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/popriveter.
   - ❑ 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