Hall Interstate, 2004.

Interest Approach

Show students some typical assemblies made by welding (weldments) and some made by brazing (brazements). Ask students to compare the characteristics of the welded pieces to those of the brazed pieces. Lead the students in a discussion about the features of the brazed assemblies. These assemblies should highlight some of the characteristics of brazing and how brazing differs from fusion welding. Students might notice the following characteristics: different types of metal can be joined together, very thin pieces can be joined together or a very thin piece can be joined to a thick piece without distortion, nonmetal parts can be joined by brazing, and parts are not fused together by the process.

Communicate the Learning Objectives

1. List some safety considerations for using the oxyacetylene outfit to braze and braze weld.
2. Explain what brazing is and how is it different from fusion welding and soldering.
3. Identify the advantages and disadvantages of brazing.
4. Explain the functions of flux in brazing procedures.
5. List some factors to consider when choosing brazing flux and filler.
6. Identify flux and filler materials commonly used for brazing mild steel.
7. Demonstrate general techniques to use when brazing and braze welding.

Instructor Directions	Content Outline
Objective 1	**List some safety considerations for using the oxyacetylene outfit to braze and braze weld.**
Introduce the topic of brazing by discussing some of the safety procedures that should be observed for brazing and braze welding. Supplement with any additional procedures as needed.	The same safety procedures used when welding or cutting with the oxyacetylene outfit should be used for brazing procedures. Some additional precautions are listed below. 1. Make sure the work area has excellent ventilation. Brazing can produce fumes that cause serious illness and even death. Some of these fumes have no odor and produce no symptoms until hours after exposure. 2. If needed, supplement ventilation with an appropriate respirator. 3. Avoid letting fluxes come into contact with skin. If fluxes do touch the skin, wash the area thoroughly with soap and water. 4. Because of the presence of fumes and toxic chemicals, do not eat or store food in the shop. 5. Wash the face and hands after working with fluxes and other toxic chemicals. 6. Wear the same type of clothing and protective clothing when brazing as when welding or cutting. Sleeves should be buttoned, gloves should be worn,

Instructor Directions	Content Outline
	and additional protective gear should be used as needed. 7. Wear goggles with filter lenses appropriate for the work being done. Lenses with shade numbers 3 and 4 are commonly used for torch brazing. Consult the manufacturer's recommendations. 8. Make sure only trained personnel handle acids used for cleaning. Persons handling acid should wear appropriate protective equipment, including rubber gloves and goggles approved for use around chemicals.
Objective 2 *Compare brazing to fusion welding and soldering. Refer to PPt 1.* PPt 1 – Differences Between Brazing and Fusion Welding	**Explain what brazing is and how is it different from fusion welding and soldering.** Brazing is a process of joining materials by adding filler metal that becomes liquid at a temperature above 840°F but below the temperature at which the base materials start to melt. The filler is distributed by capillary action, which means that it is drawn into the space between closely fitted pieces. If the materials are joined by running a braze pool to fill a groove or make a fillet instead of by capillary action, the process is called braze welding. With brazing and braze welding, the base materials do not melt so that they flow together to produce the joint. With fusion welding, the base materials are melted. Soldering is similar to brazing, except that it is done at temperatures below 840°F. The filler is distributed by capillary action.
Objective 3 *Discuss advantages and disadvantages of brazing. Examples of brazed and welded joints can be used to reinforce the information or clarify any points the students might have missed in previous discussions.*	**Identify the advantages and disadvantages of brazing.** Advantages of brazing 1. Brazing is done at lower temperatures than fusion welding. a. Very thin parts can be joined together or thin parts can be joined to thick parts with less risk of burning them. b. There is less chance of warping the materials. c. There is less chance of adding stress to the joints.

Instructor Directions	Content Outline
	2. Dissimilar metals, such as copper and steel, can be joined together. 3. Metals can be joined to nonmetals. 4. Parts can be easily disassembled and realigned without being damaged. Disadvantages of brazing 1. Brazed joints may not be as strong as similar joints made by fusion welding. 2. Assemblies that include brazed joints can only be used in applications where the operating temperature is below the service temperature of the filler material. Service temperature is the highest temperature at which the material can be used. 3. Filler metal used for braze welding may not be as resistant to chemical solutions as the base metals are.
Objective 4 *The purposes of fluxes are discussed at right, followed by some of the considerations for choosing a particular flux and filler metal. If different fluxes and fillers or fluxes and fillers in different forms are regularly used in the shop, these could be shown to the students to help familiarize them with the materials they will be using.*	**Explain the functions of flux in brazing procedures.** Flux removes oxides from the filler and base material and keeps new oxides from forming. It helps the filler flow, spread evenly, and adhere to the base material. This is known as "wetting." Without flux, the filler would bead up and roll off the base material without sticking. It facilitates capillary action.
Objective 5	**List some factors to consider when choosing brazing flux and filler.** Compatibility of the flux and filler with the base material – Use of fluxes and fillers that are not recommended for a particular application can result in joints that corrode, are brittle, and lack strength. Possible health risks – Certain fluxes produce toxic fumes or can be harmful to the skin. Brazing and service temperature required: The chemical composition of a filler affects the temperature at which it melts and at which it can be used.

Instructor Directions	Content Outline
	How the flux and filler are to be applied – Flux is available as a powder, liquid, or paste, and filler is available as preformed shapes, powder, and as bare rods or rods with flux already applied.
Objective 6 *Borax and brass, a common flux and filler used with steel, are discussed at right. If students will be using different or additional fluxes and fillers, supplement or adapt this question as needed.*	**Identify flux and filler materials commonly used for brazing mild steel.** Borax or boric acid (borax and water) is a typical base in fluxes used on steel. Brass is a typical filler for brazing ferrous metals, such as mild steel. 1. Brass is an alloy made chiefly of copper and zinc. 2. Brazing fillers are often identified by the letter "B," for brazing, followed by the symbols for the metals that make them up. For example, BCuZn indicates brass filler used for brazing. 3. Most brazing rods that are called "bronze" and used for brazing ferrous metals are, in fact, mostly made of brass, with only small amounts of tin. (Bronze is an alloy made chiefly of copper and tin.)
Objective 7 *General techniques for brazing and braze welding are discussed at right. Supplement with more detailed procedural information as needed. When students have completed the lesson on brazing, AS 1 and 2 should be used to demonstrate the correct way to run a braze-welded bead and to braze weld a corner joint using an oxyacetylene outfit. The student versions of these activities should be assigned to evaluate student competency.* AS 1 – Running a Bead With Brazing Rod	**Demonstrate general techniques to use when brazing and braze welding.** Check the fit and alignment of pieces before they are brazed or braze welded. 1. A close fit is essential for brazing. The clearance between pieces should be from .001 to .010 in. If the parts do not fit correctly, capillary action cannot occur. 2. Parts do not have to fit as closely for braze welding, but as with other welds, a good fit produces a stronger joint. Clean base materials prior to brazing or braze welding. 1. Parts to be joined by brazing must be clean for capillary action to take place. 2. Cleaning is also important prior to braze welding. 3. Parts can be cleaned by chemical or mechanical means. a. Mechanical cleaning

Instructor Directions	Content Outline
🖹 AS 2 – Braze Welding an Outside Corner Joint in Mild Steel	– Use of grinding, sanding, and wire brushing to remove surface dirt – Should be followed by washing and drying to remove particles knocked loose while cleaning b. Chemical cleaning – Use of chemicals to remove oil and grease that would be ground into the surface by mechanical cleaning – Use of acids or other solutions to remove rust and scale (pickling) – Should be followed by washing and drying Adjust the torch to the correct flame. 1. A carburizing flame produces a joint with a neat appearance, but strength may be sacrificed. 2. An oxidizing flame produces a joint that is strong but may be rough looking. 3. A neutral flame generally gives the best results for brazing and welding under normal conditions. Do not overheat the base material, filler, or flux when brazing with a torch. 1. Acetylene produces a flame with a very hot inner cone but relatively cool outer flame. If acetylene is used, care must be taken to avoid overheating a small area instead of heating a larger area uniformly. 2. Overheated flux can stop working as a flux and contaminate the joint. 3. If flux is overheated, it must be removed before continuing the process.
Application: 🖹 AS 1 – Running a Bead With Brazing Rod 🖹 AS 2 – Braze Welding an Outside Corner Joint in Mild Steel	AS 1 – AS 2 Results will vary. Other activities 1. Obtain empty metal containers (e.g., soup or soda cans) and punch holes in the bottom of them. Have students braze weld the holes to seal them. To check their work, have students put water in the cans to see if they hold water.

Instructor Directions	Content Outline
Closure/Summary	Brazing joins materials by adding filler metal through capillary action at a temperature above 840°F but below the melting temperature of the base material. It differs from fusion welding because the base material does not melt and flow together. Soldering is similar to brazing but is done at temperatures below 840°F. Flux is used during brazing to remove and prevent oxide formation, to help apply filler, and to promote capillary action. When selecting filler and flux, consider compatibility with base material, health risks such as toxic fumes, brazing and service temperature, and application method. Borax or boric acid is a typical base for fluxes used on steel. Brass is a typical filler for brazing ferrous metals, such as mild steel. Apply these general techniques for brazing: check the fit and alignment of pieces; clean base materials; adjust the torch to the correct flame; and do not overheat base material, filler, or flux. Safety considerations are similar to other oxyacetylene procedures, but give special attention to proper ventilation.
Evaluation: Quiz	Answers: 1. a 2. b 3. b 4. d 5. a 6. c 7. Students should list four of the following. a. Fumes from the fluxes, filler metals, and base metal coatings may be toxic. b. Fluxes can be harmful to skin and eyes. c. Fumes from fluxes, filler metals, and base metal coatings can contaminate food. d. Skin can be burned by hot surfaces and metal spatters. e. Skin and eyes can be burned by light rays. f. Skin and eyes can be irritated or burned by acids and cleaning solutions. 8. Students should list two of the following. a. A lower temperature can be used because the base metal does not have to melt. Using a lower temperature produces better results when joining very thin parts or joining thin parts to thick parts.

Instructor Directions	Content Outline
	There is also less chance of warping the materials and adding stress to the joints. b. Dissimilar metals can easily be joined because the base metal does not have to melt. c. The joined pieces can easily be disassembled without damaging them. 9. Students should list two of the following. a. Brazed joints may not be as strong as joints made by fusion welding. b. The lower service temperature of brazing filler metal limits its use to assemblies that will not be exposed to higher temperatures. c. Filler metal used for brazing may not be as resistant to chemical solutions as the base metal. 10. The incompatibility of flux and filler metal with the base metal can result in joints that corrode, are brittle, and lack strength.

Lesson 3: Brazing on Mild Steel

Running a Bead With Brazing Rod

Objective: Students will observe how to run a bead on a steel plate using brazing rod and the oxyacetylene outfit.

Directions: Use an oxyacetylene outfit to run a bead using brazing rod.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses if needed to supplement goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Soapstone or chalk
Straightedge
Wire brush, emery cloth, or other cleaners recommended by instructor
Pliers
Flux suitable for brazing mild steel
Steel plate(s), selected by instructor
Uncoated brazing rod(s), selected by instructor. Use the pliers to bend the back end of the rod into a hook to distinguish it from the end that could be hot.

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Wear appropriate face and eye protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Demonstrate the correct procedure for cleaning the metal for brazing.
4. Position the plate on the worktable and mark a line using the soapstone and straightedge. More lines can be laid out for additional demonstrations, if desired.
5. Set up the oxyacetylene outfit.
6. Light the torch using the spark lighter.
7. Adjust the torch to the correct flame. If a flame other than a neutral flame is used, demonstrate the correct method of adjusting the torch and explain why this flame is appropriate for the procedure.

8. Heat the end of the brazing rod and the point on the plate where the bead is to begin.
   a. Hold the torch at a 45-degree angle, with the inner flame cone approximately 1/8 in. from the work.
   b. Hold the brazing rod at a 15- to 45-degree angle to the work.
   c. Heat the rod until it is hot enough to melt the flux.
9. Dip the heated end of the brazing rod into the flux.
   a. This will melt the flux and a small amount will stick to the brazing rod.
   b. Repeat this step as often as necessary to keep the hot end of the rod coated with flux.
10. Touch the rod to the heated spot on the plate. The plate is hot enough when the rod begins to melt.
11. Once the rod starts to melt, move it into and out of the flame as needed to form a bead.
    a. When running a bead with brazing rod, the torch should be moved in a circular pattern, as it was in the oxyacetylene welding procedures.
    b. The flux should flow ahead of the filler material being added.
12. Continue moving the torch in the circular pattern and move the torch and rod forward at a speed that will keep the braze pool a uniform size and shape. If the pool becomes too large it can be controlled by moving the inner flame cone away from the work, by changing the angle of the flame, by moving at a faster rate, or by flashing the flame off the braze pool.
13. Continue until the bead is complete.
14. If desired, other beads could be run, varying factors such as the amount of time the base metal is heated and the amount of flux that is used.
15. Shut off the outfit.
16. If desired, when it is safe to do so, have students inspect the bead or beads. Explain that the ripples of the bead should be of a uniform height and width. There should be no white residue on the weld. Such residue indicates overheating.
17. If work is to be suspended, shut down the outfit.
18. Assign the student version of AS 1 to be performed by students.

Lesson 3: Brazing on Mild Steel

Running a Bead With Brazing Rod

Objective: Students will run a bead on a steel plate using brazing rod and the oxyacetylene outfit.

Directions: Students will use an oxyacetylene outfit to run a bead using brazing rod.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses if needed to supplement goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Soapstone or chalk
Straightedge
Wire brush, emery cloth, or other cleaners recommended by instructor
Pliers
Flux suitable for brazing mild steel
Steel plate(s), selected by instructor
Uncoated brazing rod(s), selected by instructor. Use the pliers to bend the back end of the rod into a hook to distinguish it from the end that could be hot.

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Wear appropriate face and eye protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Clean the metal for brazing using the recommended procedure.
4. Position the plate on the worktable and mark a line using the soapstone and straightedge. Lay out additional lines if instructed to do so.
5. Set up the oxyacetylene outfit according to the assigned procedure.
6. Light the torch using the spark lighter.
7. Adjust the torch to the correct flame.

8. Heat the end of the brazing rod and the point on the plate where the bead is to begin. Refer to Figures 1 and 2.
   a. Hold the torch at a 45-degree angle, with the inner flame cone approximately 1/8 in. from the work.
   b. Hold the brazing rod at a 15- to 45-degree angle to the work.
   c. Heat the rod until it is hot enough to melt the flux.

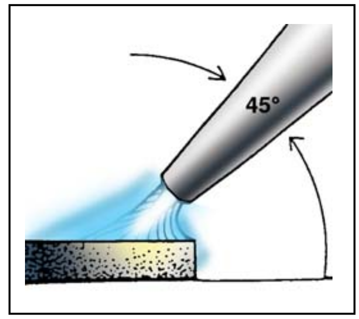


Figure 1

9. Dip the heated end of the brazing rod into the flux.
   a. This will melt the flux and a small amount will stick to the brazing rod.
   b. Repeat this step as often as necessary to keep the hot end of the rod coated with flux.
10. Touch the rod to the heated spot on the plate. The plate is hot enough when the rod begins to melt.
11. Once the rod starts to melt, move it into and out of the flame as needed to form a bead. Refer to Figure 3.
    a. When running a bead with brazing rod, the torch should be moved in a circular pattern, as it was in the oxyacetylene welding procedures.
    b. The flux should flow ahead of the filler material being added.

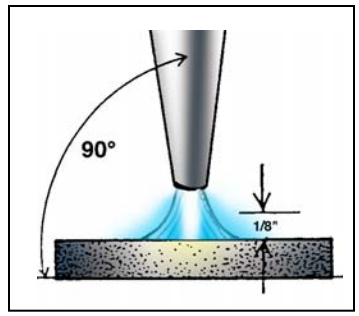


Figure 2

12. Continue moving the torch in the circular pattern and move the torch and rod forward at a speed that will keep the braze pool a uniform size and shape. If the pool becomes too large, it can be controlled by moving the inner flame cone away from the work, by changing the angle of the flame, by moving at a faster rate, or by flashing the flame off the braze pool.
13. Continue until the bead is complete.
14. Run additional beads if instructed to do so.
15. Shut off the outfit if the torch must be set down.

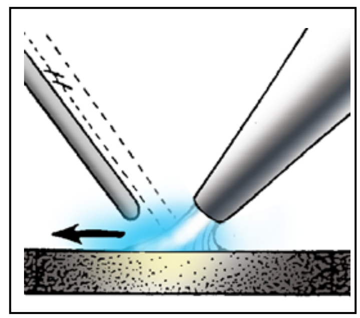


Figure 3

16. When it is safe to do so, inspect the bead or beads. Ripples should be of a uniform height and width. There should be no white residue on the weld. Such residue indicates overheating.
17. Shut down the outfit following assigned procedure. Materials and equipment should be returned to their proper places.
18. Turn in work to be graded by the instructor.

Lesson 3: Brazing on Mild Steel

Braze Welding an Outside Corner Joint in Mild Steel

Objective: Students will observe how to braze weld an outside corner joint using the oxyacetylene outfit.

Directions: Use an oxyacetylene outfit and brazing rod to make an outside corner joint in mild steel.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses if needed to supplement goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Wire brush, emery cloth, or other cleaners recommended by instructor
Pliers
Flux suitable for brazing mild steel
Firebrick or angle iron
Steel plates, selected by instructor
Uncoated brazing rods, selected by instructor. Use the pliers to bend the back end of the rod into a hook to distinguish it from the end that could be hot.

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Wear appropriate face and eye protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Clean the metal for brazing.
5. Position the plates on the worktable using firebrick or angle iron as a jig to hold the work in place.
6. Set up the oxyacetylene outfit.
7. Light the torch using the spark lighter.
8. Adjust the torch to the correct flame.
9. Use the torch and brazing rod to tack the pieces together.
10. Position the pieces so that the outside corner is ready to be welded in the flat position. Use pliers or tongs to move hot work.

11. Heat the end of the brazing rod and the edges of the plates where the bead is to begin.
    a. Hold the torch at a 45-degree angle, with the inner flame cone approximately 1/8 in. from the work.
    b. Hold the brazing rod at a 15- to 45-degree angle to the work.
    c. Heat the rod until it is hot enough to melt the flux.
12. Dip the heated end of the brazing rod into the flux.
    a. This will melt the flux and a small amount will stick to the brazing rod.
    b. Repeat this step as often as necessary to keep the hot end of the rod coated with flux.
13. Touch the rod to the heated spot on the plates. The base metal is hot enough when the rod begins to melt.
14. Once the rod starts to melt, move it into and out of the flame as needed to form a bead.
    a. When running a bead with brazing rod, the torch should be moved in a circular pattern, as it was in the oxyacetylene welding procedures.
    b. The flux should flow ahead of the filler material being added.
15. Continue moving the torch in the circular pattern and move the torch and rod forward at a speed that will keep the braze pool a uniform size and shape.
16. Continue until the bead is complete.
17. Shut off the outfit.
18. If work is to be suspended, shut down the outfit.
19. Assign the student version of AS 2 to be performed by students.

Lesson 3: Brazing on Mild Steel

Braze Welding an Outside Corner Joint in Mild Steel

Objective: Students will braze weld an outside corner joint using the oxyacetylene outfit.

Directions: Students will use an oxyacetylene outfit and brazing rod to make an outside corner joint in mild steel.

Materials and Equipment:

Oxyacetylene outfit and accessories
Welding goggles with appropriate shaded lens*
Safety glasses if needed to supplement goggles
Leather gloves and any other protective clothing recommended by instructor
Spark lighter
Wire brush, emery cloth, or other cleaners recommended by instructor
Pliers
Flux suitable for brazing mild steel
Firebrick or angle iron
Steel plates, selected by instructor
Uncoated brazing rods, selected by instructor. Use the pliers to bend the back end of the rod into a hook to distinguish it from the end that could be hot.

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear.

Procedure:

1. Wear appropriate face and eye protection and protective clothing.
2. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Clean the metal for brazing.
4. Position the plates on the worktable using firebrick or angle iron as a jig to hold the work in place.
5. Set up the oxyacetylene outfit.
6. Light the torch using the spark lighter.
7. Adjust the torch to the correct flame.
8. Use the torch and brazing rod to tack the pieces together.
9. Position the pieces so that the outside corner is ready to be welded in the flat position. Use the pliers or tongs to move hot work.

10. Heat the end of the brazing rod and the edges of the plates where the bead is to begin.
    a. Hold the torch at a 45-degree angle, with the inner flame cone approximately 1/8 in. from the work. Refer to Figures 1 and 2.
    b. Hold the brazing rod at a 15- to 45-degree angle to the work.
    c. Heat the rod until it is hot enough to melt the flux.
11. Dip the heated end of the brazing rod into the flux.
    a. This will melt the flux and a small amount will stick to the brazing rod.
    b. Repeat this step as often as necessary to keep the hot end of the rod coated with flux.
12. Touch the rod to the heated spot on the plates. The base metal is hot enough when the rod begins to melt.
13. Once the rod starts to melt, move it into and out of the flame as needed to form a bead. Refer to Figure 3.
    a. When running a bead with brazing rod, the torch should be moved in a circular pattern, as it was in the oxyacetylene welding procedures.
    b. The flux should flow ahead of the filler material being added.
14. Continue moving the torch in the circular pattern and move the torch and rod forward at a speed that will keep the braze pool a uniform size and shape. Refer to Figure 4.
15. Continue until the bead is complete.
16. Shut off the outfit if the torch must be set down.
17. Shut down the outfit following assigned procedure. Materials and equipment should be returned to their proper places.
18. Turn in work to be graded by the instructor.

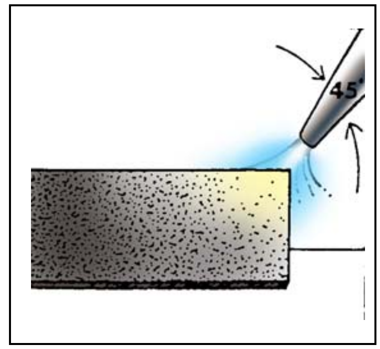


Figure 1

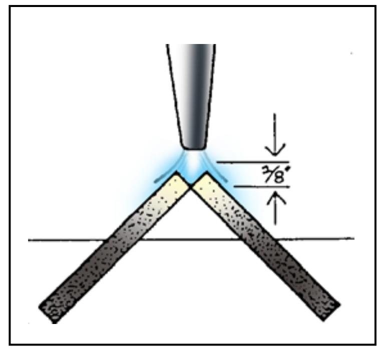


Figure 2

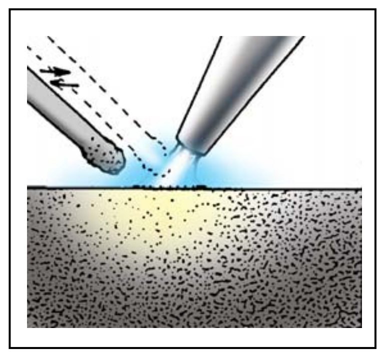


Figure 3

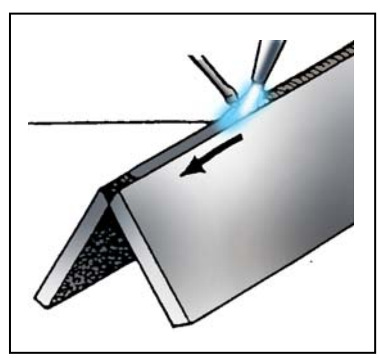


Figure 4

Unit III - Oxyacetylene Welding Name__________________________

Lesson 3: Brazing on Mild Steel Date__________________________

Assessment

Circle the letter that corresponds to the correct answer.

1. Which process does not use capillary action and does not melt the base metal?

   a. Braze welding
   b. Brazing
   c. Fusion welding
   d. Soldering

2. A correct statement about both brazing and soldering is that they:

   a. use capillary action and melt the base metal.
   b. use capillary action and do not melt the base metal.
   c. do not use capillary action and melt the base metal.
   d. do not use capillary action and do not melt the base metal.

3. Which statement is correct about brazing?

   a. Brazing cannot be used to join nonmetal materials.
   b. Distortion is decreased because a lower temperature is used.
   c. Brazing creates more stresses in the metal than fusion welding.
   d. Filler metals used for brazing are stronger than the base metals.

4. One function of flux used in brazing is to:

   a. help the filler and base metal to melt.
   b. keep the filler and base metals from melting.
   c. add oxides to the filler and base metal.
   d. remove oxides from the filler and base metal.

5. Brazing rods called "bronze" are actually made mostly of:

   a. brass.
   b. iron.
   c. tin.
   d. zinc.

6. One step that is essential in <u>both</u> brazing and braze welding is:

   a. directing the heat to only the area of the weld.
   b. using a flux to provide wetting and capillary action.
   c. cleaning the base metal before beginning the process.
   d. ensuring the pieces have a clearance of .001 to .010 in.

Complete the following short-answer questions.

7. List four potential hazards of the brazing or braze welding process.

   a.

   b.

   c.

   d.

8. Name two advantages of brazing over fusion welding.

   a.

   b.

9. Name two disadvantages of brazing over fusion welding.

   a.

   b.

10. What can happen to weld quality if the if the flux and filler metal are incompatible with the base metal?

Agricultural Science II

Curriculum Guide: *Agricultural Mechanics Unit for Agricultural Science II*

Unit: III. Oxyacetylene Welding

Unit Objective:
Students will apply principles of oxyacetylene welding by making basic welds with an oxyacetylene outfit as part of a class-wide contest.

Show-Me Standards: 2.5, CA3

References:

Agricultural Mechanics Unit for Agricultural Science II. University of Missouri-Columbia, Instructional Materials Laboratory, 2002.

American Welding Society. Accessed November 18, 2003, from http://www.aws.org/.

Hobart Institute of Welding Technology. Accessed November 17, 2003, from http://www.welding.org/.

Machinery Safety: Welding. National Ag Safety Database. Accessed November 17, 2003, from http://www.cdc.gov/nasd/menu/topic/machinery_welding.html.

Missouri CDE Handbook. Accessed November 14, 2003, from http://www.dese.mo.gov/divcareered/ag_cde_guidelines.htm.

Missouri FFA Agricultural Mechanics Career Development Event. Accessed November 19, 2003, from http://web.missouri.edu/~pavt0689/statecon.html.

Thermadyne. Victor. Accessed November 18, 2003, from http://www.thermadyne.com/vec/index.asp?div=vec.

Instructional Strategies/Activities:

- Students will engage in study questions in lessons 1 through 3.
- Students will complete AS 2.1, Running a Continuous Weld Pool With and Without Welding Rod; AS 2.2, Welding a Butt Joint in Flat Position Using Welding Rod; AS 2.3, Welding an Edge Weld in a Flanged Butt Joint Without Welding Rod; AS 2.4, Welding an Outside Corner Joint With and Without Welding Rod; AS 3.1, Running a Bead With Brazing Rod; and AS 3.2, Braze Welding an Outside Corner Joint in Mild Steel.
- Additional activities that relate to the unit objective can be found under the heading "Other Activities" in the following locations: p. III-5 (2, 3) and p. III-55.

Performance-Based Assessment:

Students will be divided into groups. The groups will represent teams and will participate in a contest that is similar to the oxyacetylene competency portion of the Agricultural Mechanics Career Development Event. Each student will use an oxyacetylene outfit to make common welds presented in the unit and discussed in class.

Assessment will be based on the ability to safely and correctly make the assigned welds using the oxyacetylene outfit.

Agricultural Mechanics Unit for Agricultural Science II
Unit III—Oxyacetylene Welding
Instructor Guide

The instructor should assign the performance-based assessment activity at the beginning of the unit. Students will work toward completing the activity as they progress through the unit lessons. The assessment activity will be due at the completion of the unit.

1. Use or adapt the activity sheets found in the unit to assess student competency at welding and braze welding with the oxyacetylene outfit. Review or supplement these activities as needed, based on student mastery of the procedures and equipment the students will be using. **NOTE: Students should only complete this performance-based activity if they have mastered all the relevant competencies and have the instructor's permission to perform the activity.**

2. For the performance-based assessment activity, have students apply the skills and procedures discussed in the unit by making basic welds with an oxyacetylene outfit as part of a class-wide contest.

3. Divide the class into groups and assign students a series of welding procedures to perform using the oxyacetylene outfit, such as welding a butt joint in flat position using welding rod, welding an outside corner joint with or without welding rod, and braze welding an outside corner joint in mild steel.
   a. Each student should perform all of the assigned procedures.
   b. Assign students welding procedures that they have mastered as part of the instructional activities for this unit.

4. This activity will help prepare students for the oxyacetylene portion of the Agricultural Mechanics Career Development Event.
   a. Explain or review event guidelines as needed.
   b. Refer to the *Missouri CDE Handbook* for guidelines regarding the Agricultural Mechanics Career Development Event. The *Missouri CDE Handbook* is available from the Missouri Department of Elementary and Secondary Education at http://www.dese.mo.gov/divcareered/ag_cde_guidelines.htm.

5. Have students perform the assigned welding procedures.
   a. Performance in the oxyacetylene welding contest will determine the student's individual score.
   b. Combine the individual scores of the group members to determine the team score for each group.

6. The final assessment score will be based on the ability to safely and correctly make the assigned welds using the oxyacetylene outfit.

7. Present an appropriate award to the high-scoring team and individual, if desired.

8. NOTE: If desired, this activity can be combined with the performance-based assessment activities from Unit II, Arc Welding, and Unit IV, Tool Sharpening and Reconditioning, to form a mini Agricultural Mechanics Career Development Event. To conduct a mini Agricultural Mechanics Career Development Event, maintain the same student groups for all of the performance-based assessment activities. An expanded score sheet is included at the end of each of these units that can be used to track individual and group performance in the mini CDE.

9. ADDITIONAL ACTIVITY: Create a display board using the students' work. Possible display board themes include the following: each student's best work using the oxyacetylene outfit, the best example of each type of procedure performed by the class, and the best work of the week.

Agricultural Mechanics Unit for Agricultural Science II
Unit III—Oxyacetylene Welding
Student Handout

1. The instructor will divide the class into groups and give you a series of oxyacetylene welding procedures to perform as part of a class-wide contest.

2. Your group will compete in the contest as a team.

3. Perform the assigned welds using the oxyacetylene outfit.
   - ❑ Wear appropriate safety equipment at all times.
   - ❑ Follow all assigned safety procedures. You can lose points for not following safety precautions and other assigned procedures.
   - ❑ Inspect the equipment, materials, and work area to ensure safe and correct operation.
   - ❑ Perform the welds using the assigned procedure.
   - ❑ Inspect your work.
   - ❑ Follow shutdown and cleanup procedures and return all equipment and materials to their assigned places.
   - ❑ Turn in your work to the instructor.

4. Your final assessment score will be based on your ability to safely and correctly make the assigned welds using the oxyacetylene outfit.

Agricultural Science II

Agricultural Mechanics Unit for Agricultural Science II
Unit III—Oxyacetylene Welding
Scoring Guide

Name ____________________

Assessment Area	Criteria	0 Points	1 Point	2 Points	3 Points	4 Points	Weight	Total
Positioning	Metal was properly positioned	Failed	Poor	Fair	Good	Excellent	X 5	
Filler Rod and Equipment Setting	Filler is appropriate for procedure and torch flame was properly adjusted	Failed	Poor	Fair	Good	Excellent	X 5	
Distortion	Welds are free of distortion	Failed	Poor	Fair	Good	Excellent	X 5	
Appearance	Weld beads are uniform	Failed	Poor	Fair	Good	Excellent	X 5	
Strength	Welds are strong and sound	Failed	Poor	Fair	Good	Excellent	X 5	
Safety and Work Habits	**Student followed all safety precautions**	**Passed**				**Failed**	**X (-25)**	Negative Points *
	Student followed all assigned procedures	**Excellent**	**Good**	**Fair**	**Poor**	**Failed**	**X (-10)**	Negative Points *
TOTAL								

Final Assessment Total ________/100 pts.
*** Overall combined score cannot be lower than 0.**

Comments:

Agricultural Mechanics II Score Sheet

Team Members	Arc Welding	Oxyacetylene Welding	Tool Sharpening/ Reconditioning	Score
Team A				
				Total:
Team B				
				Total:
Team C				
				Total:
Team D				
				Total:
Team E				
				Total:
Team F				
				Total:

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Tool Sharpening and Reconditioning
Lesson	Sharpening and Reconditioning a Twist Drill, Lawn Mower Blade, and Chain Saw Chain
Estimated Time	Four 50-minute blocks

Student Outcome

Identify the safety procedures for tool sharpening and reconditioning.
Dress a grinding wheel.
Sharpen a twist drill.
Sharpen a lawn mower blade.
Maintain a chain saw chain.

Learning Objectives

1. Identify safety procedures for using a bench grinder.
2. Identify some ways grinding wheels are classified.
3. Demonstrate the correct procedure for dressing a grinding wheel.
4. Explain some considerations for sharpening a twist drill.
5. Explain some considerations for sharpening a lawn mower blade.
6. Explain some considerations for maintaining a chain saw chain.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Dressing the Grinding Wheel Using a Mechanical Wheel Dresser
   - PPt 2 – Parts of a Twist Drill Cutting Tip
   - PPt 3 – Placement of the Drill for Sharpening
   - PPt 4 – Judging Lip Clearance
   - PPt 5 – Using a Gauge to Check the Shape and Clearance of a Twist Drill
   - PPt 6 – Filing a Lawn Mower Blade
   - PPt 7 – Parts of a Cutter
   - PPt 8 – Using the Depth Gauge Tool
   - PPt 9 – Proper Chain Tension
2. Activity Sheets
   - AS 1 – Dressing a Grinding Wheel (Instructor)
   - AS 1 – Dressing a Grinding Wheel (Student)
   - AS 2 – Sharpening a Twist Drill (Instructor)

- AS 2 – Sharpening a Twist Drill (Student)
- AS 3 – Sharpening a Lawn Mower Blade (Instructor)
- AS 3 – Sharpening a Lawn Mower Blade (Student)
- AS 4 – Maintaining a Chain Saw Chain (Instructor)
- AS 4 – Maintaining a Chain Saw Chain (Student)

3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit IV – Tool Sharpening and Reconditioning." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplies & Equipment

- ❑ See AS 1 through AS 4 for materials and equipment needed to complete the Activity Sheets.

Supplemental Information

1. Internet Sites
   - ❑ "Grinders – Bench, Floor, and Hand." Environmental Health and Safety. University of Nebraska-Lincoln. Accessed October 17, 2007, from http://ehs.unl.edu/sop/s-grinders.pdf.
   - ❑ Maxwell, S. "Keeping Your Chainsaw Sharp." *Mother Earth News*, no. 194 (October/November 2002). Accessed October 17, 2007, from http://www.motherearthnews.com/DIY/2002-10-01/Keeping-Your-Chainsaw-Sharp.aspx.
2. Print
   - ❑ Cooper, E. *Agricultural Mechanics: Fundamentals and Applications*. 3rd ed. Albany, NY: Del Mar Publishers, 1997.
   - ❑ Phipps, L. *Mechanics in Agriculture*. 4th ed. Danville, IL: Interstate Publishers, 1992.
   - ❑ Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics*. Upper Saddle River, NJ: Prentice Hall Interstate, 2004.
   - ❑ Walker, J. *Modern Metalworking*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 2000.

Interest Approach

Safety procedures for using a bench grinder were discussed in *Agricultural Mechanics Unit of Agricultural Science I*, Unit I Lesson 2. Basic procedures for sharpening and reconditioning common hand tools were discussed in *Agricultural Mechanics Unit for Agricultural Science I,* Unit IV. As a review of this material, ask what tools are commonly used for sharpening and reconditioning and what safety procedures should be observed when using a bench grinder.

Communicate the Learning Objectives

1. Identify safety procedures for using a bench grinder.
2. Identify some ways grinding wheels are classified.
3. Demonstrate the correct procedure for dressing a grinding wheel.
4. Explain some considerations for sharpening a twist drill.
5. Explain some considerations for sharpening a lawn mower blade.
6. Explain some considerations for maintaining a chain saw chain.

Instructor Directions	Content Outline
Objective 1	**Identify safety procedures for using a bench grinder.**
Introduce the lesson by discussing safety procedures for use of a bench grinder. Some of this material was covered in Agricultural Mechanics Unit for Agricultural Science II*, Unit I Lesson 2; some additional points have been added for this lesson. The instructor should include any other relevant safety considerations as well.*	Wear protective clothing. A face shield and a leather apron are recommended when using the grinder. Wear any additional protective clothing, such as an appropriate filter or respirator, when recommended by the instructor. Disconnect the grinder from its power source before making any inspections or adjustments. Make sure all guards are in place before starting the grinder. Be sure the speed of the grinder does not exceed the operating speed of the wheel. Stand to the side of the wheel when starting the grinder and let the wheel run before using. Wheels that are going to break generally do so within the first minute of use. Move the work slowly back and forth across the face of the wheel to avoid overheating the workpiece or wearing grooves in the wheel. Do not force the workpiece into the grinding wheel. Allow the speed and grit of the wheel to do the work.

Instructor Directions	Content Outline
	Inspect wheels frequently. 1. Wheels should be reconditioned to restore their abrasive work surface and bring them back into round. This is called dressing. Students should receive proper instruction and permission before dressing the wheel. 2. Frequent, light dressings are preferable to occasional heavy dressings. 3. Replace wheels that are too worn to be dressed. 4. Replace wheels that have been damaged or dropped.
Objective 2 *It is important to choose the right grinding wheel for the job. Discuss ways in which grinding wheels are classified.*	**Identify some ways grinding wheels are classified.** Type of abrasive material – Wheels can be made of natural stone, such as Arkansas stone, or manmade material, such as those made from silicon carbide or aluminum oxide. Grit – Grit is the word used to describe the small abrasive cutting particles. Grit is also a system for classifying abrasives. As the grit number of a grinding wheel increases, the abrasives become finer. Grade – Grade is a system for rating the hardness of grinding wheels, with the letter "A" being the softest and the letter "Z" the hardest. Medium-hard wheels are commonly used for tool sharpening. Bond – Bond refers to the way in which the abrasive particles are held together. Vitrified bonding is the most common process and is generally preferred over other types. With vitrified bonding, a silica agent and the abrasive particles are pressed into a mold and heated until the silica agent melts and becomes glass. The mixture is allowed to cool and harden and retains the shape of the mold when it is removed. Dimensions – Wheels can also be identified by their outside diameter and width.

Instructor Directions	Content Outline
Objective 3 *Wheels require periodic reconditioning to restore their abrasive work surface and bring them back into round. This process is called dressing. Because wheels are dressed on the grinder, students must be able to safely and correctly operate the type of grinder being used before dressing a grinding wheel or performing the activities at the end of this lesson. Basic procedures for using the bench grinder for sharpening and reconditioning hand tools were discussed in* Agricultural Mechanics Unit for Agricultural Science I, *Unit IV. Review that and any other material on using the grinder as needed. Discuss the correct procedure for dressing a grinding wheel. Refer to PPt 1.* PPt 1 – Dressing the Grinding Wheel Using a Mechanical Wheel Dresser	**Demonstrate the correct procedure for dressing a grinding wheel.** Signs that a grinding wheel needs dressing 1. The wheel is glazed (the abrasives become dull). 2. The wheel is loaded (the surface fills up with waste material). 3. The wheel is out of round. Techniques for dressing a grinding wheel 1. Follow the same safety and use guidelines as those for other procedures using the grinding wheel. 2. Use a mechanical wheel dresser or other appropriate dressing tool. 3. If heavy sparking occurs, increase pressure on the dresser. Excessive sparking indicates that the dresser is being ground away. 4. After dressing the wheel, turn off the grinder, disconnect it from the power source, and examine the wheel. It should be perfectly round and the face should be square with the sides. The grit should be sharp and free of waste particles. 5. If the tool rest was moved for the dressing procedure, readjust it so that it is 1/16 in. from the wheel.
Objective 4 *Like other cutting tools, a twist drill bit is safest and most efficient when it is sharp. Discuss the correct procedure for sharpening a twist drill. General information is listed below; supplement with more detailed procedural information as needed. Refer to PPts 2-5.* PPt 2 – Parts of a Twist Drill Cutting Tip	**Explain some considerations for sharpening a twist drill.** Some materials will dull drills faster than others. A drill that is only used on wood can remain sharp for a long time, but a drill that is used on metal becomes dull quickly. Before sharpening a drill, check to see that it is straight. 1. If the drill is not straight, try straightening it. 2. If it cannot be straightened, discard it. Bent drills will wobble and make oversize holes. Follow all assigned safety and use guidelines for using the grinding wheel.

Instructor Directions	Content Outline
PPt 3 – Placement of the Drill for Sharpening PPt 4 – Judging Lip Clearance PPt 5 – Using a Gauge to Check the Shape and Clearance of a Twist Drill	Knowing the parts of a twist drill makes it easier to understand the sharpening procedure. The parts of a twist drill cutting tip are listed below. 1. Dead center 2. Cutting lips 3. Heels On a properly sharpened twist drill, dead center is at the exact center of the drill, and each cutting lip is at a 59-degree angle to the centerline of the drill. From dead center to the heel, the cutting lips drop slightly to give the bit clearance and provide support so the cutting lips do not break. On a properly sharpened bit, the angle formed between dead center and the heel is 12 degrees for each cutting lip. Use a tool gauge to check the twist drill. 1. The correct angle for the cutting lip is 118 degrees. This angle is formed by the cutting lip and the outside edge of the drill. 2. Clearance can be checked by turning the drill slightly and measuring the gap made by the drop to the heel. For a 1-in. drill, there should be approximately a 1/8-in. gap between the drill and the corner of the tool gauge. Proper clearance can also be checked by looking at the drill end on. With the cutting lip held horizontally, the lines of the cutting lip and dead center should make an angle of about 135 degrees. An angle greater than 135 degrees indicates too much clearance; an angle less than 135 degrees indicates that there is not enough clearance.
Objective 5 *Discuss the correct procedure for sharpening a lawn mower blade. General information is listed below; supplement with more detailed information as needed. Refer to PPt 6.*	**Explain some considerations for sharpening a lawn mower blade.** Sharpen mower blades frequently. A sharp blade needs less power, produces better looking results, and does less damage to plants. Follow basic safety guidelines.

<table>
<tr><th>Instructor Directions</th><th>Content Outline</th></tr>
<tr><td>PPt 6 – Filing a Lawn Mower Blade</td><td>1. Before making any adjustments or repairs to the mower, disconnect the spark plug wire and secure it away from the spark plug. Disconnect electric mowers from their power source.
2. Wear gloves when removing or installing the blade to protect hands from scrapes and cuts.
3. Follow all assigned safety and use procedures if using a grinding wheel to sharpen the blade. Wear safety goggles or face shield and any other protective clothing recommended by the instructor.
4. Wear safety goggles and leather gloves for any filing work.
5. Follow the manufacturer’s and instructor’s guidelines for correct sharpening procedure.

Sharpen the blade back to its original angle. If the angle is not known, sharpen the blade to a 45-degree angle.

Keep one side of the mower blade flat and the other side ground to a cutting edge.

Keep the mower blade in balance.
1. A blade that is out of balance will cause the mower to vibrate, which can damage the shaft, bearing, and body of the mower.
2. Take an equal amount of metal off both ends of the blade to keep the blade in balance. Even if only one end of the blade is nicked, both ends should still be sharpened the same amount until the nick is removed.
3. Check the balance of the blade by using a blade balancer or by centering the blade hole over a thin horizontal edge. The blade should sit perfectly level.</td></tr>
<tr><td>Objective 6

Discuss the correct procedure for maintaining a chain saw chain. General information is listed below; supplement with more detailed information as needed. When discussion of these study questions is completed, AS 1-4</td><td>Explain some considerations for maintaining a chain saw chain.

A properly sharpened chain has numerous advantages.
1. Cuts more wood faster than a dull chain
2. Reduces operator fatigue
3. Increases work site safety
4. Reduces wear on the chain and saw</td></tr>
</table>

Instructor Directions	Content Outline
can be used. The student versions of these activities can be assigned to evaluate student competency. Refer to PPts 7-9. PPt 7 – Parts of a Cutter PPt 8 – Using the Depth Gauge Tool PPt 9 – Proper Chain Tension AS 1 – Dressing a Grinding Wheel AS 2 – Sharpening a Twist Drill AS 3 – Sharpening a Lawn Mower Blade AS 4 – Maintaining a Chain Saw Chain	The saw will give indications when the chain needs sharpening. 1. Chain tends to "walk" sideways while cutting 2. Cut produces fine powdery shavings instead of chips 3. Cuts take longer to make and require pressing on the saw 4. Wood gives off a burning smell during cutting Parts of a chain saw cutter 1. Top plate 2. Side plate 3. Cutting edge 4. Gullet 5. Depth gauge 6. Rivet hole 7. Toe 8. Heel Follow basic safety guidelines when making any repairs or adjustments. 1. Before making any adjustments or repairs to the saw, disconnect the spark plug wire and secure it away from the spark plug. Disconnect an electric chain saw from its power source. 2. Wear leather gloves when working with the blade to protect hands from the cutters. 3. Wear goggles and leather gloves when filing. 4. Follow manufacturer's and instructor's guidelines for correct work procedure. Use the correct equipment. 1. The basic tools for sharpening a chain saw chain are a round file and a file guide. 2. Chains differ in the design of their teeth and depth gauges. Be sure to use only manufacturer-recommended sharpening equipment in order to maintain the correct angles, shape, and proportions of the cutters. Adjust depth gauges as needed. 1. The depth gauges control the thickness of the chips the cutters make.

Instructor Directions	Content Outline
	2. Depth gauges should be checked every three or four sharpenings. Do this by using the depth gauge tool recommended by the manufacturer. 3. If the tops of the depth gauges extend above the gauge tool, the part above the tool should be filed off using a flat file. 4. The original shape of the depth gauges should be maintained. Check chain tension frequently and adjust as needed. 1. A chain that is too loose or too tight can cause increased wear or damage to the saw. 2. Improper chain tension can be a safety hazard. a. A chain that is too tight has a tendency to bind, which can lead to an accident. b. A chain that is too loose has a tendency to kick back or come off the bar. – Tension the chain when it is cold. – Follow manufacturer's and instructor's guidelines for correct procedure. – A properly adjusted chain moves freely but does not hang loose from the bar.
Application: 🖹 AS 1 – Dressing a Grinding Wheel 🖹 AS 2 – Sharpening a Twist Drill 🖹 AS 3 – Sharpening a Lawn Mower Blade 🖹 AS 4 – Maintaining a Chain Saw Chain	AS 1 – AS 4 Results will vary.
Closure/Summary	As with all cutting tools, twist drill bits, lawn more blades, and saw chains work best when sharp and in good condition. Use a well-conditioned bench grinder to sharpen drill bits. A twist drill should be straight or it should be discarded. Use a portable grinder or file to

Instructor Directions	Content Outline
	sharpen a lawn mower blade. Lawn mower blades should be sharpened frequently. Sharpen the blade to its original angle, keeping one side flat, and ensure blade is balanced. When sharpening saw chains, use the manufacture-recommended file and file guide. Adjust depth gauges as needed and check chain tension frequently. Employ proper safety guidelines when executing these procedures.
Evaluation: Quiz	Answers: 1. a 2. c 3. c 4. b 5. d 6. a 7. c 8. b 9. d 10. a 11. The purpose of dressing is to restore the effectiveness of a wheel that is out of round, loaded, or glazed. 12. Students should list three of the following: a. Abrasive material – type of natural or synthetic abrasive material b. Grit – small abrasive cutting particles in the material c. Grade – system of rating the hardness of grinding wheels d. Bond – way the abrasive particles are held together e. Dimensions – outside diameter and width of wheel 13. Students should list the following: a. Dead center b. Cutting lips c. Heels 14. Gloves are recommended to help prevent cuts and scrapes. 15. An improperly balanced lawn mower blade will cause the mower to vibrate and in turn damage the shaft, bearing, and body of the mower.

Instructor Directions	Content Outline
	16. Students should list three of the following: a. The chain tends to walk sideways while cutting. b. The cut produces fine powdery shavings instead of chips. c. The cut takes longer to make. d. More pressure is required to make the cut. e. The cut produces a smell of burned wood. 17. A loose chain saw chain has a tendency to kick back or jump off the bar, which can endanger the operator. A loose chain can also cause increased wear on parts of the saw.

Lesson 1: Sharpening and Reconditioning a Twist Drill, Lawn Mower Blade, and Chain Saw Chain

Dressing a Grinding Wheel

Objective: Students will observe how to dress a grinding wheel.

Directions: Use a mechanical wheel dresser to dress a grinding wheel.

Materials and Equipment:

Bench grinder
Grinding wheel that needs reconditioning
Mechanical wheel dresser or other appropriate dressing tool
Face shield or other approved face and eye protection*
Dust mask or respirator
Leather apron or any other protective clothing recommended by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear, a respirator, and any other protective clothing as needed.

Procedure:

1. Wear appropriate safety equipment.
2. Demonstrate the correct setup procedure for dressing a grinding wheel.
   a. Inspect equipment, materials, and work area to ensure safe and correct operation.
   b. With the power disconnected, adjust the tool rest and make sure all guards are in place.
   c. When all adjustments are made, plug in the grinder.
   d. Stand to the side of the grinder and turn it on. Let the grinder run before using.
3. Demonstrate the correct procedure for dressing the grinding wheel.

   CAUTION: Be prepared for particles of the abrasive grit to fly off the grinding wheel. The wheel is trued and dressed by removing old abrasive and waste material clogging the wheel surface.

   a. Position the wheel dresser on the grinder.
   b. Raise the dresser handle to push the dresser wheels firmly against the grinding wheel.
   c. Move the dresser back and forth across the grinding wheel, maintaining even pressure on the dresser.

   d. If there is heavy sparking, increase the pressure on the dresser. Excessive sparking indicates that the dresser is being ground away.
4. Turn off the grinder, disconnect it from the power source, and examine the wheel.
   a. It should be perfectly round and the face should be square with the sides.
   b. The grit should be sharp and free of waste particles.
   c. There should be no grooves in the surface.
5. Repeat dressing procedure if additional dressing is needed.
6. Demonstrate correct shutdown procedure.
7. Readjust the tool rest so that it is 1/16 in. from the wheel.
8. Assign the student version of AS 1 to be performed by the students.

Lesson 1: Sharpening and Reconditioning a Twist Drill, Lawn Mower Blade, and Chain Saw Chain

Dressing a Grinding Wheel

Objective: Students will dress a grinding wheel.

Directions: Students will use a mechanical wheel dresser to dress a grinding wheel.

Materials and Equipment:

- Bench grinder
- Grinding wheel that needs reconditioning
- Mechanical wheel dresser or other appropriate dressing tool
- Face shield or other approved face and eye protection*
- Dust mask or respirator
- Leather apron or any other protective clothing recommended by instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear, a respirator, and any other protective clothing as needed.

Procedure:

1. Wear appropriate safety equipment.
2. Follow the correct setup procedure for dressing a grinding wheel by using the steps below and any others as directed by the instructor.
   a. Inspect equipment, materials, and work area to ensure safe and correct operation.
   b. With the power disconnected, adjust the tool rest and make sure all guards are in place.
   c. When all adjustments are made, plug in the grinder.
   d. Stand to the side of the grinder and turn it on. Let the grinder run before using.
3. Dress the grinding wheel according to the assigned procedure.

   CAUTION: Be prepared for particles of the abrasive grit to fly off the grinding wheel. The wheel is trued and dressed by removing old abrasive and waste material clogging the wheel surface.

   a. Position the wheel dresser on the grinder.
   b. Raise the dresser handle to push the dresser wheels firmly against the grinding wheel.
   c. Move the dresser back and forth across the grinding wheel, maintaining even pressure on the dresser.

   d. If there is heavy sparking, increase the pressure on the dresser. Excessive sparking indicates that the dresser is being ground away.
4. Turn off the grinder, disconnect it from the power source, and examine the wheel.
   a. It should be perfectly round and the face should be square with the sides.
   b. The grit should be sharp and free of waste particles.
   c. There should be no grooves in the surface.
5. Repeat the dressing procedure if additional dressing is needed.
6. Perform assigned shutdown and cleanup procedures. Return materials and equipment to their storage places.
7. Readjust the tool rest so that it is 1/16 in. from the wheel.
8. Turn in work to be graded by the instructor.

Lesson 1: Sharpening and Reconditioning a Twist Drill, Lawn Mower Blade, and Chain Saw Chain

Sharpening a Twist Drill

Objective: Students will observe how to sharpen a twist drill.

Directions: Use a bench grinder to sharpen a twist drill.

Materials and Equipment:

Bench grinder with appropriate grinding wheel
Twist drill that needs sharpening
Face shield or other approved face and eye protection*
Leather apron or any other protective clothing recommended by instructor
Tool gauge
Container of water for cooling the drill
Correctly sharpened twist drill of the same size, or approximately the same size, as the drill being sharpened (optional)
Piece of scrap wood (optional)
Portable drill (optional)
Chuck key (optional)

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear and any other protective clothing as needed.

Procedure:

1. (Optional) Have students examine the sharp and dull twist drills and compare the two. This can be done by examining the drills visually and also by checking them with the tool gauge. Discuss the appearance of a properly sharpened drill. The instructor can refer to PPt 3 Placement of the Drill for Sharpening, PPt 4 Judging Lip Clearance, and PPt 5 Using a Gauge to Check the Shape and Clearance of a Twist Drill, if desired. Points covered could include the following.
   a. Dead center should appear as a small straight line in the exact center of the drill.
   b. The cutting lips should be at a 59-degree angle to the centerline of the drill.
   c. From dead center to the heel, the cutting lips should drop slightly to give the bit clearance. On a properly sharpened bit, the angle formed between dead center and the heel should be 12 degrees for each cutting lip.
   d. The angle formed by the cutting lip and the outside edge of the drill should be 118 degrees.

   e. Check to see if the drill is bent. If it is, it should be straightened before being sharpened. If the drill cannot be straightened, it should be replaced.
2. (Optional) Demonstrate the value of keeping drills sharp by using the portable drill to make a hole in the scrap wood, first using the dull twist drill, then using the sharp one. Observe all safety procedures for using the portable drill. These can be reviewed, if desired. Discuss differences between the performance of the dull drill and the sharp one.
3. Wear appropriate safety equipment.
4. Follow the correct procedure for setting up the grinding wheel.
   a. Inspect equipment, materials, and work area to ensure safe and correct operation.
   b. With the power disconnected, adjust the tool rest and make sure all guards are in place. The tool rest should be horizontal to the center of the wheel. There should be a 1/16-in. space between the tool rest and the face of the wheel.
   c. When all adjustments are made, plug in the grinder.
   d. Stand to the side of the grinder and turn it on. Let the grinder run before using.
5. Demonstrate the correct procedure for sharpening the twist drill. (Steps a. through e. explain the positioning of the twist drill.)

   CAUTION: The operator should not touch the drill to the grinding wheel before the drill is in the proper position.

   a. Hold the drill perpendicular to the face of the wheel.
   b. Swing the drill around to the left so that it is at a 59-degree angle to the face of the wheel.
   c. Rotate the drill until one cutting lip is horizontal to the center of the wheel.
   d. Hold the drill between the thumb and index finger of the left hand with approximately 1 in. of the drill exposed. Use the right hand to hold the shank of the drill.
   e. Place the back of the left index finger on the tool rest. Be careful to not let the fingers touch the grinding wheel.
   f. Touch the cutting lip to the face of the grinding wheel and slowly elevate the cutting tip by lowering the back end of the drill. At the same time, give the drill a slight clockwise turn.
   g. Dip the drill in water frequently to avoid overheating it.
   h. Use the tool gauge to check the lip angle and heel clearance.
   i. Make additional passes as needed to restore the cutting edge.
   j. When one lip is properly sharpened, turn the drill half a turn and repeat the procedure for the other lip.
6. Perform shutdown and cleanup procedures.
7. Assign the student version of AS 2 to be performed by the students.

Lesson 1: Sharpening and Reconditioning a Twist Drill, Lawn Mower Blade, and Chain Saw Chain

Sharpening a Twist Drill

Objective: Students will sharpen a twist drill.

Directions: Students will use a bench grinder to sharpen a twist drill.

Materials and Equipment:

Bench grinder with appropriate grinding wheel
Twist drill that needs sharpening
Face shield or other approved face and eye protection*
Leather apron or any other protective clothing recommended by instructor
Tool gauge
Container of water for cooling the drill

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear and any other protective clothing as needed.

Procedure:

1. Wear appropriate safety equipment.
2. Follow correct procedure for setting up the grinding wheel.
   a. Inspect equipment, materials, and work area to ensure safe and correct operation.
   b. With the power disconnected, adjust the tool rest and make sure all guards are in place. The tool rest should be horizontal to the center of the wheel. There should be a 1/16-in. space between the tool rest and the face of the wheel.
   c. When all adjustments are made, plug in the grinder.
   d. Stand to the side of the grinder and turn it on. Let the grinder run before using.
3. Follow the correct procedure for sharpening the twist drill. Use the following steps and any others recommended by the instructor. (Steps a. through e. explain the positioning of the twist drill.)

   CAUTION: Do not touch the drill to the grinding wheel before the drill is in the proper position.

a. Hold the drill perpendicular to the face of the wheel.
b. Swing the drill around to the left so that it is at a 59-degree angle to the face of the wheel.
c. Rotate the drill until one cutting lip is horizontal to the center of the wheel.
d. Hold the drill between the thumb and index finger of the left hand with approximately 1 in. of the drill exposed. Use the right hand to hold the shank of the drill.
e. Place the back of the left index finger on the tool rest. Be careful to not let the fingers touch the grinding wheel.
f. Touch the cutting lip to the face of the grinding wheel and slowly elevate the cutting tip by lowering the back end of the drill. At the same time, give the drill a slight clockwise turn.
g. Dip the drill in water frequently to avoid overheating it.
h. Use the tool gauge to check lip angle and heel clearance.
i. Make additional passes as needed to restore the cutting edge.
j. When one lip is properly sharpened, turn the drill half a turn and repeat the procedure for the other lip.

4. Perform assigned shutdown and cleanup procedures. Materials and equipment should be returned to their proper places.
5. Turn in work to be graded by the instructor.

Lesson 1: Sharpening and Reconditioning a Twist Drill, Lawn Mower Blade, and Chain Saw Chain

Sharpening a Lawn Mower Blade

Objective: Students will observe how to sharpen a lawn mower blade.

Directions: Use a file or portable grinder to sharpen a lawn mower blade.

Materials and Equipment:

Portable grinder with appropriate grinding wheel or
Appropriate flat file(s)
Safety goggles, face shield, or other approved face and eye protection*
Gloves, for removing and installing the blade and any filing procedures
Any other protective clothing recommended by instructor
Tool gauge with the correct angle for the sharpened blade
Socket wrench and socket
Bench vise
Blade balancer or a thin edge for checking the balance of the blade
Lawn mower with a blade that needs sharpening

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear and any other protective clothing as needed.

Note: Lawn mower blades can be sharpened using a file or a portable grinder. General information for using these tools is given below. The instructor should supplement these steps with more detailed information about the tools he or she uses for this activity as needed. Students should have demonstrated the ability to safely and correctly use these tools before proceeding with the activity.

Procedure:

1. Wear appropriate safety equipment.
2. Demonstrate the correct procedure for preparing to sharpen the lawn mower blade.
   a. Consult the owner’s manual for the correct angle for sharpening the blade or any other relevant information. A typical angle for a properly sharpened lawn mower blade is 45 degrees.
   b. Inspect equipment, materials, and work area to ensure safe and correct operation.

3. Disconnect the spark plug wire and secure it away from the spark plug. Disconnect an electric mower from its power source.
4. Demonstrate the proper procedure for removing the mower blade, including the following steps and any others as needed.
   a. Tip the mower on its side, with the crankcase down.
   b. Secure the mower so that it will not fall over while it is being worked on.
   c. Use a socket wrench and socket to remove the blade.
5. Demonstrate the correct procedure for sharpening the mower blade.
   a. Secure the blade in the vise.
   b. Use the grinder or file to remove any nicks in the blade.
      1. When using a file, apply pressure on the forward stroke and lift the file for the return stroke.
      2. When using a grinder, be careful not to overheat the metal.
      3. When using a file or grinder, be careful to remove metal evenly from both sides of the blade to avoid throwing it out of balance.
   c. Use the sharpening tool to restore the flat side of each end of the blade.
   d. Restore the cutting edge of each end of the blade.
   e. Use the tool gauge to check the angle of each end of the blade.
   f. Use the blade balancer or a thin edge to check the balance of the blade.
   g. If needed, reclamp the blade and carefully file or grind the heavy side of the blade until it is in balance.
6. When the blade is balanced and the cutting edges have the correct angle, reinstall the blade.
7. Set the mower back down in the cutting position and reattach the spark plug wire.
8. Perform cleanup procedures.
9. Assign the student version of AS 3 to be performed by the students.

Sharpening a Lawn Mower Blade

Objective: Students will sharpen a lawn mower blade.

Directions: Students will use a file or portable grinder to sharpen a lawn mower blade.

Materials and Equipment:

Portable grinder with appropriate grinding wheel or
Appropriate flat file(s)
Safety goggles, face shield, or other approved face and eye protection*
Gloves, for removing and installing the blade and any filing procedures
Any other protective clothing recommended by instructor
Tool gauge with the correct angle for the sharpened blade
Socket wrench and socket
Bench vise
Blade balancer or a thin edge for checking the balance of the blade
Lawn mower with a blade that needs sharpening

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear and any other protective clothing as needed.

Procedure:

1. Wear appropriate safety equipment.
2. Use the correct procedure for preparing to sharpen the lawn mower blade.
   a. Consult the owner's manual for the correct angle for sharpening the blade or any other relevant information. A typical angle for a properly sharpened lawn mower blade is 45 degrees.
   b. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Disconnect the spark plug wire and secure it away from the spark plug. Disconnect an electric mower from its power source.
4. Follow the proper procedure for removing the mower blade, including the following steps and any others as directed by the instructor.
   a. Tip the mower on its side, with the crankcase down.
   b. Secure the mower so that it will not fall over while it is being worked on.
   c. Use the socket wrench and socket to remove the blade.

5. Follow the correct procedure for sharpening the mower blade.
   a. Secure the blade in the vise.
   b. Use the grinder or file to remove any nicks in the blade.
      1. When using a file, apply pressure on the forward stroke and lift the file for the return stroke.
      2. When using a grinder, be careful not to overheat the metal.
      3. When using a file or grinder, be careful to remove metal evenly from both sides of the blade to avoid throwing it out of balance.
   c. Use the sharpening tool to restore the flat side of each end of the blade.
   d. Restore the cutting edge of each end of the blade.
   e. Use the tool gauge to check the angle of each end of the blade.
   f. Use the blade balancer or a thin edge to check the balance of the blade.
   g. If needed, reclamp the blade and carefully file or grind the heavy side of the blade until it is in balance.
6. When the blade is balanced and the cutting edges have the correct angle, reinstall the blade.
7. Set the mower back down in the cutting position and reattach the spark plug wire.
8. Perform assigned cleanup procedures. Materials and equipment should be returned to their proper places.
9. Turn in work to be graded by the instructor.

Lesson 1: Sharpening and Reconditioning a Twist Drill, Lawn Mower Blade, and Chain Saw Chain

Maintaining a Chain Saw Chain

Objective: Students will observe how to sharpen the chain, adjust the depth gauges, and adjust the chain tension on a chain saw.

Directions: Use the appropriate tools to sharpen the chain, adjust the depth gauges, and adjust the chain tension of a chain saw.

Materials and Equipment:

Appropriate round file and file guide
Flat file
Appropriate depth gauge tool
Safety goggles*
Gloves
Any other protective clothing recommended by instructor
Combination wrench set
Standard or Phillips screwdriver
Chain saw with a chain that needs sharpening
Recommended chain oil
Chain saw with a properly sharpened blade (optional)
A log or piece of scrap wood of a size that could be safely cut with the type of saw(s) being used (optional)

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear and any other protective clothing as needed.

Procedure:

1. Wear appropriate safety equipment.
2. (Optional) Before beginning the demonstration, secure the log or scrap wood and make a cut, first using the saw with the dull chain and then with the saw with the sharpened chain. Observe all safety and correct use procedures for working with a chain saw. Discuss differences in the ways the saws worked and in the chips they produced. Discuss why the saw with the sharpened chain is safer to use and produces better results.
3. Demonstrate the correct procedure for preparing to sharpen the chain and make adjustments to the saw.

a. Consult the owner's manual for instructions on sharpening the chain or any other relevant information. Be sure to use only manufacturer-recommended sharpening equipment in order to maintain the correct angles, shape, and proportions of the cutters.
b. Inspect equipment, materials, and work area to ensure safe and correct operation.

4. Disconnect the spark plug wire and secure it away from the spark plug. Disconnect an electric chain saw from its power source.
5. Demonstrate the proper procedure for sharpening a chain saw chain, including the following steps and any others as needed.
   a. Start by finding the most damaged cutter. Using a gloved hand, rotate the chain, if needed, to bring this cutter to the top of the saw and into a comfortable work position.
   b. Put the file guide and round file in position on the cutter. Keep the sharpening angle mark on the file guide parallel to the bar.
   c. File from the inside out, keeping the file level. Apply pressure only on the forward stroke and lift the file for the return stroke.
   d. Move to the next cutter on the same side and repeat the process.
   e. File each cutter as needed to sharpen them and keep them equal to one another.
   f. Rotate the chain as needed until all of the cutters on one side are sharpened.
   g. Turn the saw around and repeat the process on the other side.
6. Demonstrate the correct procedure for adjusting the depth gauges, including the following steps and any others as needed.
   a. Put the depth gauge tool in position on the chain so that a depth gauge is in the opening on the tool.
   b. If the depth gauge sticks up above the tool, file off the part that extends above the tool with the flat file.
   c. File from the inside out, keeping the file level. Apply pressure only on the forward stroke and lift the file for the return stroke.
   d. Once the depth gauge has been filed down flat, use the flat file to restore the gauge to its original shape. This generally means rounding off the front edge of the gauge. Tilt the depth gauge tool up for this operation to expose the front of the depth gauge and to protect the sharpened cutter while filing.
7. Move to the next cutter on the same side and repeat the process.
8. File each gauge as needed.
9. Rotate the chain as needed until all the gauges on one side are sharpened.
10. Turn the saw around and repeat the process on the other side.
11. Demonstrate the correct procedure for adjusting the chain tension, including the following steps and any others as needed. Tension the chain saw when it is cold.
    a. Use the wrench to loosen the bar nuts.
    b. Use the screwdriver to adjust the chain tension screw until the chain just touches the bottom of the bar.

c. Oil the chain, then pull it around the bar by hand. The chain should fit snugly but still move freely when pulled.
d. Hold the tip of the bar up and tighten the bar nuts.
e. Pull the chain around the bar again to be sure it is still moving freely.

12. When all repairs and adjustments are complete, reattach the spark plug wire.
13. Perform cleanup procedures.
14. Assign the student version of AS 4 to be performed by the students.

Lesson 1: Sharpening and Reconditioning a Twist Drill, Lawn Mower Blade, and Chain Saw Chain

Maintaining a Chain Saw Chain

Objective: Students will sharpen the chain, adjust the depth gauges, and adjust the chain tension on a chain saw.

Directions: Students will use the appropriate tools to sharpen the chain, adjust the depth gauges, and adjust the chain tension of a chain saw.

Materials and Equipment:

Appropriate round file and file guide
Flat file
Appropriate depth gauge tool
Safety goggles*
Gloves
Any other protective clothing recommended by instructor
Combination wrench set
Standard or Phillips screwdriver
Chain saw with a chain that needs sharpening
Recommended chain oil

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear and any other protective clothing as needed.

Procedure:

1. Wear appropriate safety equipment.
2. Prepare to sharpen the chain and make adjustments to the saw.
   a. Consult the owner's manual for instructions on sharpening the chain or any other relevant information. Be sure to use only manufacturer-recommended sharpening equipment in order to maintain the correct angles, shape, and proportions of the cutters.
   b. Inspect equipment, materials, and work area to ensure safe and correct operation.
3. Disconnect the spark plug wire and secure it away from the spark plug. Disconnect an electric chain saw from its power source.
4. Sharpen a chain saw chain by using the following steps and any others as directed by the instructor.

a. Start by finding the most damaged cutter. Using a gloved hand, rotate the chain, if needed, to bring this cutter to the top of the saw and into a comfortable work position.
b. Put the file guide and round file in position on the cutter. Keep the sharpening angle mark on the file guide parallel to the bar.
c. File from the inside out, keeping the file level. Apply pressure only on the forward stroke and lift the file for the return stroke.
d. Move to the next cutter on the same side and repeat the process.
e. File each cutter as needed to sharpen them and keep them equal to one another.
f. Rotate the chain as needed until all of the cutters on one side are sharpened.
g. Turn the saw around and repeat the process on the other side.

5. Adjust the depth gauges by using the following steps and any others as instructed.
   a. Put the depth gauge tool in position on the chain so that a depth gauge is in the opening on the tool.
   b. If the depth gauge sticks up above the tool, file off the part that extends above the tool with the flat file.
   c. File from the inside out, keeping the file level. Apply pressure only on the forward stroke and lift the file for the return stroke.
   d. Once the depth gauge has been filed down flat, use the flat file to restore the gauge to its original shape. This generally means rounding off the front edge of the gauge. Tilt the depth gauge tool up for this operation to expose the front of the depth gauge and to protect the sharpened cutter while filing.
   e. Move to the next cutter on the same side and repeat the process.
   f. File each gauge as needed.
   g. Rotate the chain as needed until all the gauges on one side are sharpened.
   h. Turn the saw around and repeat the process on the other side.
6. Adjust the chain tension by using the following steps and any others as instructed. Tension the chain saw when it is cold.
   a. Use the wrench to loosen the bar nuts.
   b. Use the screwdriver to adjust the chain tension screw until the chain just touches the bottom of the bar.
   c. Oil the chain, then pull it around the bar by hand. The chain should fit snugly but still move freely when pulled.
   d. Hold the tip of the bar up and tighten the bar nuts.
   e. Pull the chain around the bar again to be sure it is still moving freely.
7. When all repairs and adjustments are complete, reattach the spark plug wire.
8. Perform assigned cleanup procedures. Return materials and equipment to their proper places.
9. Turn in work to be graded by the instructor.

Unit IV - Tool Sharpening and Reconditioning Name_________________________

Lesson 1: Sharpening and Reconditioning Date_________________________
a Twist Drill, Lawn Mower Blade, and Chain Saw Chain

Assessment

Circle the letter that corresponds to the correct answer.

1. Before changing a wheel on a grinder, the operator should:

   a. unplug the grinder.
   b. dress the new wheel.
   c. let the wheel run for a minute.
   d. put the guards in operating position.

2. How should an object being ground be moved on the grinding wheel?

   a. Side to side on the side of the wheel
   b. Up and down on the side of the wheel
   c. Side to side on the face of the wheel
   d. Up and down on the face of the wheel

3. As the grit number of grinding wheels decreases, the abrasives become:

   a. harder.
   b. softer.
   c. coarser.
   d. finer.

4. Which grade of wheel is commonly selected for tool sharpening?

   a. Hard
   b. Medium hard
   c. Medium soft
   d. Soft

5. At what degree angle should the cutting lip of a twist drill be to the center of the drill?

    a. 25
    b. 32
    c. 47
    d. 59

6. What tool is used to measure the tip of a twist drill?

    a. Tool gauge
    b. File guide
    c. Depth gauge
    d. Blade balancer

7. What tool maintains the file at proper depth and angle when sharpening a chain saw chain?

    a. Blade balancer
    b. Depth gauge
    c. File guide
    d. Tool gauge

8. What is the typical angle on a lawn mower blade?

    a. 35
    b. 45
    c. 55
    d. 65

9. A link in a chain saw chain is called a:

    a. Toe
    b. Heel
    c. Gullet
    d. Cutter

10. Which two tools are typically used to sharpen a chain saw chain?

   a. Round file and file guide
   b. Round file and grinder
   c. Depth gauge and file guide
   d. Depth gauge and grinder

Complete the following short-answer questions.

11. What is the purpose of dressing a grinding wheel?

12. List three specifications to consider when choosing a grinding wheel and describe what each specification means.

   a.

   b.

   c.

13. What are the three parts of a tip on a twist drill?

   a.

   b.

   c.

14. What protective clothing is recommended for removing and installing a lawn mower blade and why?

15. Why is it important to balance a lawn mower blade?

16. List three signs that a chain saw chain needs sharpening.

    a.

    b.

    c.

17. What can happen if the tension of a chain saw chain is too loose?

Agricultural Science II

Curriculum Guide: *Agricultural Mechanics Unit for Agricultural Science II*

Unit: IV. Tool Sharpening and Reconditioning

Unit Objective:

Students will apply principles of tool sharpening and reconditioning by participating in a tool reconditioning contest.

Show-Me Standards: 2.5, CA3

References:

Agricultural Mechanics Unit for Agricultural Science II. University of Missouri-Columbia, Instructional Materials Laboratory, 2002.

Missouri CDE Handbook. Accessed November 14, 2003, from http://www.dese.mo.gov/divcareered/ag_cde_guidelines.htm.

Missouri FFA Agricultural Mechanics Career Development Event. Accessed November 19, 2003, from http://web.missouri.edu/~pavt0689/statecon.html.

Instructional Strategies/Activities:

- Students will engage in study questions in lesson 1.
- Students will complete AS 1.1, Dressing a Grinding Wheel; AS 1.2, Sharpening a Twist Drill; AS 1.3, Sharpening a Lawn Mower Blade; and AS 1.4, Maintaining a Chain Saw Chain.

Performance-Based Assessment:

Students will be divided into groups. The groups will represent teams and will participate in a tool reconditioning contest that is similar to the tool sharpening and reconditioning portion of the Agricultural Mechanics Career Development Event. Each student will perform a sharpening or reconditioning procedure presented in the unit or discussed in class, such as sharpening a twist drill or lawn mower blade or maintaining a chain saw chain.

Assessment will be based on the ability to perform the assigned sharpening or reconditioning procedure safely and correctly.

Agricultural Mechanics Unit for Agricultural Science II
Unit IV—Tool Sharpening and Reconditioning
Instructor Guide

The instructor should assign the performance-based assessment activity at the beginning of the unit. Students will work toward completing the activity as they progress through the unit lessons. The assessment activity will be due at the completion of the unit.

1. Use or adapt the activity sheets found in the unit to assess student competency at tool sharpening and reconditioning. Review or supplement these activities as needed, based on student mastery of the procedures and the tools the students will be using. **NOTE: Students should only complete this performance-based activity if they have mastered all the relevant competencies and have the instructor's permission to perform the activity.**

2. For the performance-based assessment activity, have students apply the skills and procedures discussed in the unit by participating in a tool reconditioning contest.

3. Divide students into groups and assign each student a sharpening or reconditioning procedure to perform. Procedures covered in the unit include sharpening a twist drill and a lawn mower blade and maintaining a chain saw chain.
   a. Provide students with tools in need of sharpening or reconditioning or have students supply tools. If students supply tools, they must follow any and all school procedures for transporting tools to and from class. Inspect and approve any tools supplied by students prior to the activity.
   b. Assign students a sharpening or reconditioning procedure that they have mastered as part of the instructional activities for this unit.

4. This activity will help prepare students for the tool sharpening and reconditioning portion of the Agricultural Mechanics Career Development Event.
   a. Explain or review event guidelines as needed.
   b. Refer to the *Missouri CDE Handbook* for guidelines regarding the Agricultural Mechanics Career Development Event. The *Missouri CDE Handbook* is available from the Missouri Department of Elementary and Secondary Education at http://www.dese.mo.gov/divcareered/ag_cde_guidelines.htm.

5. Have students sharpen or recondition their assigned tool.
   a. Performance in the tool sharpening contest will determine the student's individual score.
   b. Combine the individual scores of the group members to determine the team score for each group.

6. The final assessment score will be based on the ability to safely and correctly sharpen or recondition the assigned tool.

7. Present an appropriate award to the high-scoring team and individual, if desired.

8. NOTE: If desired, this activity can be combined with the performance-based assessment activities from Unit II, Arc Welding, and III, Oxyacetylene Welding, to form a mini Agricultural Mechanics Career Development Event. To conduct a mini Agricultural Mechanics Career Development Event, maintain the same student groups for all of the performance-based assessment activities. An expanded score sheet is included at the end of each of these units that can be used to track individual and group performance in the mini CDE.

Agricultural Mechanics Unit for Agricultural Science II
Unit IV—Tool Sharpening and Reconditioning
Student Handout

1. The instructor will divide the class into groups and assign each member of your group a tool to sharpen or recondition in a tool reconditioning contest.

2. Your group will compete in the contest as a team.

3. Sharpen or recondition your assigned tool.
   - ❑ Wear appropriate safety equipment at all times.
   - ❑ Follow all assigned safety procedures. You can lose points for not following safety precautions and other assigned procedures.
   - ❑ Inspect the equipment, materials, and work area to ensure safe and correct operation.
   - ❑ Sharpen or recondition the tool using the assigned procedure.
   - ❑ Inspect your work.
   - ❑ Follow cleanup procedures and return all tools and materials to their assigned places.
   - ❑ Turn in your work to the instructor.

4. Your final assessment score will be based on your ability to perform the assigned sharpening or reconditioning procedure safely and correctly.

Agricultural Science II

Agricultural Mechanics Unit for Agricultural Science II
Unit IV—Tool Sharpening and Reconditioning
Scoring Guide

Name ____________________

Assessment Area	Criteria	0 Points	1 Point	2 Points	3 Points	4 Points	Weight	Total
Tool Sharpening and Reconditioning	Tool is properly sharpened or reconditioned	Failed	Poor	Fair	Good	Excellent	X 25	
Safety and Work Habits	**Student followed all safety precautions**	**Passed**				**Failed**	**X (-25)**	Negative Points *
	Student followed all assigned procedures	**Excellent**	**Good**	**Fair**	**Poor**	**Failed**	**X (-10)**	Negative Points *
TOTAL								

Final Assessment Total ________/100 pts.
*** Overall combined score cannot be lower than 0.**

Comments:

Agricultural Mechanics II Score Sheet

Team Members	Arc Welding	Oxyacetylene Welding	Tool Sharpening/ Reconditioning	Score
Team A				
				Total:
Team B				
				Total:
Team C				
				Total:
Team D				
				Total:
Team E				
				Total:
Team F				
				Total:

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Cold Metal Work
Lesson	Working With Cold Metal
Estimated Time	Two 50-minute blocks

Student Outcome

Lay out cold metal.
Shape cold metal.
Fasten cold metal.

Learning Objectives

1. Explain how cold metal is marked and laid out.
2. Identify what tools are used for cutting metal.
3. Explain how cold metal can be bent.
4. Explain how cold metal can be fastened.
5. Explain how burrs can be removed from cold metal.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Selecting a Hacksaw Blade
   - PPt 2 – Cutting Metal With a Cold Chisel
   - PPt 3 – Types of Cold Chisels
   - PPt 4 – Cutting Metal With Snips
   - PPt 5 – Types of Files
   - PPt 6 – Filing Metal
   - PPt 7 – Cold Forming Metal
   - PPt 8 – Setting Cold Rivets
   - PPt 9 – Pop Riveting
   - PPt 10 – Types of Taps
   - PPt 11 – Using a Die
2. Activity Sheets
   - AS 1 – Techniques for Bending Cold Metal (Instructor)
   - AS 2 – Fastening Metal With Rivets and Pop Rivets (Instructor)
   - AS 3 – Using a Tap and Die Set (Instructor)
3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.

4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, “Unit V – Cold Metal Work.” University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplies & Equipment

- See AS 1 through AS 3 for materials and equipment needed to complete the Activity Sheets.

Supplemental Information

1. Internet Sites
   - Bianchina, P. Pop Blind Riveters. DoItYourself. Accessed October 22, 2007, from http://www.doityourself.com/stry/poppriveter.
   - Capotosto, R. “Metalworking Basics.” *Popular Mechanics*, (December 2001). Accessed October 22, 2007, from http://www.popularmechanics.com/home_journal/workshop/1274426.html?page=3.
   - Ramsey, D. Hacksaw. HowStuffWorks. Accessed October 22, 2007, from http://home.howstuffworks.com/hacksaw.htm.
   - Tap and Die. Wikipedia. Accessed October 22, 2007, from http://en.wikipedia.org/wiki/Taps_and_dies.
2. Print
   - Cooper, E. *Agricultural Mechanics: Fundamentals and Applications.* 3rd ed. Albany, NY: Del Mar Publishers, 1997.
   - Phipps, L. *Mechanics in Agriculture.* 4th ed. Danville, IL: Interstate Publishers, 1992.
   - Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics*. Upper Saddle River, NJ: Prentice Hall Interstate, 2004.

Interest Approach

1. The features and uses of basic metal working tools were discussed in *Agricultural Mechanics Unit for Agricultural Science I,* Unit I Lesson 2. Begin the discussion of cold metalwork by reviewing these tools and other common cold metalworking tools commonly used in the shop.

2. Review safety procedures for working with metal and using metalworking tools. Basic shop safety procedures were discussed in *Agricultural Mechanics Unit for Agricultural Science II*, Unit I Lesson 2. Review these and any additional safety procedures for working with metal using hand or power tools as needed.

3. Most of the material and activities on metalwork in *Agricultural Mechanics Unit for Agricultural Science I* and *Agricultural Mechanics Unit for Agricultural Science II* have focused on procedures for the shielded metal arc welder or the oxyfuel outfit. Ask students to name common cold metalworking procedures and when they would be likely to use them. Discuss any advantages or disadvantages of cold metal procedures as compared with methods of using a torch or arc welder to cut or join metal. One example of a common cold metal procedure would be fastening pieces of thin metal stock together using sheet metal screws. The advantage of this procedure could be that it is quick and easy and allows for easy disassembly and reassembly of parts. Also there is no danger of heat distortion. Disadvantages could include the facts that holes would have to be made in the metal, and a joint that is only held together with sheet metal screws is not watertight, if that is a consideration.

Communicate the Learning Objectives

1. Explain how cold metal is marked and laid out.
2. Identify what tools are used for cutting metal.
3. Explain how cold metal can be bent.
4. Explain how cold metal can be fastened.
5. Explain how burrs can be removed from cold metal.

Instructor Directions	Content Outline
Objective 1 *Begin the lesson by discussing ways to mark and lay out cold metal. Much of this material was covered in* Agricultural Mechanics Unit for Agricultural Science I*, Unit I Lesson 2; some additional points have been added for this lesson.*	**Explain how cold metal is marked and laid out.** Scratch awl 1. Used with a straightedge to scratch straight lines 2. Must be kept sharp to ensure fine, accurate marks Dividers 1. Used for scribing arcs and circles 2. Used for transferring measurements Soapstone 1. Marks surfaces rather than scratches

Instructor Directions	Content Outline
	2. Harder to rub off than a chalk or pencil mark Permanent marker 1. Must be a hard-tipped, fine-point marker to make an accurate line 2. Harder to rub off than a chalk or pencil mark 3. Safer than an awl Center punch 1. Is a steel punch with the end ground to a 90-degree angle 2. Makes a small dent in metal for marking the center of a hole and starting a twist drill bit Layout dye 1. Applied to metal to provide a background for layout lines 2. Must remove grease and oil to ensure that dye adheres properly
Objective 2 *Discuss ways of cutting metal cold. Refer to PPts 1-6. Students could also be shown the tools in the shop. Ask them to identify the tools and review proper safety and use procedures for working with them. Discuss any other cutting tools commonly used in the shop as needed.* PPt 1 – Selecting a Hacksaw Blade PPt 2 – Cutting Metal With a Cold Chisel PPt 3 – Types of Cold Chisels PPt 4 – Cutting Metal With Snips	**Identify what tools are used for cutting metal.** Hacksaw 1. Blades are available with 14, 18, 24, and 32 teeth per inch. The number of teeth per inch is called the blade's pitch. 2. When selecting a hacksaw blade, choose a blade that will have three teeth in contact with the work at a time. a. Fewer teeth will tend to get stripped off. b. More teeth will make the saw hard to operate. 3. Always install the blade with the teeth pointing away from the handle. The saw is designed to cut only on the forward stroke. 4. Use long, even cutting strokes with light pressure on the forward stroke and no pressure on the return stroke. 5. If a blade breaks while a cut is being made, do not force the new blade into the kerf made by the old one. a. A new blade will have a wider set in its teeth than a used one, even of the same type and pitch, and the new blade will be damaged. b. Always begin the cut in a new place.

Instructor Directions	Content Outline
PPt 5 – Types of Files PPt 6 – Filing Metal	Cold chisels 1. Chisels are classified by their cutting edge. a. Flat – used for general cutting b. Cape – used for cutting narrow rectangular grooves c. Round-nose – used for cutting round grooves d. Diamond – used for cutting square grooves and corners 2. For shearing metal in a vise, hold the chisel at a 60-degree angle to the work and advance the chisel so that each cut is made by the center of the edge. 3. For cutting thicker stock and round stock, use a chisel to cut a groove along the cutting line completely around the stock. The metal is then bent back and forth until it breaks. 4. Do not use a chisel with a mushroomed head. It must be properly reconditioned before it can be used safely. Snips and shears 1. Snips and shears are scissorlike tools used for cutting sheet metal. There are different kinds of snips and shears. a. Regular snips do all their work by the force applied by the operator. b. Compound or aviation snips have compound handles that increase leverage for cutting heavier stock. c. Some snips are designed for making a specific kind of cut (e.g., straight cuts, left-hand cuts, or right-hand cuts). d. Combination snips can be used for making straight or curved cuts. 2. Open the blades widely to improve leverage. 3. Insert metal as far back in the blades as possible. 4. Do not allow the snips to close completely before advancing the snips for the next cut. This helps avoid making a cut with a ragged edge. Power shears 1. Large power shears are useful for cutting structural steel that would be difficult or slow to cut by hand or by power saw.

Instructor Directions	Content Outline
	2. Shears can be operated by a handle, a treadle, or hydraulic power. 3. Operate power shears by lining up the cut with the stationary blade. 4. Do not exceed the capacity of the shear. 5. As with all equipment, follow all safety and use procedures from the manufacturer and the instructor. As part of basic shutdown procedure, be sure that the shear cannot be operated accidentally. Files 1. Files are used for cutting and shaping metal. They can be identified by the design of their teeth, the shape of the file, and the coarseness of their teeth. a. Design of teeth – single cut, double cut, rasp cut, and curve cut b. Shape of file – flat, round, half-round, and three-cornered c. Coarseness of cut – bastard cut, second cut, smooth cut 2. Always use a file with a handle to avoid puncture wounds. 3. Hold the file with both hands. 4. Use long, even strokes with light pressure on the forward stroke and no pressure on the return stroke. Files cut only on the forward stroke. 5. To reduce vibration when filing, secure the work in a vise, with the area to be filed just above the jaws of the vise. 6. Maintain files and store them properly. a. Keep files dry to avoid rusting. b. To avoid dulling them, do not store files in contact with one another or with other hardened steel tools. c. Use a file card to clean the file. Do not hit it against a hard surface to knock loose filings.
Objective 3 *There are various methods for bending cold metal. Discuss the methods that students will be using in the shop. Refer to PPt 7.*	**Explain how cold metal can be bent.** Thin, narrow flat stock and square and round stock that is approximately 1/2 in. thick or less can be bent at an angle by securing it in a vise and pushing it with one hand while hammering it just above the jaws of the vise.

Instructor Directions	Content Outline
PPt 7 – Cold Forming Metal	Metal can be rounded by bending it around a piece of pipe or round stock in a vise. A long piece of pipe can be placed over the metal to provide additional leverage for bending. Metal can be twisted by securing it in a vise and turning it with an adjustable wrench. Sheet metal can be bent at a right angle by securing it and bending it over the edge of a bench top and using a mallet or a hammer. If the angle of the bench is not sharp enough, a piece of angle iron can be clamped to it. For small projects using light stock, pieces of angle iron can be set over the jaws of the vise to serve as jaw caps and to extend the work surface. The angle iron is placed over the vise jaws with the stock between them. The vise is tightened and the metal is bent over the angle iron using a hammer or mallet. Machines, such as the cornice brake and the box and pan brake, are also available for bending metal. 1. These machines can be used on different types of material, such as flat, round, or angled stock, to make different types of bends. The types will depend on the design of the machine. 2. If there is a brake in the shop, all guidelines from the manufacturer and the instructor should be followed for the safe and correct use of that particular machine.
Objective 4 *Discuss ways of fastening cold metal. Begin by reviewing any techniques students should already be familiar with, such as fastening with bolts and screws. General information about fastening with screws is in* Agricultural Mechanics Unit for Agricultural Science I*, Unit*	**Explain how cold metal can be fastened.** Screws and bolts 1. Screws and bolts have the advantage of allowing easy assembly and disassembly of parts. 2. Two common screws used for fastening metal are sheet metal screws and cap screws. a. Sheet metal screws are designed for fastening thin stock. They have widely spaced threads that run the length of the shank and allow the metal to sit between the threads.

Instructor Directions	Content Outline
III Lesson 4. Discuss other fastening methods, such as riveting, pop riveting, and using a tap and die, as well as any additional tools or techniques used in the shop. Refer to PPts 8-11. PPt 8 – Setting Cold Rivets PPt 9 – Pop Riveting PPt 10 – Types of Taps PPt 11 – Using a Die	b. Cap screws are designed for fastening thick stock. They are used with metal that has matching threads. 3. To fasten metal using a bolt and a nut, drill or punch a hole through both pieces of metal the same diameter as the bolt, put the bolt through both pieces, thread on a lock washer and nut, and tighten the bolt. 4. To fasten metal with only a bolt, use a similar procedure, except that the piece of metal that the bolt threads into will need a slightly smaller hole to leave enough material to cut internal threads. Determining what size hole to make and tapping a hole are discussed below. 5. To fasten metal with a sheet metal screw, drill or punch a hole in the first piece of metal to accommodate the shank of the screw, and drill or punch a smaller pilot hole in the second piece of metal. Do not overtighten the screw or the pilot hole will be stripped out and the screw won't hold. Rivets 1. When fastening metal with a rivet, be sure to choose a rivet of the correct length. A general rule for selecting a rivet is that it should be as long as the thickness of both pieces of metal together plus the diameter of the rivet. A 1/8-in. diameter rivet should protrude approximately 1/8 in. above the two pieces of stock. 2. Use a ball peen hammer or a hammer and rivet set to draw the pieces together and form a rounded head on the exposed end of the rivet. 3. Do not flatten the rivet head; this weakens the rivet. Pop rivets 1. Pop rivets are useful for situations in which it would be difficult to support the rivet and use the hammer at the same time, or when only one side of the metal is accessible. 2. Choose rivets that are compatible with the metal being fastened. Do not use aluminum rivets to fasten steel. 3. The rivet is drawn up and the pieces tightened by squeezing the handles of the pop riveter until the pin in the rivet breaks. This may require several strokes.

Instructor Directions	Content Outline
	Tap and die set 1. A tap and die set can be used to cut threads in metal. a. A tap is turned with a tap wrench to cut internal threads in a piece of metal. b. A die is turned with a diestock to cut external threads onto a rod or bolt. 2. The types of thread systems most likely to be encountered in the U.S. are listed below. a. National Coarse (NC) – These threads are frequently chosen for general-purpose work. Coarse threads allow for quicker assembly and are more resistant to cross-threading than fine threads are. b. National Fine (NF) – These threads are frequently chosen for precision assemblies and for high-stress and high-load assemblies because they are less likely to loosen under these conditions. c. International Standards Organization (ISO) coarse – coarse metric threads d. ISO fine – fine metric threads e. National Pipe Threads (NPT) – The pipe thread system is specifically used for making and indicating threads on pipes. Pipe threads differ from bolt threads because bolt threads are straight and can be cut the whole length of a rod. Pipe threads taper to create a seal that can hold gas, liquid, or steam under pressure without leaking. 3. Hand taps are generally available in sets of three for a given diameter. a. Taper tap – The taper tap is used to start a thread easily or to thread a hole that goes all the way through the stock. b. Plug tap – The plug tap is used after the taper tap. Like the taper tap, it is tapered at the end, but the plug tap has approximately the first three threads tapered, whereas the taper tap has six or more threads backed off (tapered). c. Bottoming tap – The bottoming tap is backed off approximately one to one and a half threads. It is used to finish a blind hole (a hole that doesn't go all the way through the stock). To make a blind

Instructor Directions	Content Outline
	hole, start with the taper tap, then use the plug tap, and finish the hole with the bottoming tap. 4. To tap a hole, it is important to drill a hole the proper size for the bolt that will be used. The correct tap drill hole will be slightly smaller than the tap to leave enough material for the tap to cut the thread. To select a tap drill, consult a table or use the following formula. a. TDS = D - 1/N, where TDS = tap drill size, D = diameter of the tap, and N = number of threads per inch b. Information about tap diameter and the number and type of threads is generally stamped on the tap and appears as a sequence that looks like this: 3/8 - 16NC, which indicates a 3/8-in. tap with 16 threads per inch, in the National Coarse group. c. To find the tap drill size for the example above, the equation would be TDS = 3/8 - 1/16. d. Remember that to add or subtract fractions they must have the same denominator (bottom number). An equivalent fraction for 3/8 is 6/16, so the equation can also be written as 6/16 - 1/16. e. 6/16 - 1/16 = 5/16. A 5/16-in. hole must be drilled for this tap. 5. The hole is tapped by alternately advancing the tap clockwise to cut the threads and backing it off to break the chips that form. This is done until the tap is through the stock or the bottom of the hole is reached. Add oil as needed during the tapping process. 6. To thread a rod or bolt using a hand die, start with a piece of round stock and chamfer the end to a 45-degree angle using a file. This will make it easier to start the die. 7. Thread the rod by putting the tapered side of the die on the rod and advancing the die to cut the threads and then turning it backward to break the chips that form. Add oil as needed.
Objective 5 *Discuss reasons for and methods of removing burrs.*	**Explain how burrs can be removed from cold metal.** Burrs are the sharp, turned up edges produced on metal by most drilling and cutting processes.

Instructor Directions	Content Outline
	There are various reasons why burrs should be removed. 1. Safety of handling 2. Correct fit of parts 3. To avoid damage to tools or equipment 4. To improve the appearance of the work Burrs are generally removed from the edges of stock with a grinder or a file. Burrs can be removed from holes by drilling a small chamfer, using a drill bit two times the size of the hole.
Application: 🖹 AS 1 – Techniques for Bending Cold Metal 🖹 AS 2 – Fastening Metal With Rivets and Pop Rivets 🖹 AS 3 – Using a Tap and Die Set	AS 1 – AS 3 Results will vary.
Closure/Summary	Cold metal can be laid out, cut, shaped, and fastened. Common tools or materials used to mark cold metal include a scratch awl, dividers, soapstone, permanent marker, center punch, and layout die. Tools for cutting cold metal include a hacksaw, cold chisels, snips and shears, power shears, and files. Cold metal is shaped by bending using various techniques and smoothed by removing burrs with a grinder, file, or drill bit. Screws and bolts, rivets, pop rivets, and a tap and die set are commonly used to fasten cold metal.
Evaluation: Quiz	Answers: 1. b 2. d 3. b 4. c 5. b 6. c 7. c 8. a

Instructor Directions	Content Outline
	9. c 10. d 11. b 12. a. Pitch – number of teeth per inch b. Set – positioning of teeth to allow for a wider kerf than the width of the blade 13. The hacksaw blade should be installed with the teeth facing the front of the saw, away from the handle. 14. The correct way to hold a file is with both hands by grasping the point with thumb and pointer finger and holding the handle in the other hand. 15. The handle is installed on the tang to prevent injuries. 16. Screws should not be overtightened because this will strip the threads in the hole. 17. A rivet set is used to draw the pieces of metal together and form a smooth rounded head on a rivet. 18. A taper tap is useful for starting a thread in a hole or threading a hole that goes all the way through the metal. 19. 12/16 - 1/16 = 11/16 An 11/16-in. hole should be drilled for this tap. 20. Students should list two of the following: a. Allow for safe handling b. Provide for correct fit of parts c. Avoid damage to tools and equipment d. Improve the appearance of the work

Lesson 1: Working With Cold Metal

Techniques for Bending Cold Metal

Objective: Students will observe how to bend cold metal.

Directions: Use a vise and common metalworking hand tools to bend cold metal.

Materials and Equipment:

Bench vise
Safety goggles or glasses*
Gloves
Ball-peen or blacksmith's hammer
Adjustable wrench
Straightedge
Soapstone, scratch awl, permanent marker, or other marking tool
Flat, round, or square metal pieces to be bent, selected by the instructor
Small piece of sheet metal
Pipe or round stock, to be used as a form for rounding a piece of metal
Angle iron, to be used as jaw caps on the vise

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear and any other protective clothing as needed.

Note: The following demonstrations are intended to illustrate bending techniques covered during the classroom discussion. The demonstrations below are of some of the techniques presented in the lesson. If additional or different techniques were covered in class, they should be added to or substituted for those below.

Procedure:

1. Wear appropriate safety equipment.
2. Demonstrate the correct procedure for using a hammer and a vise to bend flat, square, or round stock approximately 1/2 in. thick or less.
   a. Using the layout tools, mark the metal at the point where the bend is to occur.
   b. Secure the work in the vise with the mark for the bend at the top of the jaws and the longer portion of the stock extending above the vise.
   c. Push the metal with one hand using a hammer just above the vise to form the metal into the desired angle.
   d. Be sure to bend the metal sharply at the jaws of the vise, not above it.

3. Demonstrate the correct procedure for rounding metal of a similar dimension.
   a. Select a piece of pipe or round stock the same diameter as the desired bend.
   b. Secure the end of the work to be bent and the round stock tightly in the vise.
   c. Push and hammer the metal to bend it around the stock.
   d. Loosen the vise and adjust the work to continue the bend, tighten the vise, and continue pushing and hammering.
   e. Repeat until the desired bend is obtained.
4. Demonstrate the correct procedure for twisting metal.
   a. Mark where the twist is to begin.
   b. Make a second mark above the first equal to 1 1/2 times the width of the metal.
   c. Place the metal in the vise with the point where the twist is to begin at the top of the jaws.
   d. Position the wrench on the metal so that the bottom of the wrench is even with the second mark and the jaws extend the width of the metal.
   e. Hold the metal perpendicular to the vise with one hand and turn the wrench with the other hand until the desired amount of twist is reached.
5. Demonstrate the correct procedure for bending small pieces of sheet metal.
   a. Lay out a line where the bend is to occur.
   b. Place the angle iron over the jaws of the vise to serve as jaw caps and to extend the work surface.
   c. Put the stock between the pieces of angle iron and tighten the vise.
   d. Bend the metal over the angle iron using a hammer.
6. If there are any machines in the shop that can be used for bending, such as a box and pan brake, demonstrate the correct use of the machine or machines. Discuss all safety procedures students must observe for working with the machine.
7. Demonstrate the correct cleanup procedure.

Lesson 1: Working With Cold Metal

Fastening Metal With Rivets and Pop Rivets

Objective: Students will observe how to fasten metal using different types of rivets.

Directions: Use rivets and pop rivets to fasten metal.

Materials and Equipment:

Safety goggles or glasses*	Rivets
Gloves	Riveting pliers
Ball peen hammer	Pop rivets
Portable or stationary drill and appropriate twist drill	Bench vise
Center punch	Metal stock, selected by the instructor
Rivet set	Anvil or other appropriate work surface

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear and any other protective clothing as needed.

NOTE: The following demonstrations are intended to illustrate fastening techniques covered during the classroom discussion. The demonstrations below are of techniques presented in the lesson. If additional or different techniques were covered in class, they should be added to or substituted for those below.

Procedure:

1. Wear appropriate safety equipment.
2. Demonstrate the correct procedure for fastening metal using rivets.
   a. Use the center punch to lay out the center of the hole on two pieces of metal.
   b. Secure one piece of stock and drill a hole in it the same diameter as the rivet to be used. Repeat with the second piece.
   c. Choose a rivet of the correct length. A general rule for selecting a rivet is that it should be as long as the thickness of both pieces of metal together plus the diameter of the rivet. For example, a 1/8-in. diameter rivet should protrude approximately 1/8 in. above the two pieces of stock.
   d. Put the pieces on the rivet and set the assembled pieces, with the head of the rivet down, on an anvil or other appropriate base. For round-head rivets, a support with a recess that fits the rivet head can be used.
   e. Use a hammer and a rivet set to draw the pieces together.

  f. Strike the rivet squarely in the center, using the face of the hammer, to expand the rivet and tighten the pieces.
  g. Use the peen of the hammer or a rivet set to form a rounded rivet head on the exposed end. Do not flatten the rivet head; this will weaken the rivet.

3. Demonstrate the correct procedure for fastening metal using pop rivets.
   a. Mark both pieces of metal using the punch.
   b. Drill a hole in both pieces that is the same size as the rivet to be used.
   c. Choose rivets that are compatible with the metal being fastened.
   d. Make sure the pieces are held firmly together. Put the pin of the rivet in the pop riveter and put the rivet in the hole.
   e. Draw the rivet up by squeezing the handles until the pin breaks. This may require several strokes.
4. Demonstrate the correct cleanup procedure.

Lesson 1: Working With Cold Metal

Using a Tap and Die Set

Objective: Students will observe how to make internal and external threads using a tap and die set.

Directions: Use a tap and die set to tap a hole and thread a rod.

Materials and Equipment:

Safety goggles or glasses*
Gloves
Portable or stationary drill and appropriate twist drill
Center punch
Tap and die set
Bench vise
File
Cutting oil
Metal stock, selected by the instructor

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear and any other protective clothing as needed.

NOTE: The following demonstrations are intended to illustrate threading techniques covered during the classroom discussion. The demonstrations below are of techniques presented in the lesson. If additional or different techniques were covered in class, they should be added to or substituted for those below.

Procedure:

1. Wear appropriate safety equipment.
2. Demonstrate the correct procedure for tapping a hole using the tap and die set. The activities below are set up so that the procedures can be demonstrated independently. If desired, the instructor could combine the activities by threading a rod in the second procedure that would fit the hole threaded in the first procedure.
   a. Mark the metal using the center punch.
   b. Secure the work and drill a hole the proper size for the bolt that will be used. The correct tap drill hole will be slightly smaller than the tap to leave enough material for the tap to cut the thread. To select a tap drill, consult a table or use the formula DS = D - 1/N.

c. Drill the hole for the tap. If using a portable drill, be careful to keep the drill at a 90-degree angle to the work.
d. Put the tap in the wrench, place the end of the tap squarely in the hole, and apply cutting oil to the tap.
e. Apply even, downward pressure and turn the tap wrench clockwise about half a turn.
f. Turn the wrench back counterclockwise about a quarter of a turn to break the metal chip that forms as the threads are cut.
g. Continue advancing the wrench and turning it backward to break the chips until the tap is through the stock or the bottom of the hole is reached. Once the tap has started, downward pressure is not necessary. The tap should thread itself into the hole. Add oil as needed.
h. Clean oil and metal chips from the tools, parts, and work area, following all steps for correct procedure and safety.
i. Dispose of oily rags or paper towels in an appropriate container.

3. Demonstrate the correct procedure for threading a rod using the tap and die set.
   a. Start with a piece of round stock. The end should be at a right angle to the side. Secure the piece and chamfer the end to a 45-degree angle using a file.
   b. Select the correct die and put it in the stock.
   c. Add cutting oil to the tapered side of the die and the chamfered end of the stock and place the tapered side of the die on the stock.
   d. Apply even downward pressure and turn the stock clockwise about half a turn.
   e. Turn the wrench back counterclockwise about a quarter turn to break the metal chip.
   f. Continue advancing the die and turning it backward to break the chips until the desired length has been threaded. Add oil as needed.
   g. Remove the die and clean all tools, parts, and the work area.
   h. Dispose of oily rags or paper towels in an appropriate container and demonstrate any additional cleanup procedures as needed.

Unit V - Cold Metal Work Name__________________________

Lesson 1: Working With Cold Metal Date__________________________

Assessment

Circle the letter that corresponds to the correct answer.

1. Which tool is designed to scribe arcs and circles on metal?

   a. Center punch
   b. Dividers
   c. Scratch awl
   d. Soapstone

2. Which tool is designed to mark the center of a hole for starting a twist drill?

   a. Soapstone
   b. Scratch awl
   c. Dividers
   d. Center punch

3. When cutting with a hacksaw, how many teeth should be on the metal at all times?

   a. Two
   b. Three
   c. Four
   d. Five

4. Which type of cold chisel is best for shearing metal?

   a. Cape
   b. Diamond
   c. Flat
   d. Round nose

5. For best results when cutting with snips, the operator should:

   a. close the blades completely on a cut.
   b. open the blades wide to improve leverage.
   c. keep the metal at the front part of the blades.
   d. prevent the metal from lifting up during the cut.

6. Which tool would probably be best for cutting structural steel?

    a. Cold chisel
    b. File
    c. Power shears
    d. Snips

7. Which cutting design of a file has individual teeth that are raised and sharp?

    a. Curve
    b. Double
    c. Rasp
    d. Single

8. Which tools or materials are used to round cold metal?

    a. Ball-peen hammer and pipe
    b. Ball-peen hammer and angle iron
    c. Vise and adjustable wrench
    d. Vise and angle iron

9. When fastening metal with a 3/16-in. diameter rivet, how far should the rivet extend above the metal?

    a. 1/16 in.
    b. 1/8 in.
    c. 3/16 in.
    d. 1/4 in.

10. A cutting tool designed to cut external threads on round metal is called a:

    a. tap drill.
    b. tap.
    c. die stock.
    d. die.

11. Which type of thread system is typically used for fastening metal that will be under high-stress situations?

    a. NC
    b. NF
    c. ISO coarse
    d. NPT

Complete the following short-answer questions.

12. Define the following terms as related to a saw blade.

    a. Pitch -

    b. Set -

13. How should a hacksaw blade be installed?

14. What is the correct way to hold a file?

15. What part of a file does the handle go on? Why is it important to use a handle when filing?

16. Why is it important to not overtighten a screw?

17. What is the function of a rivet set?

18. What is a taper tap used for?

19. What is the correct tap drill size for a 3/4 - 16NF tap? Show your work.

20. List two reasons that burrs should be removed from metalworking projects.

a.

b.

Name______________________________

Metalworking Plans

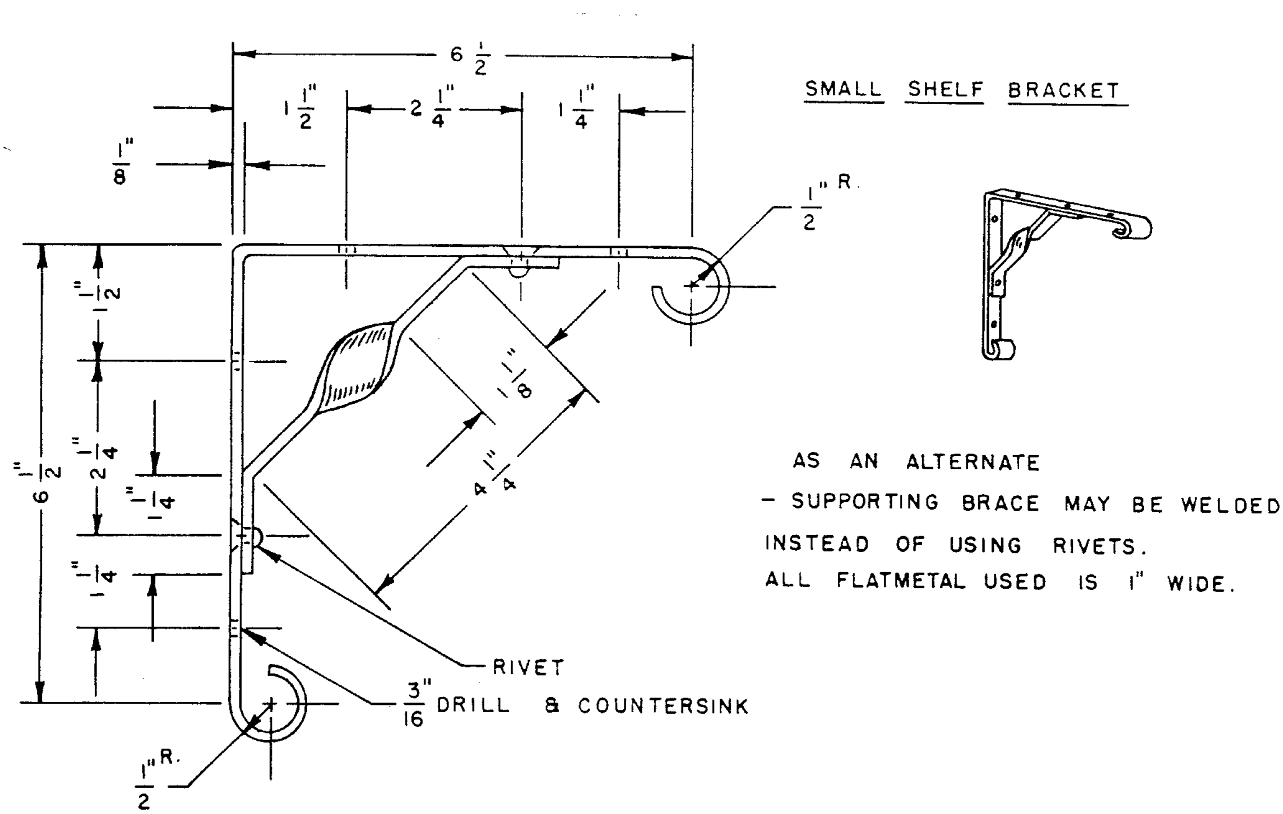
Objective: Students will use the skills learned in this unit to construct metalworking projects.

The following metalworking plan is included in this activity.

- Small shelf bracket

The instructor should choose project plans for this unit based on the skill level of the students and the time available to work on the project. If students are selecting their own projects, the instructor should screen all student plans to determine that they are appropriate as part of a vocational agricultural curriculum.

The Instructional Materials Laboratory at the University of Missouri-Columbia has the following additional plans available: *Agricultural Mechanics Building Plans* (a set of plans for wood, metal, and wood and metal projects; catalog number 10-7804-I) and *Agricultural Mechanic Plans (Set)* (a set of 28 bulletin plans with pictures and sequenced building procedures and 50 single-sheet plans in woodworking, metals, and welding; catalog number 10-7810-S). Materials can be ordered online at http://iml.missouri.edu/ or by calling (800) 669-2465.



Bill of Material

1 - 1/8" x 1" x 16 1/2" flat mild steel
1 - 1/8" x 1" x 6 3/4" flat mild steel
2 - 3/16" x 1/4" soft iron rivets

Construction Procedure

1. Cut or shear material to length.
2. Make all bends and twists cold.
3. Curved ends may be bent with the aid of a piece of round pipe or metal and a vise. Bend the curved ends before drilling any holes.
4. Twist in brace is a 90-degree twist, which can be made cold by fastening metal in a vise and twisting with the aid of an adjustable end wrench.
5. Drill and countersink all holes, except one hole for one end of brace.
6. Hammer ends of rivets down flush into the countersink holes.
7. Square up shelf bracket with a square and then drill the last hole for one end of brace.
8. Bracket can be welded instead of riveting.
9. Finish by blacking or painting.

Plan reprinted from *Agricultural Mechanics Plans (Set)*. University of Missouri-Columbia: Instructional Materials Laboratory.

Agricultural Science II

Curriculum Guide: *Agricultural Mechanics Unit for Agricultural Science II*

Unit: V. Cold Metal Work

Unit Objective:

Students will apply principles of cold metal work by constructing an appropriate metalworking project.

Show-Me Standards: 2.5, CA3

References:

Agricultural Construction Volume II. University of Missouri-Columbia, Instructional Materials Laboratory, 1989.

Agricultural Mechanics Building Plans. University of Missouri-Columbia, Instructional Materials Laboratory, 1994.

Agricultural Mechanics Plans (Set). University of Missouri-Columbia, Instructional Materials Laboratory.

Agricultural Mechanics Unit for Agricultural Science II. University of Missouri-Columbia, Instructional Materials Laboratory, 2002.

Instructional Strategies/Activities:

- Students will engage in study questions in lesson 1.
- Students will observe instructor demonstrations of the following activities and perform the activities at the instructor's discretion: AS 1.1, Techniques for Bending Cold Metal; AS 1.2, Fastening Metal With Rivets and Pop Rivets; and AS 1.3, Using a Tap and Die Set.

Performance-Based Assessment:

Students will use common metalworking tools and procedures discussed in class to lay out and construct an appropriate metalworking project.

Assessment will be based on the overall quality of the work and the ability to safely and correctly complete the project within the available time.

Agricultural Mechanics Unit for Agricultural Science II
Unit V—Cold Metal Work
Instructor Guide

The instructor should assign the performance-based assessment activity at the beginning of the unit. Students will work toward completing the activity as they progress through the unit lessons. The assessment activity will be due at the completion of the unit.

1. Use the activity sheets to demonstrate techniques for working with cold metal. Adapt these sheets as needed and use them to assess student competency at performing basic metalworking procedures. Review or supplement these activities as needed, based on student mastery of the procedures and the tools the students will be using. **NOTE: Students should only complete this performance-based activity if they have mastered all the relevant competencies and have the instructor's permission to perform the activity.**

2. For the performance-based assessment activity, have students apply the skills and procedures discussed in the unit to construct an appropriate metalworking project.
   a. See the Unit V Activity, Metalworking Plans, pp. V-43–V-44, for a project plan and additional details. The activity includes a plan for a small shelf bracket.
   b. For additional project plans, see *Agricultural Mechanics Building Plans* and *Agricultural Mechanics Plans (Set)*, available from the Instructional Materials Laboratory, University of Missouri-Columbia, accessed November 13, 2003, at http://www.iml.coe.missouri.edu/.

3. The student handout for this activity is a Project Completion Checklist and Project Evaluation Checklist. Students can use the checklists to track the progress of their project and evaluate their work. Supplement or modify the student handout to reflect actual projects as needed.

4. Have students turn in their completed projects.

5. The final assessment score will be based on the overall quality of the work and the ability to safely and correctly complete the project within the available time.

6. ADDITIONAL ACTIVITY: If all students are building the same project, a display board can be made as a teaching aid for the project. To make a display board, mount correctly made examples of each project piece on a board. Label each piece and indicate the number of pieces needed. Have students compare their project pieces with the correctly made examples. Students should make sure their pieces match the examples before proceeding.

Agricultural Mechanics Unit for Agricultural Science II
Unit V—Cold Metal Work
Student Handout

Name____________________

Use the Project Completion Checklist and Project Evaluation Checklist to track the progress of your project.

Project Completion Checklist

Procedure	Date Due
❑ Master all competencies necessary to complete the project.	
❑ Receive instructor approval to build the project.	
❑ Review safety precautions for tools to be used. You can lose points for not following safety precautions and other assigned procedures.	
❑ Perform a quality control inspection of the project during construction. Use the Project Evaluation Checklist.	
❑ Complete project construction.	
❑ Perform a quality control inspection of the project following completion. Use the Project Evaluation Checklist.	
❑ Turn in the completed project. Your final assessment score will be based on the overall quality of the work and your ability to safely and correctly complete the project within the available time.	

Project Evaluation Checklist

Quality Control and Shop Procedures	**Criteria**
Quality of Work	❑ Fasteners are correct type and size. ❑ Holes and cut edges are deburred and there are no sharp edges. ❑ Measurements are correct. ❑ Cuts are accurate. ❑ Parts fit well for optimum strength. ❑ Project is square and straight. ❑ Work was completed on time.
Design and Suitability	❑ Project is well balanced, proportional, and pleasing to the eye. ❑ Project is the right size for its use. ❑ Project is suitable for its intended purpose. ❑ Project is good enough to sell.
Safety and Work Habits: Observe these safety procedures whenever you are in the shop.	❑ Know how to use the equipment before you attempt to use it. Only use tools and materials the instructor has approved you to use. ❑ Wear appropriate personal protective equipment. ❑ Follow safety guidelines from your instructor and safety information on labels, equipment, and signs in the work area. ❑ Follow assigned setup and cleanup procedures. ❑ Return equipment and materials to their assigned places. ❑ Do not use equipment that does not function properly. ❑ Tell the instructor about any damaged or malfunctioning equipment.

Agricultural Science II

Agricultural Mechanics Unit for Agricultural Science II
Unit V—Cold Metal Work
Scoring Guide

Name ____________________

Assessment Area	Criteria	0 Points	1 Point	2 Points	3 Points	4 Points	Weight	Total
Quality of Work	❑ Fasteners are correct ❑ Holes and cut edges are deburred and there are no sharp edges ❑ Cuts and measurements are accurate ❑ Parts fit well ❑ Project is square and straight ❑ Work was completed on time	Failed	Poor	Fair	Good	Excellent	X 20	
Design and Suitability	❑ Project is well balanced and pleasing to the eye ❑ Project is the right size for its use ❑ Project is suitable for its intended purpose ❑ Project is good enough to sell	Failed	Poor	Fair	Good	Excellent	X 5	
Safety and Work Habits	**Student followed all safety precautions**	**Passed**				**Failed**	**X (-25)**	Negative <u>Points</u> *
	Student followed all assigned procedures	**Excellent**	**Good**	**Fair**	**Poor**	**Failed**	**X (-10)**	Negative <u>Points</u> *
TOTAL								

Final Assessment Total ________/100 pts.
*** Overall combined score cannot be lower than 0.**

Comments:

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Material Selection, Plan Reading, and Interpretation
Lesson	Planning a Project
Estimated Time	50 minutes

Student Outcome

Describe how to choose and plan a project.

Learning Objectives

1. Explain why it is important to plan a project.
2. Explain what factors should be considered when choosing a project.
3. Explain the steps that should be followed when planning a project.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slide
   - PPt 1 – Sample Cutting List and Bill of Materials
2. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
3. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit VI – Material Selection, Plan Reading, and Interpretation." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Print
   - ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding*. Tinley Park, IL: Goodheart-Willcox, 2000.
   - ❑ Burkybile, C., D. Johnson, J. Lee, and C. Shelhamer. *Agricultural Power and Technology*. Danville, IL: Interstate Publishers, 2005.
   - ❑ Jeffus, L. *Welding Principles and Applications.* 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
2. Electronic Media
   - ❑ Google SketchUp. Google, 2008. Google offers a free version of its design software, SketchUp. This is a powerful drawing program that is easy to teach and learn. The software comes with a tutorial package as well as very detailed instructions. Dimensions and annotations can be added to drawings to make them applicable for use in designing a project. Accessed October 26, 2007, from http://sketchup.google.com/.

Interest Approach

Show students projects that have been built in the shop by students in the past. These can be pictures or a PowerPoint presentation of projects that have won awards or that were particularly well made; they can also be the actual projects, if they are available. These projects do not have to be in like-new condition. A project that shows signs of actual use could be used to illustrate points discussed below and in previous lessons, such as (a) choose a project that meets a need, (b) lay out, prepare, and assemble parts carefully, and (c) finish and maintain the project properly to help ensure years of reliable service. A project that the instructor made when he or she was a student could be one such example.

Communicate the Learning Objectives

1. Explain why it is important to plan a project.
2. Explain what factors should be considered when choosing a project.
3. Explain the steps that should be followed when planning a project.

Instructor Directions	Content Outline
Objective 1 *Discuss reasons for having a plan before beginning a project.*	**Explain why it is important to plan a project.** By thinking a project through, time, effort, and materials can be saved. Cost can be reduced. Mistakes, such as errors in the design or bill of materials, can be detected and more easily fixed before work begins. Ways of improving the original design may be found.
Objective 2 *There are a variety of factors to be weighed when deciding on a project, and many questions can be asked to gather the information needed to decide if the project is a good choice. The factors and questions in the content outline are some examples that can be a starting point for class discussion. Ask students what factors they would consider and guide the discussion to include any points*	**Explain what factors should be considered when choosing a project.** Function – Function refers to the usefulness of the project. 1. Is there a need for a particular project? 2. Will this project do the job as it is designed, or will it need to be redesigned in some way? Procedure – Procedure includes all the skills needed to complete the project and their difficulty. 1. Will the project reinforce existing skills? 2. Do new skills have to be learned to complete the project? 3. Is the project challenging but manageable?

Instructor Directions	Content Outline
they might miss. Hand out examples of shop plans that are suitable for the students to build. (Note: Each plan should already have been screened and determined to be acceptable for the class in terms of the factors at right, as well as any others the instructor chooses to add. Plans should also have been screened by the instructor to determine that they have educational value and are appropriate as part of a vocational agricultural curriculum.) Discuss one or more of the plans in reference to each of the factors discussed.	Appearance 1. Does the project have eye appeal? 2. Do all the parts seem to work together? 3. Does the project seem balanced and well designed? Time 1. How soon is the completed project needed? 2. Can the project be completed in the time available? Cost 1. How much do the materials cost? 2. Are there any hidden costs, such as tools or parts that must be purchased, in addition to the basic materials?
Objective 3 *Ask students what steps they would follow when planning a project. Tell the students what materials will be available from the vocational agriculture shop or FFA and which materials they will need to obtain elsewhere. List local sources for these materials. Refer to PPt 1.* PPt 1 – Sample Cutting List and Bill of Materials	**Explain the steps that should be followed when planning a project.** Choose a project. 1. Use a checklist such as the one above to evaluate possible projects. 2. Choose the project that ranks best overall. Make a working drawing if none is available. 1. Possible sources for working drawing ideas include the instructor, agricultural mechanics textbooks, and manufacturers. 2. Be sure to review any plans from outside sources with the instructor to determine that they are acceptable before proceeding. Develop a plan of procedure. 1. A plan of procedure is a step-by-step list of everything that needs to be done to complete the project. 2. To make a plan of procedure, study the working drawing carefully. Find a starting point and work through the plans from beginning to end, putting the steps in a logical order.

Instructor Directions	Content Outline
	3. Consider all the factors that could affect the project. For a small project this might mean purchasing a particular part or tool, for larger projects it could include such things as arranging financing and complying with code stipulations. 4. Group similar operations together, such as doing all crosscutting at once. This will save time and materials once work begins. 5. Information gathered while writing the plan of procedure will be used for the next steps, making a cutting list and a bill of materials. Prepare a cutting list. 1. The cutting list is prepared by looking at the stock that will be used in the project and grouping together items that have similar rough dimensions. 2. Grouping items that can be cut from the same piece of stock helps save cost and materials. Draw up a bill of materials. 1. The bill of materials is a list of all the materials that will be needed to complete the project, including hardware and finish. Each item is identified by the amount, size, and kind needed. 2. The bill of materials is important for estimating cost and purchasing the correct amount of materials. 3. Keep in mind that there are different formats for bills of materials. Sometimes, for example, information may be divided into a construction bill of materials, which lists all items in their final dimension and can be used to prepare a cutting list, and a purchasing bill of materials, which would list materials in standard sizes and be used for figuring cost and buying supplies. The important thing is to have completed the plan of procedure and any bills of materials before starting to work on the project. Obtain all necessary supplies and have them readily available before work begins.

Instructor Directions	Content Outline
Closure/Summary	Planning a project enables the builder to save time, money, and materials, find and correct mistakes in the design, and make improvements in the design. Things to consider when choosing a project include its function, the procedures that will be needed to build it and their difficulty, its appearance, the time needed, and the cost of the project. When planning a project, the builder should (a) choose a project that best meets the need, (b) develop a plan for making it, (c) prepare a cutting list, and (d) draw up a bill of materials.
Evaluation: Quiz	Answers: 1. c 2. a 3. Planning a building project promotes efficiency; saves time, effort, and money; and allows for detection and correction of errors. Reviewing the project gives the builder the opportunity to change or improve the design if needed. 4. Student should list three of the following factors: a. Function – The function of a project is its purpose or usefulness. Builders should determine if there is a need for a project and if it will be functional as designed. b. Procedure – The procedure includes all the skills needed to complete the work and their level of difficulty. Builders should determine if they already have the skills required or if they will need to learn new skills. c. Appearance – The working drawing of a project provides information about its appearance and quality. A good design is eye appealing, balanced, and proportional. In addition, all the parts should work together. d. Time – Builders should find out when a project must be completed and if they can complete it on time. The difficulty of a project is an important factor in making scheduling decisions. e. Cost – The cost includes all the tools and materials that must be purchased for a project. Builders need to decide if the project is affordable.

Instructor Directions	Content Outline
	5. a. Choose a project. b. Make a working drawing, if none is available. c. Develop a plan of procedure. d. Prepare a cutting list. e. Prepare a bill of materials. f. Obtain all necessary supplies and have them readily available when needed.

Unit VI - Material Selection, Plan Reading, and Interpretation

Name_________________________

Lesson 1: Planning a Project

Date_________________________

Assessment

Circle the letter that corresponds to the correct answer.

1. Which of the following describes a bill of materials?

   a. Overall design of a project
   b. Steps for building a project
   c. All materials required to build a project
   d. Exact sizes of materials that need to be cut

2. Which of the following describes a working drawing?

   a. Overall design of a project
   b. Steps for building a project
   c. All materials required to build a project
   d. Exact sizes of materials that need to be cut

Complete the following short-answer questions.

3. Describe why planning a project is important. List at least three advantages of planning.

4. List three factors to consider when choosing a project and explain briefly why each factor is important.

   a.

   b.

   c.

5. List the six steps in planning a project.

   a.

   b.

   c.

   d.

   e.

   f.

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Material Selection, Plan Reading, and Interpretation
Lesson	Making and Reading Working Drawings
Estimated Time	50 minutes

Student Outcome

Interpret a working drawing.
Prepare a working drawing.

Learning Objectives

1. Explain why working drawings are important.
2. Define a working drawing.
3. Explain what views should be included in a working drawing.
4. List some symbols and lines used in drawings and plans.
5. Explain how a working drawing is prepared and dimensioned.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Common Drawing Symbols
   - PPt 2 – Common Lines and Dimensioning Techniques
   - PPt 3 – Dimensioning a Drawing
2. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
3. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit VI – Material Selection, Plan Reading, and Interpretation." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Print
   - Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding.* Tinley Park, IL: Goodheart-Willcox, 2000.
   - Huth, M., Wells, W. *Understanding Construction Drawings.* 3rd ed. NY: Cengage Delmar Learning, 2004.
   - Jeffus, L. *Welding Principles and Applications.* 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
   - Koel, L. *Construction Print Reading.* NY: Delmar Learning, 1999.

2. Electronic Media
   - ❑ Google SketchUp. Google, 2008. Google offers a free version of its design software, SketchUp. This is a powerful drawing program that is easy to teach and learn. The software comes with a tutorial package as well as very detailed instructions. Dimensions and annotations can be added to drawings to make them applicable for use in designing a project. Accessed October 26, 2007, from http://sketchup.google.com/.

Interest Approach

1. Point out a tool, machine, or structure in the shop, such as a plane, band saw, or workbench. It should be an object for which the instructor has a photo or photos and a complete working drawing. Show students the photo or photos. Ask them if they could build the object using the photo as a guide, assuming they had the tools and skills. Could they send the photo to someone who'd never seen the object before and expect that person to build it? Would the parts be likely to interchangeable? Show students the working drawing or drawings. Guide the discussion to the conclusion that drawings are a way of communicating between the planner and the builder and ensuring consistency.

2. Utilize the free SketchUp software from Google to have students design a project. Once the students have designed the project, have them create a cut list and materials list from the drawing.

Communicate the Learning Objectives

1. Explain why working drawings are important.
2. Define a working drawing.
3. Explain what views should be included in a working drawing.
4. List some symbols and lines used in drawings and plans.
5. Explain how a working drawing is prepared and dimensioned.

Instructor Directions	Content Outline
Objective 1 *Begin the lesson by discussing reasons for making working drawings. Some of this information is also included in the first Interest Approach at the beginning of the lesson. That question can be used to introduce the topic, and the discussion can be summarized with the content outline material. The instructor should add any other reasons he or she feels are relevant. Working drawings can be shown or passed out to students as examples.*	**Explain why working drawings are important.** Working drawings are a way of communicating between the planner and the builder. They help standardize the building process and ensure consistency. They help ensure accurate repairs. Knowing how to read existing working drawings allows a builder to make his or her own working drawings.

Instructor Directions	Content Outline
Objective 2 *Discuss working drawings and how they are different from simple sketches. Explain to students how much detail they will need to include in the drawings they make.*	**Define a working drawing.** A working drawing is a drawing that includes all the dimensions and specifications necessary to build an object. It may or may not be drawn to scale, but the general shape and arrangement of parts in relation to each other should be clear. Drawn to scale means that a unit of measurement used on the drawing directly corresponds to another unit used to measure the actual object.
Objective 3 *Discuss what views need to be included in a working drawing. If example drawings were shown or distributed to students, these can be referred to.*	**Explain what views should be included in a working drawing.** A working drawing should include as many views as needed to show all the parts of the object and how they work together. For many objects, views of the front, top, and one side are sufficient. If needed, other views, detail views, or sectional views, which show the interior of the object, can be added.
Objective 4 *Discuss symbols and lines used for making working drawings. Focus on symbols students are likely to use and encounter. Refer to PPts 1 and 2.* PPt 1 – Common Drawing Symbols PPt 2 – Common Lines and Dimensioning Techniques	**List some symbols and lines used in drawings and plans.** There are many symbols and lines used for indicating features and construction materials in drawings that would otherwise be difficult to represent. Because these lines and symbols are standardized, any builder can look at another builder's plans and quickly understand it. 1. Some symbols may be in the same scale as the rest of the drawing and represent features such as doors and windows. 2. Symbols can be used to indicate where electrical or plumbing fixtures are located. 3. Symbols can also be used to indicate the grade or type of material used, such as rough or finished wood, steel, or brick. Lines are distinguished by their form and thickness. Some common lines and what they are used for are listed below.

Instructor Directions	Content Outline
	1. Border line – a heavy solid line used to enclose the entire drawing or separate one drawing from another 2. Object or visible line – a solid line used to show the visible edge of the object 3. Hidden line – a dashed line used to show edges that cannot be seen 4. Dimension line – a thin solid line with arrowheads at the ends that is used to indicate the length, width, or height of an object 5. Extension line – a thin line used to mark the corner or edge of an object 6. Break line – a solid line with zigzags that is used to indicate that part of the object has been left out 7. Center line – a thin line that is made of long, short, long segments and used to indicate the center of a round object 8. Leader line – a line with one arrowhead that is used to point out some feature of the object
Objective 5 *Explain how to draw and dimension a working drawing. Some general information is included below; discuss any other information about completing working drawings as needed. Refer to PPts 2 and 3.* PPt 2 – Common Lines and Dimensioning Techniques PPt 3 – Dimensioning a Drawing	**Explain how a working drawing is prepared and dimensioned.** Draw a border line along each side of the paper. 1. This establishes the work area for the drawing and gives it a finished look. 2. Border lines are generally placed 1/2 in. from the edge of the paper. Add a title block to the drawing. 1. A title block gives information about the whole drawing. 2. Typical information found in a title block includes (a) who made the drawing, (b) when it was made, (c) the name of the drawing, and (d) the scale of the drawing. Determine the scale, if the drawing is to be made to scale. Decide on the views that will be drawn and where they will be positioned. 1. A typical working drawing includes three views of the object. The front view is located in the lower left-hand corner, the top view is directly above it, and an end view is to the right.

Instructor Directions	Content Outline
	2. Using a layout like the one mentioned above means that dimensions can represent more than one view, which helps keep the drawing uncluttered and easy to read. Make the working drawing using a sharp lead pencil. Add dimensions and any construction notes using dimension, extension, and leader lines.
Application:	Other activities 1. If time allows, have students prepare a working drawing of a small shop project. If the students have no plan for their chosen shop projects, they should draw up plans at this time.
Closure/Summary	Working drawings are important because they allow planners and builders to communicate, they help standardize the building process and aid in making repairs, and because knowing how to read drawings enables a builder to make his or her own working drawings. A working drawing should include all the dimensions and specifications necessary to build an object. A working drawing should include as many views as needed to show all the parts of the object and how they work together. Views should be laid out so that the drawing is uncluttered and easy to read.
Evaluation: Quiz	Answers: 1. d 2. c 3. b 4. a 5. c 6. h 7. g 8. b 9. d 10. f 11. a 12. e 13. Student should list two of the following benefits of using a working drawing: a. Efficiency in construction process

Instructor Directions	Content Outline
	b. Consistency and accuracy in final product c. Accuracy of a repair 14. a. Person who made the drawing b. When the drawing was made c. Name of the drawing d. Scale of the drawing

Unit VI - Material Selection, Plan Reading, and Interpretation

Name_________________________

Lesson 2: Making and Reading Working Drawings

Date__________________________

Assessment

Circle the letter that corresponds to the correct answer.

1. What size is an object drawn at a scale of 6" = 1'?

    a. 1/24
    b. 1/12
    c. 1/4
    d. 1/2

2. The length of an object measures 36 in. What would the length of the object be on paper if drawn using a 3" = 1' scale?

    a. 4"
    b. 6"
    c. 9"
    d. 12"

3. Which type of view is a cutaway that reveals the interior part of an object?

    a. Detail
    b. Sectional
    c. Top
    d. Side

4. Symbols in a working drawing are used to represent:

    a. building materials.
    b. dimensions.
    c. procedural steps.
    d. views.

Match the description in column B to the correct line name in column A.

A	B
_____ 5. Border	a. Thin line that is made of long, short, long segments
_____ 6. Object	b. Thin, solid line with arrowheads on each end
_____ 7. Hidden	c. Heavy, solid line that encloses the drawing
_____ 8. Dimension	d. Thin line that marks the edge of a part to be dimensioned
_____ 9. Extension	e. Line with one arrowhead that usually is accompanied by a note
_____ 10. Break	f. Solid line with zigzags
_____ 11. Center	g. Dashed line used to show edges that cannot be seen in drawing
_____ 12. Leader	h. Solid line used to show visible edges

Complete the following short-answer questions.

13. List two benefits of using a working drawing to build a project.

a.

b.

14. List four pieces of information found in a title block.

a.

b.

c.

d.

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Material Selection, Plan Reading, and Interpretation
Lesson	Selecting Building Materials
Estimated Time	Three 50-minute blocks

Student Outcome

Identify common building supplies using standard terms and sizes.

Learning Objectives

1. Describe softwood and hardwood.
2. Explain how softwood is classified.
3. Explain how hardwood is classified.
4. Describe how lumber is measured and sold.
5. Describe plywood and how it is graded and measured.
6. Describe some common steel materials and how they are measured and sold.
7. Describe some other common building materials and how they are measured and sold.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Common Softwood Classifications and Grades
   - PPt 2 – Sample Plywood Grade Stamps
   - PPt 3 – Veneer Grades
   - PPt 4 – Dimensions of Steel Stock
2. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
3. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit VI – Material Selection, Plan Reading, and Interpretation." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplemental Information

1. Internet Sites
   - ❑ Engineered Composite Science. Forest Products Laboratory. USDA Forest Service. Accessed October 26, 2007, from http://www.fpl.fs.fed.us/rwu4706/.
   - ❑ Structural Materials. Sci-Tech Encyclopedia. McGraw-Hill Encyclopedia of Science and Technology. The McGraw-Hill Companies, Inc., 2005. Accessed October 26, 2007, from http://www.answers.com/topic/structural-materials?cat=technology.
2. Print
   - ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding*. Tinley Park, IL: Goodheart-Willcox, 2000.

Interest Approach

Show students two pieces of lumber or plywood that have the same dimensions but are of different grades. Ask students how the pieces are similar and different. Differences could include factors such as cost, appearance, and the applications the samples can be used for. Next show students samples that include grade stamps and ask if they know what the stamps are for and what they say about the wood. If needed, explain the purpose of the grade stamps and guide the conversation to include any or all of the following points, or any others that seem relevant.

- Grades allow the builder to pick the material best suited for the job.
- They help ensure that the materials will be consistent for the whole project.
- They allow the builder to specify the type of material he or she needs and enable the supplier to fill the orders efficiently.

Communicate the Learning Objectives

1. Describe softwood and hardwood.
2. Explain how softwood is classified.
3. Explain how hardwood is classified.
4. Describe how lumber is measured and sold.
5. Describe plywood and how it is graded and measured.
6. Describe some common steel materials and how they are measured and sold.
7. Describe some other common building materials and how they are measured and sold.

Instructor Directions	Content Outline
Objective 1 *Begin the lesson by discussing the difference between softwood and hardwood.*	**Describe softwood and hardwood.** Softwood comes from coniferous (cone-bearing) trees. These trees have needles and are often called evergreens because they remain green throughout the year. Examples include pine, fir, and spruce. Hardwood comes from deciduous trees, which have broad leaves that fall off and are replaced each year. Examples include oak, walnut, and maple. "Softwood" and "hardwood" do not refer to the actual hardness or softness of the wood.
Objective 2 *There are a number of ways softwood is classified. Several common methods are covered in general terms below. Discuss all*	**Explain how softwood is classified.** By how it will be used 1. Construction or yard lumber - the least expensive and most readily available lumber; used for general construction

Instructor Directions	Content Outline
methods that will be used in the shop, in as much detail as needed. Refer to TM 3.1 Common Softwood Classifications and Grades. PPt 1 – Common Softwood Classifications and Grades	2. Factory and shop or remanufacture lumber - made and graded to be significantly reworked for a specific application, such as doors or windows By its size 1. Boards – nominal thickness is less than 2 in. 2. Dimension lumber – nominal thickness is at least 2 in. and less than 5 in. 3. Timbers – nominal thickness and width are 5 in. or greater By how much it has been dressed or worked 1. Rough lumber – has been sawed and trimmed to length but has not had any of the surfaces smoothed (dressed) 2. Dressed or surfaced lumber – has had at least one surface planed smooth. A piece of lumber designated S2S1E has been surfaced on two sides and one edge. 3. Worked lumber – has been surfaced and had some additional processing, such as cut with a tongue on one edge and a groove on the other so that pieces can be fit together By its grade 1. Grades are based on moisture content, intended use, and the location and size of irregularities, such as knots, splits, decay, and manufacturing defects. 2. The basis for softwood lumber grades is the American Softwood Lumber Standard PS 20-70, which is published by the U.S. Department of Commerce and applied and expanded on by lumber producers, such as the Western Wood Products Association. 3. Most lumber is graded on a number system from 1 to 5, with 1 being the best. There may be additional grades, such as Select. 4. Appearance grades are given to lumber that is used in applications where appearance is important, such as flooring and paneling. They range from A to D, with A being the best. 5. The grade assigned to a piece of lumber is stamped on it and contains the following information. a. Grading agency

Instructor Directions	Content Outline
	b. Species of the wood c. Grade d. Mill identification e. Moisture content when the wood was stamped
Objective 3 *Discuss hardwood classification.*	**Explain how hardwood is classified.** A board's grade is based on the size and number of pieces without defects that can be cut from it. Standards for hardwood are set by the National Hardwood Lumber Association. The general grades of hardwood are as follows: 1. Firsts and Seconds 2. Selects 3. Number 1 Common 4. Number 2 Common 5. Number 3 Common Hardwood may be sold separately by grade or in a combination of grades. Lumber designated FAS would include pieces that were Firsts and Seconds.
Objective 4 *Explain how lumber is measured and sold. This question includes information on calculating board feet. Calculating board feet was discussed in* Agricultural Mechanics Unit for Agricultural Science I, *Unit III Lesson 1. As a review, the instructor can ask students how board feet is figured, if desired.*	**Describe how lumber is measured and sold.** The common unit of measurement for lumber is the board foot. 1. To determine board feet, multiply the thickness of the board in inches by its width in inches by its length in feet and then divide by 12: (T″ x W″ x L′) ÷ 12 = board feet. Label the answer in board feet (BF or bd ft). 2. A board foot is a piece of lumber 1 in. thick, 12 in. wide, and 12 in. long, or 144 cubic in. 3. Stock that is less than 1 in. thick is figured as 1 in. 4. For boards over 1 in. thick, use the nominal size for figuring board feet. 5. Nominal or "name only" size is based on the dimensions of the lumber when it is green and its surfaces are rough. The same piece of lumber will have a smaller actual size after it has been dried and planed. This is why a 2 x 4 has an actual measurement of 1 1/2 in. by 3 1/2 in.

Instructor Directions	Content Outline
	6. Remember to take into account the difference between nominal and actual size when figuring the bill of materials. Orders for lumber should indicate the grade desired and be written in nominal dimensions using standard terms. Softwood is cut to standard thickness, width, and length. Common lengths range from 8 ft to 20 ft in 2-ft intervals. Because hardwoods are in limited supply, they are generally cut and sold in random widths and lengths.
Objective 5 *Discuss how plywood is measured and sold. Refer to PPts 2 and 3.* PPt 2 – Sample Plywood Grade Stamps PPt 3 – Veneer Grades	**Describe plywood and how it is graded and measured.** Plywood is a structural panel made of a core material between two thin sheets of wood called face veneers. Typical plywood cores include additional sheets of veneer, thin boards laid side by side, and composite materials, such as wood chips or pressed paper. Plywood is classified as softwood or hardwood based on the type of wood used for the face veneers. Plywood is also classified based on the type of adhesive used to manufacture it. 1. Exterior grade plywood is made with fully waterproof adhesives. 2. Interior grade plywood uses moisture-resistant adhesives. Both softwood and hardwood plywood are commonly designated by the general grade G2S or G1S, meaning "good two sides" or "good one side." (They may also be referred to as S2S and S1S, meaning surfaced or sanded on one or two sides.) Both softwood and hardwood plywood panels are stamped with grades from the group that oversees their manufacture. This stamp includes information about the panel, including such things as the following. 1. Species of wood on the face veneer 2. Quality of the face veneer

Instructor Directions	Content Outline

	3. Type of adhesive used
	4. Standard governing manufacture
	5. Mill identification
	
	Standards for softwood plywood are set by manufacturers associations, such as the APA-Engineered Wood Association, in accordance with specifications made by the National Bureau of Standards.
	1. Veneer grades are assigned to the front and back face veneer.
	    a. The best grade of veneer is N, which is suitable for a natural finish.
	    b. Other grades range from A to D, with A being the best.
	    c. A typical veneer grade might be A-D, which would indicate a panel with A-grade veneer on one face and D-grade on the other. This type of panel would generally be used for an interior application where the appearance of only one side was important.
	2. The grade stamp also includes a group number.
	    a. All the woods that are used for making softwood plywood are put into one of five groups according to their strength, with one being the strongest.
	    b. The group number is assigned based on the weakest wood used in the face veneer.
	    c. Sanded panels include the exact species of wood as well.
	
	Standards for hardwood plywood
	1. Standards for hardwood plywood are set by the Hardwood Plywood & Veneer Association.
	2. Face veneers are given a number from 1 to 4, with 1 being the best. Specialty cuts can also be ordered.
	3. Like softwood plywood, hardwood plywood is available in a number of different combinations of front and back panel grades.
	
	Plywood is commonly sold by the square foot.
	1. To figure square feet, multiply length in feet by width in feet. Label the answer as square feet or sq. ft.

Instructor Directions	Content Outline
	2. A standard sheet of plywood measures 4 ft by 8 ft and contains 32 sq ft.
Objective 6 *Discuss common steel materials and how they are sold. Pipe and some basic shapes of steel stock are covered below. Refer to PPt 4.* PPt 4 – Dimensions of Steel Stock	**Describe some common steel materials and how they are measured and sold.** Rounds 1. Specify external diameter 2. Standard length is 20 ft Angle iron 1. Specify the width of each leg and the thickness 2. Standard length is 20 ft Flats and strips 1. Specify width and thickness 2. Standard length is 20 ft Channel iron 1. Specify depth of channel and width of flange 2. Standard length is 20 ft Black or galvanized steel pipe 1. Specify inside diameter 2. Standard length is 21 ft
Objective 7 *Discuss additional common building materials that students might need to include on a bill of materials. A few examples are listed below, along with their usual unit of measure. Include any additional materials as needed.*	**Describe some other common building materials and how they are measured and sold.** Items like molding and dowel rod are measured and sold in linear or running feet. 1. Linear feet is a measurement of the actual length of the material. 2. It does not include thickness or width. Roofing is sold by the square (1 square equals 100 sq ft). One bundle of shingles contains 1/3 of a square. Hardware cloth and screening are sold by the linear or running foot. Hardboard, waferboard, and particle board are manufactured in panels, typically 4 ft wide by 8 ft long. They are measured in square feet.

Instructor Directions	Content Outline
Application:	
🖹 Unit VI Activity	Answers to Unit VI Activity Answers may vary. Below are the original construction procedure, cut list, and bill of materials from the feed bunk project. Construction Procedure 1. Cut four 22″ x 3″ channel for the Legs. 2. Cut two 27 1/2″ x 3″ channel for the Crossbraces. 3. Cut two 27 1/2″ x 1 1/4″ Sch 40 pipe for the Stabilizers. See figure 3. 4. Cut two 8′ x 1/14″ Sch 40 pipe for the Runners. 5. Weld the Crossbraces and Stabilizers to the Legs. Use pipe bar clamps to assemble. Check for squareness, tack, and weld. 6. Bend 30 degree angles on the Runners 9″ from the end as shown in figure 2. 7. Notch the bottom of leg assembly to fit the pipe Runners. 8. Drill 5/16″ holes for the carriage bolts as shown in figure 1 and figure 2. 9. Grind all sharp edges smooth, remove weld spatter, prime metal, and paint with enamel paint. 10. Cut two 24 1/2″ x 2″ x 6″ boards for the Center support. 11. Square, mark, and cut seven 8′ x 2″ x 6″ boards for the Floor and Sides. 12. Assemble with 16p nails and carriage bolts. Cutting List 1. 4 - 22″ x 3″ Channel - Legs 2. 2 - 27 1/2″ x 3″ Channel - Crossbraces 3. 2 - 8′ x 1 1/4″ Sch 40 Pipe - Runners 4. 2 - 27 1/2″ x 1 1/4″ Sch 40 Pipe - Stabilizers 5. 7 - 8′ x 2″ x 6″ Boards - Floor and Sides 6. 2 - 24 1/2″ x 2″ x 6″ Boards - Ends 7. 1 - 27 1/2″ x 2″ x 6″ Board - Center Support Bill of Materials 1. 12′ x 3″ Channel Iron 2. 21′ x 1 1/4″ Sch 40 Pipe

Instructor Directions	Content Outline
	3. 8 - 8′ x 2″ x 6″ Lumber 4. 26 - 5/16″ x 2″ Carriage bolts 5. 1# - 16p Nails 6. Metal Primer 7. Enamel Paint Other activities 1. In place of the unit activity, students could draw up a plan of procedure, cutting list, and bill of materials for the project they will be building, if these do not already exist. 2. Ask a knowledgeable representative from a local lumberyard or other building material supply store to speak to the class about grades of lumber that the business carries and how other common building materials are classified and sold.
Closure/Summary	Understanding how building materials are classified, measured, and sold allows a builder to fill out bills of materials correctly and helps ensure that he or she gets the right materials for the job. This lesson includes general information about how some common building materials are classified and the standard units in which they are measured and purchased.
Evaluation: Quiz	Answers: 1. a 2. b 3. d 4. d 5. b 6. d 7. a 8. d 9. d 10. b 11. e 12. a 13. c 14. a. Softwood – Wood cut from coniferous trees (trees that do not shed their leaves) b. Hardwood – Wood cut from deciduous trees (broad-leaved trees that shed their leaves in the fall)

Instructor Directions	Content Outline
	c. Nominal size – Measurement of a board when it is green and has not been planed; boards are sold using their nominal measurements d. Actual size – Measurement of a board after it has dried and has been planed 15. Student should list three of the following: a. How the wood will be used b. By the size of the wood c. By how much the wood has been dressed d. By the grade of the wood 16. a. 28 bd ft b. 16 bd ft 17. a. $24.00 b. $7.68

Unit VI - Material Selection, Plan Reading, and Interpretation

Name___________________________

Lesson 3: Selecting Building Materials

Date____________________________

Assessment

Circle the letter that corresponds to the correct answer.

1. Which of the following is a hardwood?

   a. Ash
   b. Cedar
   c. Pine
   d. Redwood

2. Softwood that has a nominal thickness ranging from 2 in. to 5 in. is called:

   a. Boards
   b. Dimensional lumber
   c. Stock
   d. Timbers

3. Lumber that has been surfaced on all sides and one edge is designated:

   a. G1S
   b. G2S
   c. S2S1E
   d. S4S1E

4. Which grade is the lowest quality for softwood used for finishing?

   a. A
   b. B
   c. C
   d. D

5. Which hardwood grade is the best quality?

   a. Selects
   b. Firsts and Seconds
   c. Number 1 Common
   d. Number 2 Common

6. In a board measurement of 2" x 6" x 16', what does the 6" measurement refer to?

   a. Height
   b. Length
   c. Thickness
   d. Width

7. Which softwood plywood grade is the best quality?

   a. N
   b. C
   c. B
   d. A

8. Plywood is measured and sold by the:

   a. board foot
   b. linear foot
   c. running foot
   d. square foot

Match the description in column B to the correct structural metal in column A.

	A	B
_____	9. Round	a. Shaped like a C
_____	10. Angle iron	b. Two legs that form a 90-degree angle
_____	11. Flats and strips	c. Shaped like a tube
_____	12. Channel iron	d. Bar of solid metal
_____	13. Steel pipe	e. Flat pieces of metal

Complete the following short-answer questions.

14. Define the following terms relating to lumber.

    a. Softwood -

    b. Hardwood -

    c. Nominal size -

    d. Actual size -

15. List three ways that softwood is classified.

    a.

    b.

    c.

16. Calculate the board feet of the following lumber:

    a. Seven boards measuring 1/2" x 4" x 12' = _________ bd ft

    b. Two boards measuring 2" x 6" x 8' = __________ bd ft

17. Calculate the total cost of the following lumber:

    a. Five boards measuring 1" x 8" x 18' and priced at $0.40 per board foot = ______total cost

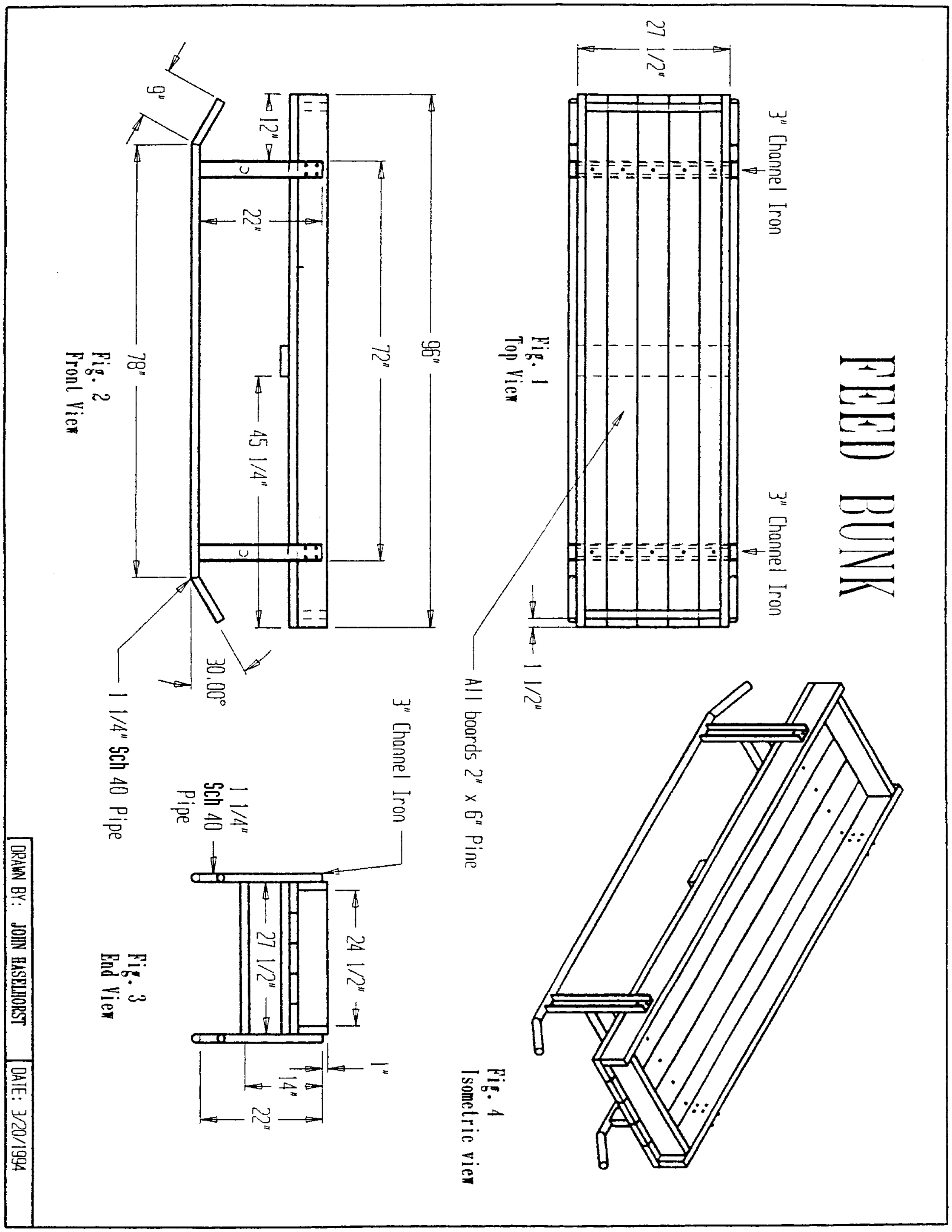
    b. Three boards measuring 2" x 6" x 8' and priced at $0.32 per board foot = ______total cost

Name______________________________

Preparing a Plan of Procedure, Cutting List, and Bill of Materials

Objective: Students will develop a plan of procedure, a cutting list, and a bill of materials from a working drawing of a project.

Directions: Use the working drawing on the other side of this sheet to draw up a plan of procedure, a cutting list, and a bill of materials on separate paper. Review Lessons 1, 2, and 3 in Unit VI as needed. Remember that bills of materials can be written in different ways. Look at bills of materials for other projects made in the shop and set up your bill of materials in a similar way.



Plan reprinted from *Single Sheet Agricultural Mechanics Plans*. University of Missouri-Columbia: Instructional Materials Laboratory, 1994.

Agricultural Science II

Curriculum Guide: *Agricultural Mechanics Unit for Agricultural Science II*

Unit: VI. Material Selection, Plan Reading, and Interpretation

Unit Objective:

Students will demonstrate an understanding of material selection and plan reading and interpretation by devising a plan of procedure, cutting list, and bill of materials for a project.

Show-Me Standards: 1.8, CA3

References:

Agricultural Construction Volume I. University of Missouri-Columbia, Instructional Materials Laboratory, 1989.

Agricultural Mechanics Building Plans. University of Missouri-Columbia, Instructional Materials Laboratory, 1994.

Agricultural Mechanics Plans (Set). University of Missouri-Columbia, Instructional Materials Laboratory.

Agricultural Mechanics Unit for Agricultural Science II. University of Missouri-Columbia, Instructional Materials Laboratory, 2002.

Pastoret, J. *Measurements and Pricing of Primary Wood Materials*. MU Extension. University of Missouri-Columbia. Accessed November 26, 2003, from http://muextension.missouri.edu/explore/agguides/forestry/g05506.htm.

Instructional Strategies/Activities:

- Students will engage in study questions in lessons 1 through 3.
- Additional activities that relate to the unit objective can be found under the heading “Other Activities” in the following locations: p. VI-14 and p. VI-30 (1, 2).

Performance-Based Assessment:

Students will develop a plan of procedure, cutting list, and bill of materials for a project based on a working drawing.

Assessment will be based on the thoroughness and accuracy of the plan of procedure, cutting list, and bill of materials.

Agricultural Mechanics Unit for Agricultural Science II
Unit VI—Material Selection, Plan Reading, and Interpretation
Instructor Guide

The instructor should assign the performance-based assessment activity at the beginning of the unit. Students will work toward completing the activity as they progress through the unit lessons. The assessment activity will be due at the completion of the unit.

1. Have students develop a plan of procedure, cutting list, and bill of materials for a project based on a working drawing.
   a. See the Unit VI Activity, Preparing a Plan of Procedure, Cutting List, and Bill of Materials, pp. VI-45–VI-46, for a project plan and additional details. The activity includes a working drawing for a feed bunk. The plan of procedure, cutting list, and bill of materials for the feed bunk are included on p. VI-31 of the Instructor Guide.
   b. For additional project plans, see *Agricultural Mechanics Building Plans* and *Agricultural Mechanics Plans (Set)*, available from the Instructional Materials Laboratory, University of Missouri-Columbia, accessed November 13, 2003, at http://www.iml.coe.missouri.edu/.
   c. This activity could also be adapted for use with students' class projects, if desired.

2. The student handout for this activity is a cutting list work sheet, a bill of materials work sheet, and a plan of procedure work sheet.
   a. The student handout work sheets are adapted from WS 3.1, Estimated Bill of Materials, p. VI-33, and WS 4.1, List of Tools and Procedures, p. VI-45, of *Agricultural Construction Volume I*, available from the Instructional Materials Laboratory, University of Missouri-Columbia, accessed November 13, 2003, at http://www.iml.coe.missouri.edu/.
   b. For additional work sheets, handouts, and related material, see Unit VI, Project Construction, of *Agricultural Construction Volume I*.

3. The final assessment score will be based on the overall thoroughness and accuracy of the plan of procedure, cutting list, and bill of materials.

4. ADDITIONAL ACTIVITY: Divide the class into groups. Have the groups draw up a purchasing bill of material for the same project but assign each group different materials for the project. Variations in materials could include different types of material and different grades or dimensions of lumber. Have students present their findings to the class. Lead a discussion comparing the bills of materials. Ask students to explain which materials they would use and why.

Agricultural Mechanics Unit for Agricultural Science II
Unit VI—Material Selection, Plan Reading, and Interpretation
Student Handout

Date__________ **Name______________________**

Project Title_______________________

Cutting List

Develop a cutting list from a working drawing.

Number of Pieces	Dimensions	Stock	Part and Use

Date__________

Project Title________________________

Bill of Materials

Determine the materials you will need from a working drawing. Write "N/A" if a heading does not apply to a particular material.

Number of Pieces or Amount of Material	Dimensions	Material

Date__________ **Name_______________________**

Project Title________________________

Plan of Procedure

Develop of plan of procedure from a working drawing.

Construction Procedure

Agricultural Mechanics Unit for Agricultural Science II
Unit VI—Material Selection, Plan Reading, and Interpretation
Scoring Guide **Name** ____________________

Criteria	0 Points	1 Point	2 Points	3 Points	4 Points	Weight	Total
Cutting list includes all necessary materials in their final dimensions	Failed	Poor	Fair	Good	Excellent	X 7.5	
Bill of materials includes all necessary materials in standard dimensions, as well as any fasteners and finish	Failed	Poor	Fair	Good	Excellent	X 7.5	
Plan of procedure includes all steps needed to complete the project	Failed	Poor	Fair	Good	Excellent	X 10	

Final Assessment Total ________/100 pts.

Comments:

Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Painting and Finishing
Lesson	Spray Painting and Finishing
Estimated Time	Three 50-minute blocks

Student Outcome

Identify the safety procedures for spray painting and finishing.
Demonstrate the procedures for spray painting and finishing.
Maintain spray painting and finishing equipment.

Learning Objectives

1. Explain the safety procedures which should be followed when spray painting.
2. Describe what types of spray equipment are available.
3. Identify the major parts of a typical air spray gun.
4. Explain how surfaces are prepared for painting.
5. Describe primer and paint and some considerations for choosing them.
6. Explain the general procedures that should be followed when using spray equipment.
7. Identify some common problems that occur when spray painting.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Types of Spray Systems
   - PPt 2 – Parts of a Spray Gun
   - PPt 3 – Spray Patterns
   - PPt 4 – Positioning the Spray Gun
   - PPt 5 – Spray-Painting Technique
   - PPt 6 – Spray Painting a Panel
   - PPt 7 – Special Spray-Painting Techniques
2. Activity Sheets
   - AS 1 – Spray Painting (Instructor)
   - AS 1 – Spray Painting (Student)
3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit VII – Painting and Finishing." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplies & Equipment

- ❑ See AS 1 for materials and equipment needed to complete the Activity Sheet.

Supplemental Information

1. Internet Sites
   - ❑ Spray Operation Standards. Occupational Safety and Health Administration. U. S. Department of Labor. Accessed October 26, 2007, from http://www.osha.gov/SLTC/sprayoperations/standards.html.
2. Print
   - ❑ Burkybile, C., D. Johnson, J. Lee, and C. Shelhamer. *Agricultural Power and Technology*. Danville, IL: Interstate Publishers, 2005.
   - ❑ Phipps, L. *Mechanics in Agriculture*. 4th ed. Danville, IL: Interstate Publishers, 1992.
   - ❑ Phipps, L. and G. Miller. *Introduction to Agricultural Mechanics*. Upper Saddle River, NJ: Prentice Hall Interstate, 2004.

Interest Approach

Safety with paints and solvents was covered in *Agricultural Mechanics Unit for Agricultural Science I*, Unit VII Lesson 1. Safety with compressed air was discussed in Unit 1, Lessons 1 and 2 of this curriculum. As a review of this material, ask students what safety procedures should be followed when working with paint and compressed air.

Communicate the Learning Objectives

1. Explain the safety procedures which should be followed when spray painting.
2. Describe what types of spray equipment are available.
3. Identify the major parts of a typical air spray gun.
4. Explain how surfaces are prepared for painting.
5. Describe primer and paint and some considerations for choosing them.
6. Explain the general procedures that should be followed when using spray equipment.
7. Identify some common problems that occur when spray painting.

Instructor Directions	Content Outline
Objective 1	**Explain the safety procedures which should be followed when spray painting.**
Introduce the lesson by discussing safety procedures that should be observed when working with spray equipment and finishes. Much of this information is a review of material presented in Agricultural Mechanics Unit for Agricultural Science I, *Unit VII Lesson 1.*	Wear appropriate protective clothing and gear. 1. Safety glasses or goggles to protect the eyes from splattered paints and solvents 2. Approved respirator for all spray painting procedures and for surface preparation that produces dust or toxic fumes 3. Rubber gloves for handling bleaches, solvents, or other caustic materials Work in a well-ventilated area. Supplement natural ventilation with forced ventilation if needed. Keep sparks, flames, and devices that can produce them out of the work area. Have an approved fire extinguisher readily available. Follow safety procedures for all equipment and materials used in preparation or for painting. This includes equipment such as steam cleaners, sanders, and ladders, as well as spray equipment, paints, and solvents. Do not point a spray gun, particularly an airless spray gun, at any part of the body or at anyone else. 1. Liquid is propelled from the airless spray gun with

Instructor Directions	Content Outline
	enough pressure to penetrate the skin. If this happens, get medical attention immediately. 2. Even when the pump is shut off, an airless spray system remains under pressure until the pressure is discharged through the spray gun. Observe safe cleanup procedures. 1. Clean spills as they happen. 2. Use the appropriate solvent or cleaning solution. 3. Store chemicals in approved containers and flammable finishes and solutions in a fireproof cabinet. 4. Dispose of cleanup rags properly. 5. Wash hands after working with chemicals that are toxic or could harm skin.
Objective 2 *Discuss different types of spray equipment. This discussion can be used to give students an overview of some of the systems available and also as an introduction to the type of equipment they will be using in the shop. Shop equipment can be used as a reference point for comparing and contrasting the various systems, if desired. Refer to PPt 1.* PPt 1 – Types of Spray Systems	**Describe what types of spray equipment are available.** Two basic types of spray equipment: air spray and airless 1. Air spray a. Compressed air and finish are mixed and propelled from the spray gun as a fine mist. b. Air spraying produces a high-quality finish and can be used with most finishes, including stain, sealer, and topcoat. c. Because of the large quantities of air mixed with the finish, the air spray system is not as efficient at transferring the finish as the airless spray system is. More paint can be lost to overspray and by bouncing off the surface being painted. 2. Airless spray a. A high-pressure fluid pump is used to deliver finish to the nozzle of the spray gun, where it is broken into small droplets. b. Airless spray is generally more efficient than air spraying, and finish can be applied faster and in heavier coats. c. The airless sprayer does not break up the coating material as finely as the air sprayer does, which means it may produce a lower quality finish.

Instructor Directions	Content Outline
Objective 3 PPt 2 – Parts of a Spray Gun	**Identify the major parts of a typical air spray gun.** Trigger – controls the flow of finish or air and finish through the spray gun Air valve – controlled by the trigger 1. By pulling the trigger halfway, air flows through the spray gun. 2. The trigger is pulled back the rest of the way to begin applying finish. Fluid adjustment screw – controls the amount of the finish flowing through the spray gun Spreader adjustment valve – used to set the spray pattern by controlling airflow through the wing ports Air cap – directs compressed air into the stream of finish to break it up into the desired spray pattern; done by three sets of holes, or ports, in the cap Wing ports – holes in the wings of the air cap; amount of air flowing through the wing ports determines the pattern of the spray Fluid tube – carries finish from the cup to the body of the spray gun Fluid tube screen – keeps any lumps or foreign material from entering the spray gun
Objective 4 *Surfaces must be properly prepared before finishes are applied. Discuss surface preparation of metal and wood.*	**Explain how surfaces are prepared for painting.** Metal 1. Clean any welds by using a chipping hammer and wire brush. 2. Remove surface dirt and grease with a steam cleaner, high-pressure washer, or approved cleaning solution. Do not use gasoline. 3. Remove loose paint and rust and smooth any pitted areas by wire brushing, hand or power sanding, or a combination of techniques. 4. Strip off the old finish if a smooth surface is desired. If the finish is not badly damaged, feather the edges

Instructor Directions	Content Outline
	of chipped areas using sandpaper. (Feathering means tapering the uneven areas of a surface until no roughness or edges can be felt.) 5. Clean surfaces with a preparatory solvent. 6. Use masking tape to cover any areas that should not be painted. 7. Apply an appropriate primer coat. Wood 1. Remove surface dirt and grease using approved cleaning solutions. 2. Apply a sealer to new stock to keep out moisture, which can warp or rot the wood. 3. Remove or repair surface marks, such as mill marks and dents. 4. Remove old paint using paint stripper, a wire brush, or sandpaper. 5. Repair defects and fill holes with caulk or wood filler, as needed. Seal areas requiring filler before filler is applied. Dry wood can pull moisture from the filler, which will cause it to shrink, become loose, and crack the paint. 6. Remove excess glue from surfaces to be painted, if glue has been used for repairs. 7. Sand using fine-grit sandpaper if a smooth finish is desired. 8. Clean surfaces with a tack rag. (A tack rag is a cloth that has been chemically treated so that it will pick up dust and grit.) 9. Use masking tape to cover any areas that should not be painted. 10. Apply an appropriate primer coat.
Objective 5 *Discuss the factors below that influence the choice of a particular primer and finish. The discussion could be expanded by asking students what factors they would consider when choosing a finish or by giving examples of common*	**Describe primer and paint and some considerations for choosing them.** Definitions of primer and paint 1. Primer – undercoating that prepares the surface for painting a. Less surface absorption of paint b. Improves the surface's ability to hold paint c. Improves the paint's ability to adhere to the surface

Instructor Directions	Content Outline
painting jobs and asking students what paint they would use for the job and why.	2. Paint – finish that is made up of a vehicle (usually oil- or water-based) that carries a pigment (the substance that adds color to the paint) Considerations for selecting a primer and paint 1. Intended use a. Indoor or outdoor use b. Need for resistance to water, acids, solvents, or other agents 2. Compatibility a. Paint and primer should be designed to work together. b. Both should be appropriate for the surface being finished. 3. Drying time a. Time needed between applying a primer and a finish coat or between coats of finish varies greatly, depending on the formulation of the individual coating. b. Other factors, such as temperature, can also affect drying time. 4. Type of finish desired a. Flat b. Satin c. Semigloss d. High gloss
Objective 6 *Discuss the basic techniques for spray painting. Supplement with more detailed procedural information as needed. Refer to PPts 3-7.* PPt 3 – Spray Patterns PPt 4 – Positioning the Spray Gun PPt 5 – Spray-Painting Technique	**Explain the general procedures that should be followed when using spray equipment.** Protect against overspray. 1. Droplets of paint can float for long distances, settle where they are not wanted, and ruin good finishes. 2. Items that could be damaged by overspray should be removed from the work area. Prepare the finish. 1. Mix the finish thoroughly. 2. If multiple cans of the same color are to be used, mix them all together to ensure that the color will be uniform when it is applied. 3. Thin the finish, if needed, using an appropriate thinner.

Instructor Directions	Content Outline
PPt 6 – Spray Painting a Panel PPt 7 – Special Spray-Painting Techniques	a. Finish must have the correct viscosity (tendency to flow) for work being done. b. Follow the manufacturer's instructions for the correct ratio of finish to thinner; results can be checked using a viscosimeter. 4. Strain the finish. This is done to remove any lumps or debris in the finish. Adjust the spray gun. 1. Set up the equipment. Follow all assigned procedures for safe and correct use of the equipment. 2. Test the spray pattern. a. Hold the spray gun the correct distance from a piece of paper, cardboard, or scrap material and briefly press the trigger. b. For air spray systems, the correct distance is approximately 8 in. 3. Make any corrections to the spray pattern, if needed. a. Normal spray pattern - If the pattern is normal, the equipment is ready for use. b. Split spray pattern – This pattern is usually caused by the air pressure being too high or by trying to get too wide a spray with thin material. – To correct, reduce the air pressure or open the fluid adjustment screw slightly and close the spreader adjustment valve slightly. – Recheck the spray pattern and adjust until the correct pattern is reached. c. Fan spray pattern – A top- or bottom-heavy pattern is generally caused by dried material around the nozzle blocking airflow. – To correct, remove the air nozzle and clean the fluid tip using a rag and appropriate thinner. – This pattern can also be caused by a loose air nozzle or a bent fluid nozzle or needle tip. – To correct, tighten the air nozzle or replace the fluid nozzle or needle tip, if needed. d. Crescent spray pattern – A pattern that is heavy on one side is caused by dried material blocking airflow through a wing port.

Instructor Directions	Content Outline
	– To correct, clean the port using thinner. Do not use metal tools to clean nozzle openings. Paint the surface. 1. Hold the spray gun the correct distance from the work at a 90-degree angle. 2. Tipping the spray gun up or down results in an uneven finish. 3. Move the spray gun parallel to the surface being painted. Moving the gun in an arcing motion results in thin spots at the points where the gun is far away from the work and thick spots where it is close to it. 4. Paint edges and corners first. 5. For flat areas, use the following techniques. a. Make the first pass at the top of the panel, moving left to right. b. Aim the spray gun so that the middle of the spray pattern is at the top edge of the panel. c. Start each pass at a point 2 to 3 in. outside the panel. d. While the gun is in motion, pull the trigger and move across the panel at a constant rate of speed. e. Release the trigger while the gun is still moving. Starting and stopping the paint flow while the gun is in motion prevents an excessive buildup of paint where passes overlap. f. Move down and make the second pass, moving from right to left. This pass should overlap the previous one by 50%. g. Continue painting, alternating left and right passes, until the panel is completed. 6. Special techniques for some surfaces a. Use a vertical spray pattern for thin vertical pieces. b. Paint inside corners as though they were two flat surfaces. c. Use a banding technique to paint narrow edges. d. Use a horizontal spray pattern to paint outside corners. Aim the gun so that the middle of the spray pattern is at the edge of the corner. Clean the spray gun. 1. Empty the paint cup. Store the material in an

Instructor Directions	Content Outline
	appropriate, labeled, sealed container, or dispose of it properly. 2. Follow the manufacturer's recommendations and instructor's directions for correct cleaning procedure for the equipment used. 3. Use the appropriate cleaning solution for the material that was sprayed. 4. Use cleaning solution to clean any dried material from the air cap. Do not use wires or other metal objects to clean orifices on the paint gun. 5. Dry all parts and reassemble the spray gun. 6. If the sprayer has been used to spray water-based material, such as latex paint, run mineral spirits through the gun to remove any moisture and keep the gun from rusting. 7. Dispose of all clean-up materials safely and properly. 8. Return all materials and equipment to their proper places.
Objective 7 *If painters are able to recognize common finishing problems, they can avoid making the same mistakes and better protect their buildings and equipment. Some common finishing problems are discussed below. Examples of these or other finishing problems can be shown to students to illustrate or expand on this question. When discussion of these study questions is completed, AS 1 should be used. The student version of this activity should be assigned to evaluate student competency.* 🖹 AS 1 – Spray Painting	**Identify some common problems that occur when spray painting.** Runs and sags 1. Possible causes a. Finish applied too heavy b. Gun operated too close to surface c. Finish mixed too thin d. Fluid pressure too high e. Speed of operation too slow 2. Corrective actions a. Learn to calculate depth of wet finish. b. Operate spray gun farther from work. c. Add enough finish to produce the correct viscosity. d. Use fluid control knob to reduce fluid pressure. e. Increase speed of operation. Streaks 1. Possible causes a. Gun operated too far from surface b. Passes not overlapped properly c. Air pressure too high d. Speed of operation too fast

Instructor Directions	Content Outline
	2. Corrective actions a. Operate gun closer to surface. b. Follow previous pass more accurately. c. Reduce air pressure. d. Decrease speed of operation. Orange peel 1. Possible causes a. Finish not properly thinned b. Overspray striking tacky finish c. Pressure too high or too low 2. Corrective actions a. Add enough thinner to produce correct viscosity. b. Adjust spraying sequence or procedure. c. Adjust pressure as needed. Rust 1. Possible cause – poor surface preparation 2. Corrective action – remove finish and rust, treat with an appropriate primer coat, and refinish.
Application: AS 1 – Spray Painting	AS 1 Results will vary. Other activities 1. Ask an auto collision repair specialist or other professional spray painter to give a presentation to the class about spray painting. Areas that could be covered include safety procedures, setting up equipment, preparing surfaces and finishing materials, techniques for applying spray paint, and methods for avoiding common painting defects. Have students prepare questions for the presenter before the visit.
Closure/Summary	Proper surface preparation is critical for good painting results, whether working with metal or wood surfaces. Selecting the appropriate primer (an undercoat) and paint (a finish made up of a vehicle and a pigment) depends on such factors as intended use, compatibility, drying time, and desired finish. Steps in the spray-painting process include protecting against overspray, preparing the

Instructor Directions	Content Outline
	finish, adjusting the spray gun, painting the surface, and cleaning the spray gun. Recognize and avoid common problems such as runs and sags, streaks, orange peel, and rust. Apply spray paint safely by wearing protective clothing, working in a well-ventilated area, avoiding sparks and flames, and following all safety procedures recommended by the manufacturer and instructor.
Evaluation: Quiz	Answers: 1. c 2. d 3. a 4. d 5. c 6. b 7. a 8. c 9. d 10. b 11. a. Air spray equipment – uses compressed air b. Airless spray equipment – uses high pressure created by fluid pump 12. a. Trigger b. Air valve c. Fluid adjustment screw d. Spreader adjustment valve e. Air cap f. Wing ports g. Fluid tube h. Fluid tube screen 13. Student should list two of the following. a. Treats surface so less paint is absorbed b. Improves surface's ability to hold paint c. Improves paint's ability to adhere to the surface 14. Student should list two of the following. a. Intended use (e.g., inside or outdoors) b. Compatibility of primer and paint with each other and surface to be painted c. Drying time for primer and paint d. Type of finish desired (e.g., flat, satin, semigloss, and high gloss) 15. Student should list two of the following. a. Split spray pattern – This problem can be corrected by reducing the air pressure or opening

Instructor Directions	Content Outline
	the fluid adjustment screw slightly and closing the spreader adjustment valve slightly. b. Fan spray pattern – This problem can be corrected by cleaning the nozzle and fluid tip with thinner, tightening the air nozzle, or replacing the fluid nozzle or needle tip. c. Crescent spray pattern – This problem can be corrected by cleaning the port with thinner. 16. Finishing material can dry in the equipment causing it to be inoperable.

Lesson 1: Spray Painting and Finishing

Spray Painting

Objective: Students will observe how to finish a project using spray equipment.

Directions: Use spray equipment to apply primer and finish.

Materials and Equipment:

Spray equipment and accessories
Safety goggles*
Respirator
Rubber gloves and any other protective clothing recommended by instructor
Wooden paint stirring paddle
Unpainted shop project
Appropriate paint
Compatible primer
Thinner
Solvent cleaner
Paint strainers
Masking tape
Clean cloths
Clean containers for mixing and storing paint
Paper, cardboard, or scrap material for testing spray pattern
Mineral spirits to clean spray gun, if water-based finish is used

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear, a respirator, and any other protective clothing as needed.

Procedure:

1. Wear appropriate safety equipment.
2. Demonstrate the correct procedure for preparing the surface to be finished. Steps for preparing wood and metal were covered under learning objective 4. That material and any additional material on surface preparation discussed in class can be presented again as a review. Procedures include, but aren't limited to, the following.
   a. Clean the surface.
   b. Repair surface imperfections.
   c. Use masking tape to cover areas that should not be painted.
3. Prepare the primer coat following the manufacturer's instructions.
4. Demonstrate the correct procedure for setting up the spray equipment.
   a. Set air pressure.
   b. Adjust the spray gun.
   c. Test the spray pattern using the paper or cardboard.
   d. Make any adjustments to the spray pattern, if needed.

5. Demonstrate the correct procedure for applying primer with the spray equipment using techniques discussed in the lesson and following an appropriate spraying sequence.
   a. Hold the gun the correct distance from the work. For air spray equipment, this is approximately 8 in.
   b. Paint corners and edges first.
   c. Keep the gun at a 90-degree angle to the work.
   d. Move the gun parallel to the work through the whole pass.
   e. Begin and end spraying with the gun in motion.
   f. Overlap passes by 50%.
6. Demonstrate the correct procedure for cleaning the spray gun.
   a. Empty the paint cup.
   b. Use an appropriate solvent for cleaning.
   c. Do not use wires or other metal objects to clean orifices on the paint gun.
   d. Dry all parts and reassemble the spray gun.
   e. If the sprayer has been used to spray water-based material, run mineral spirits through the gun to remove any moisture and keep the gun from rusting.
   f. Dispose of cleaning cloths properly.
   g. Dispose of or store any unused primer properly.
7. When the primer coat is dry, demonstrate the correct way to prepare the finish.
   a. Mix the finish.
   b. Thin the finish, if needed.
   c. Strain the finish.
8. Finish the project using an appropriate spraying sequence.
9. Clean the spray gun.
10. Dispose of cleaning cloths properly.
11. Dispose of or store any unused finish properly.
12. Assign the student version of AS 1 to be performed by students.

Lesson 1: Spray Painting and Finishing

Spray Painting

Objective: Students will finish a project using spray equipment.

Directions: Students will use spray equipment to apply primer and finish.

Materials and Equipment:

Spray equipment and accessories
Safety goggles*
Respirator
Rubber gloves and any other protective clothing recommended by instructor
Wooden paint stirring paddle
Unpainted shop project
Appropriate paint
Compatible primer
Thinner
Solvent cleaner
Paint strainers
Masking tape
Clean cloths
Clean containers for mixing and storing paint
Paper, cardboard, or scrap material for testing spray pattern
Mineral spirits to clean spray gun, if water-based finish is used

* Everyone participating in or observing the demonstration should wear appropriate protective eyewear, a respirator, and any other protective clothing as needed.

Procedure:

1. Wear appropriate safety equipment.
2. Prepare the surface to be finished following assigned steps. Procedures include, but aren't limited to, the following.
   a. Clean the surface.
   b. Repair surface imperfections.
   c. Use masking tape to cover areas that should not be painted.
3. Prepare the primer coat following manufacturer instructions.
4. Set up the spray equipment following assigned procedure.
   a. Set air pressure.
   b. Adjust the spray gun.
   c. Test the spray pattern using the paper or cardboard.
   d. Make any adjustments to the spray pattern, if needed.

5. Apply primer with the spray equipment using techniques discussed in the lesson and following an appropriate spraying sequence. Refer to Figures 1 and 2.
   a. Hold the gun the correct distance from the work. For air spray equipment, this is approximately 8 in.
   b. Paint corners and edges first.
   c. Keep the gun at a 90-degree angle to the work.
   d. Move the gun parallel to the work through the whole pass.
   e. Begin and end spraying with the gun in motion.
   f. Overlap passes by 50%.
6. Clean the spray gun.
   a. Empty the paint cup.
   b. Use an appropriate solvent for cleaning.
   c. Do not use wires or other metal objects to clean orifices on the paint gun.
   d. Dry all parts and reassemble the spray gun.
   e. If the sprayer has been used to spray water-based material, run mineral spirits through the gun to remove any moisture and keep the gun from rusting.
   f. Dispose of cleaning cloths properly.
   g. Dispose of or store any unused primer properly.
7. When the primer coat is dry, prepare the finish.
   a. Mix the finish.
   b. Thin the finish, if needed.
   c. Strain the finish.
8. Finish the project using an appropriate spraying sequence.
9. Clean the spray gun.
10. Dispose of cleaning cloths properly.
11. Dispose of or store any unused finish properly.
12. Return materials and equipment to their assigned places.
13. Turn in work to be graded by the instructor.

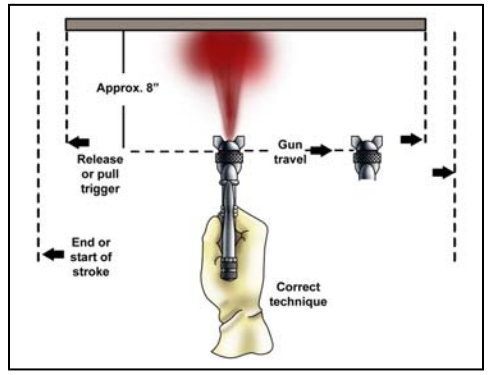


Figure 1

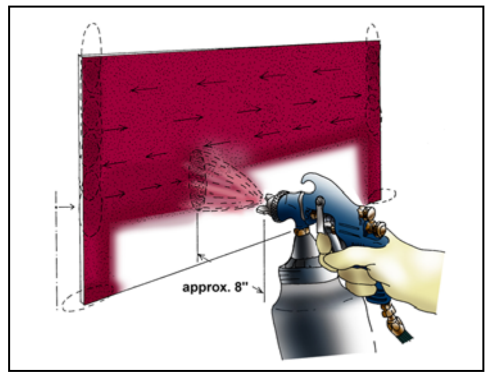


Figure 2

Unit VII - Painting and Finishing

Name________________________

Lesson 1: Spray Painting and Finishing

Date________________________

Assessment

Circle the letter that corresponds to the correct answer.

1. When compared with airless spray equipment, a correct statement about air spray equipment is it:

   a. creates less overspray of finish.
   b. delivers the finish more quickly.
   c. produces a higher quality finish.
   d. uses a higher degree of pressure.

2. Which part of a spray gun controls the shape of the spray pattern?

   a. Air cap
   b. Air valve
   c. Fluid adjustment screw
   d. Spreader adjustment valve

3. If the paint on a wood or metal surface is in bad condition, what should be done to the old paint before repainting?

   a. Strip it off.
   b. Feather the edges.
   c. Clean it thoroughly.
   d. Apply primer over it.

4. What must many paints be mixed with before they can be used in spray equipment?

   a. Acid
   b. Cleaner
   c. Primer
   d. Thinner

5. When painting with a spray gun, at what angle should the gun be held?

    a. 55 degrees
    b. 65 degrees
    c. 90 degrees
    d. 100 degrees

6. How many inches should a spray gun be held from the surface being painted?

    a. 4
    b. 8
    c. 12
    d. 16

7. When painting with spray equipment, what is the proper way to move the gun?

    a. In a straight line
    b. In an arcing motion
    c. With a twisting motion
    d. With an up and down movement

8. When spray painting, what percentage of the previous pass should be overlapped?

    a. 20%
    b. 40%
    c. 50%
    d. 70%

9. One possible cause of runs or sags in a paint job is:

    a. operating the gun too far from the surface.
    b. setting the fluid pressure too low.
    c. using finish that is too thick.
    d. moving the gun too slowly.

10. One possible cause of streaks in a paint job is:

    a. operating the gun too close to the surface.
    b. not overlapping passes properly.
    c. setting the air pressure too low.
    d. moving the gun too slowly.

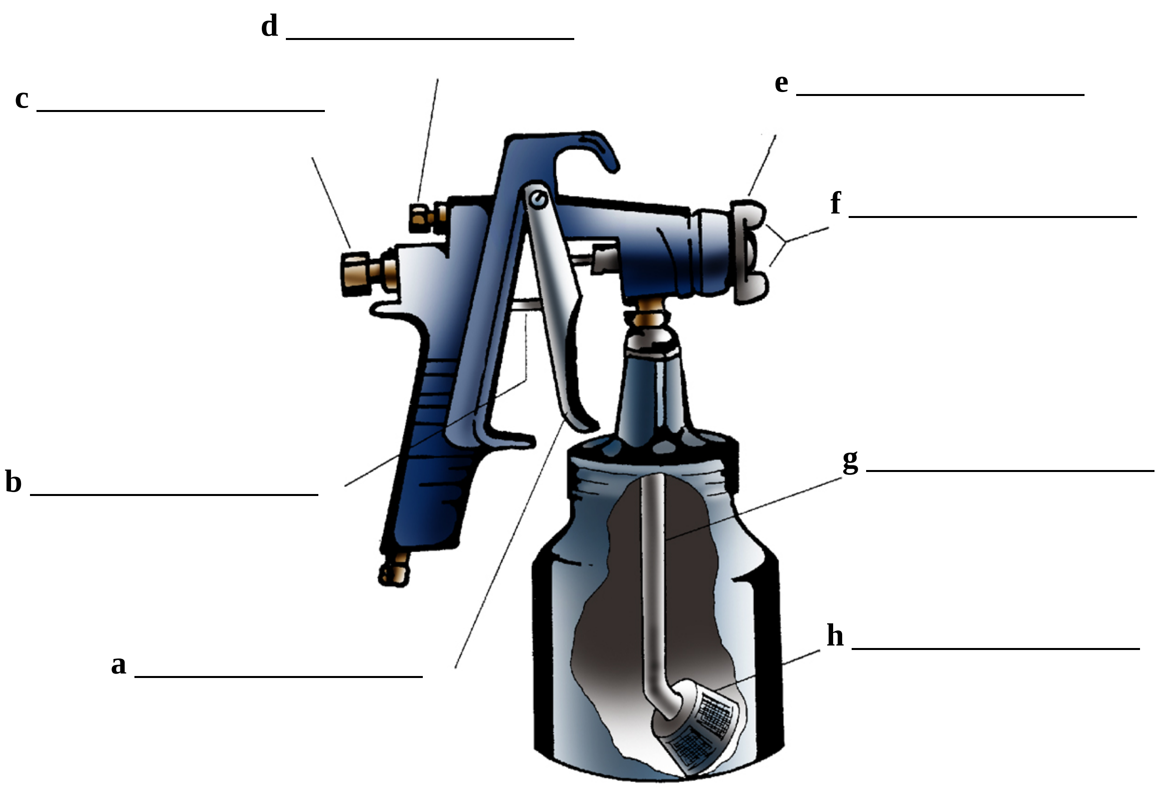
Complete the following short-answer questions.

11. What does each system below use to atomize the finish?

a. Air spray equipment -

b. Airless spray equipment -

12. Label the parts of the spray gun below.



13. List two benefits of applying primer to a surface before painting.

  a.

  b.

14. List two factors to consider when choosing primer and paint.

  a.

  b.

15. List two kinds of undesirable spray patterns and how to correct each one.

  a.

  b.

16. What can happen if the spray equipment is not cleaned after every use?

Agricultural Science II

Curriculum Guide: *Agricultural Mechanics Unit for Agricultural Science II*

Unit: VII. Painting and Finishing

Unit Objective:

Students will apply principles of painting by finishing a project using air spray or airless spray equipment.

Show-Me Standards: 2.5, CA3

References:

Agricultural Construction Volume II. University of Missouri-Columbia, Instructional Materials Laboratory, 1989.

Agricultural Mechanics Unit for Agricultural Science II. University of Missouri-Columbia, Instructional Materials Laboratory, 2002.

Healthy Indoor Painting Practices. U. S. Consumer Product Safety Commission. Accessed November 25, 2003, from http://www.cpsc.gov/cpscpub/pubs/456.pdf.

Safe Use, Storage and Disposal of Paint. Household Hazardous Waste Project. MU Extension. University of Missouri-Columbia. Accessed November 20, 2003, from http://muextension.missouri.edu/explore/wasteman/wm6001.htm.

Instructional Strategies/Activities:

- Students will engage in study questions in lesson 1.
- Students will complete AS 1.1, Spray Painting.
- Additional activities that relate to the unit objective can be found under the heading “Other Activities” in the following location: p. VII-8.

Performance-Based Assessment:

Students will finish a project using air spray or airless spray equipment. Acceptable projects would include those made for the Agricultural Science II class or outside projects that the instructor determines are appropriate for the curriculum. Students will choose the appropriate primer, paint, and other necessary supplies.

Assessment will be based on the overall quality of the work and the ability to safely and correctly complete the project within the available time.

Agricultural Mechanics Unit for Agricultural Science II
Unit VII—Painting and Finishing
Instructor Guide

The instructor should assign the performance-based assessment activity at the beginning of the unit. Students will work toward completing the activity as they progress through the unit lessons. The assessment activity will be due at the completion of the unit.

1. Use or adapt AS 1.1, Spray Painting, to assess student competency at painting with spray equipment. Review or supplement the lesson as needed, based on student mastery of these procedures and the equipment the students will be using. **NOTE: Students should only complete this performance-based activity if they have mastered all the relevant competencies and have the instructor's permission to perform the activity.**

2. For the performance-based assessment activity, have students apply the skills and procedures discussed in the unit to finish a project using spray painting equipment.
   a. Choose projects based on the skill level of the students and the time available to work on the project. For example, if students built projects for the Agricultural Science II class, have them paint these projects.
   b. If students bring in outside projects to be painted, screen these projects to determine if they are appropriate for the curriculum and can be completed in the time available.

3. Have students choose appropriate primer, paint, and other necessary supplies. Review and approve students' material and equipment selection before they begin working.

4. The student handout for this activity is a Project Completion Checklist and Project Evaluation Checklist. Students can use the checklists to track the progress of their project and evaluate their work. Supplement or modify the student handout to reflect actual projects as needed.

5. Have students turn in their completed projects.

6. The final assessment score will be based on the overall quality of the work and the ability to safely and correctly complete the project within the available time.

Agricultural Mechanics Unit for Agricultural Science II
Unit VII—Painting and Finishing
Student Handout

Name______________________

Use the Project Completion Checklist and Project Evaluation Checklist to track the progress of your project.

Project Completion Checklist

Procedure	**Date Due**
❑ Master all competencies necessary to complete the project.	
❑ Receive instructor approval for the materials and equipment you plan to use. Are they appropriate for the project?	
❑ Review safety precautions for the materials and equipment you will use. You can lose points for not following safety precautions and other assigned procedures.	
❑ Prepare the project surface.	
❑ Apply the primer coat.	
❑ Paint the project.	
❑ Clean all equipment using the appropriate cleaner. Return the equipment and materials to their proper place and dispose of rags and other hazardous materials properly. You can lose points for not following assigned cleanup procedures.	
❑ Perform a quality control inspection of the project following completion. Use the Project Evaluation Checklist.	
❑ Turn in the completed project. Your final assessment score will be based on the overall quality of the work and your ability to safely and correctly complete the project within the available time.	

Project Evaluation Checklist

Quality Control and Shop Procedures	**Criteria**
Quality of Work	❑ Primer is appropriate for the project. ❑ Primer is properly applied. ❑ Paint is appropriate for the project. ❑ Paint is properly applied. ❑ Paint job is of high quality and pleasing to the eye: no runs, streaks, or orange peeling. ❑ Project is good enough to sell. ❑ Work was completed on time.
Safety and Work Habits: Observe these safety procedures whenever you are in the shop.	❑ Know how to use the equipment and materials before you attempt to use them. Only use equipment and materials the instructor has approved you to use. ❑ Wear appropriate personal protective equipment. ❑ Follow safety guidelines from your instructor and safety information on labels, equipment, and signs in the work area. ❑ Do not use primers, finishes, or other products with missing or unreadable labels. ❑ Follow assigned setup and cleanup procedures. ❑ Return equipment and materials to their assigned places.

Agricultural Science II

Agricultural Mechanics Unit for Agricultural Science II
Unit VII—Painting and Finishing
Scoring Guide **Name** ____________________

Criteria	0 Points	1 Point	2 Points	3 Points	4 Points	Weight	Total
Primer is appropriate and properly applied	Failed	Poor	Fair	Good	Excellent	X 5	
Paint is appropriate and properly applied	Failed	Poor	Fair	Good	Excellent	X 5	
Paint job is of high quality and pleasing to the eye	Failed	Poor	Fair	Good	Excellent	X 5	
Project is good enough to sell	Failed	Poor	Fair	Good	Excellent	X 5	
Work was completed on time	Failed	Poor	Fair	Good	Excellent	X 5	
Student followed all safety precautions	**Passed**				**Failed**	**X (-25)**	Negative Points *
Student followed all assigned procedures	**Excellent**	**Good**	**Fair**	**Poor**	**Failed**	**X (-10)**	Negative Points *
TOTAL							

Final Assessment Total ________/100 pts.
***Overall combined score cannot be below 0.**

Comments: