

# 4-H Wood Science

## Leader Guide

4-H 442L  
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## Introduction

Congratulations! You are embarking on an adventure in working with wood and tools. The experience can be fun and educational for you and for your members. This guide has been designed to introduce you, the leader, to the exciting world of wood science and woodworking.

As a leader in the 4-H Wood Science Program, you hold a key position in the lives of your 4-H'ers. You may start a child toward a noble career or help develop an avocation in woodworking or wood science that will last throughout his or her lifetime. If you enjoy working with young people and like woodworking and wood science, you will find the time and effort spent as a 4-H leader most rewarding.

## Objectives

The objective of the 4-H wood science program is to help boys and girls develop leadership skills, character, and citizenship responsibilities by sharing woodworking experiences. Realizing that youth have their own individual backgrounds, talents, experiences, and aspirations, the aim of this program is to accept boys and girls where they are in terms of woodworking knowledge and skills, and to help them build upon their current levels of attainment until they are able to achieve personal goals, which they have set for themselves, in the wood science project.

Woodworking provides one of the best “learn by doing” opportunities in 4-H. Members almost have an unlimited scope of interesting, educational challenges including designing, constructing, finishing and refinishing, analyzing, identifying, and experimenting with numerous woods, tools, processes, and materials. Many youngsters, especially senior 4-H'ers, can build or design their own work areas; procure tools, machines, and equipment; design and build their own work benches and tables; and make tool panels, too. 4-H'ers can have many positive experiences while making useful articles for home, school, and/or recreational use. With the help of this guide, you will be able to plan and conduct enjoyable, educational activities and experiences for youth.

The 4-H wood science program gives youth opportunities to:

- Develop leadership abilities, build character, and assume citizenship responsibilities
- Develop an understanding and appreciation of the many products from the forest

- Acquire knowledge and develop skills in the selection and appropriate use of various types of wood and wood products
- Acquire knowledge and develop skills in the selection, care, and safe use of woodworking tools and machinery
- Explore career opportunities associated with the manufacture and utilization of forest products
- Develop an awareness for business and economics of the forest products industry





## Working with Young People

How can the wood science program be tailored to the needs of boys and girls at different levels of maturity? In general, young people at certain ages have identifiable characteristics. The subject matter and style of presentation can usually be tailored to meet the needs of various age groups. Some of the characteristics of three groups are identified:

### 9–12 Year Olds

- Are active
- Are interested in tangible ideas, not abstract
- Have short attention span
- Need and accept guidelines from adults and teens
- Like group activities
- Are easily motivated, eager to try new things
- Need recognition and praise
- Like to be with members of their own sex

### 13–15 Year Olds

- Like to explore community beyond immediate neighborhood
- Have a broadened span of interests
- May find it hard to accept help from older people
- Are beginning to think of what they'll do when they grow up
- Are often questioning
- Are often self conscious

### 16–19 Year Olds

- Look toward adulthood and career
- Have longer attention span

- Are developing selected interests; choose a few and study fully
- Handle abstractions; understand principles behind ideas
- May understand that there are no simple answers
- Work cooperatively with adults
- May be ready to give leadership to younger club members
- Need guidance regarding vocations
- Desire and need a strong voice in planning own activity
- Are interested in traveling

These characteristics are only generalizations and should be used as a base for dealing with youth. Each 4-H'er has his or her own unique qualities.

### Your Challenge

An effective 4-H leader is an adult or teen who makes it possible for 4-H'ers to get together as a group to learn to do things they would not do alone. A successful leader offers security, suggestions, and support; has the confidence of the members; understands their viewpoint; is tolerant, patient, and sympathetic. A leader makes friendly suggestions that will encourage members to broaden their educational experiences, and the wise leader recognizes work well done in such a way that 4-H'ers will be encouraged to do even better. The group is only meaningful when the individual members are the doers and the learners. 4-H teaches "learning by doing." Remember, members' mistakes can actually be helpful learning experiences. The "leader" is really a helper, and leadership is "helpership." As your 4-H'ers grow and develop in their wood science program, they too can become helpers of others.

### Tips for Helpership in Wood Science and Woodworking

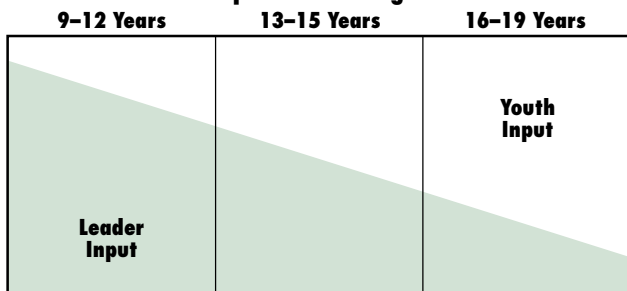
1. Read the section called "Basic Information About Wood" found in this leader guide.
2. Obtain a set of the member manuals that accompany this guide and study them together. Become familiar with all the project materials.
3. Familiarize yourself with available resources and use them. (See the "Resources" section in the back of this manual.)
4. Help members set goals they can realistically meet. Help them plan and select woodworking projects that suit their age and abilities.
5. Don't do project work for members.
6. Familiarize yourself with the woodworking tools, materials, and machinery being used in this project.

### Hints for Working With Young People

As an effective leader, you want to remember that at each age level there is a need to emphasize different skills and provide different degrees of leader input. As members grow older or progress in projects, the need for leader guidance decreases.

You will want to be aware of your members' development and reinforce positive attitudes. The characteristics listed here for the various age levels may help you in planning your role as a 4-H leader.

Proportions of Leader Input and Youth Input at Three Age Levels





Supervise members whenever using tools and machinery, especially power tools.

7. Avoid comparing the progress of one member with that of another.
8. Praise members for a job well done.
9. Help members get to know themselves, including their strengths and weaknesses.
10. Don't determine or direct all of the group's activities. Let the members share in the planning.
11. Solicit the help of parents, families, and friends, when needed.

## Program Division

The national 4-H wood science program literature is divided into three units. Units are planned as 1-year projects. After Unit I, each additional unit becomes more difficult than the preceeding one. Ideally, a 9- to 12-year-old member will enroll in Unit I the first year and in a new unit each of the following years.

Every member should have the program manual that corresponds to the unit in which he or she is enrolled. As a 4-H wood science program leader, you should have copies of all manuals used by your members.

**Unit I "Working With Wood and Tools"** presents elementary information about wood structures. It explains how to buy and use lumber and plywood. It tells how to measure, mark, cut, sand, and smooth wood, how to use glues and finishes, and how to use a variety of beginner woodworking tools, such as crosscut and coping saws, C clamps, and electric woodburning tools. Woodworking plans are included for making simple items from wood.

**Unit II "The Wonderful World of Wood"** is designed to help 4-H members continue to grow in their ability to create and assemble items of wood. It discusses more sophisticated processes and tools than those found in Unit 1. It tells the steps involved in converting trees into wood products. It discusses grains, how warping and swelling affect the use of wood, how to use the grid system to make patterns of irregular shaped objects, and introduces additional woodworking tools. The combination square, pencil compass, hand drill, bit brace and auger, and rip and compass saws are included. Electric tools and safety rules for using them are introduced. The electric drill, jig and saber saws, and oscillating sander are presented. Woodworking plans are provided for utilizing these tools.

**Unit III "Building Bigger Things"** covers the physical structure, properties, and characteristics of wood, and helps members better understand how the properties of wood affect its use. It tells how woods are named and classified, discusses economics of the forest

products industry, and introduces more woodworking tools and machinery. Simple activities and experiments are included to help members learn more about wood.

### Project Records

The 4-H project record is important. It helps the 4-H'er remember what has been done, and it serves as a kind of measuring stick. The recorded information keeps both the member and leader informed of progress being made in the project. A record form is available for this project. Record forms may be supplied by the local Extension office or State 4-H office. Contact your local 4-H office for further information.

## Your Job as a Leader

### Leader Liability

The question of liability is very difficult to answer. Generally speaking, the 4-H leader is not liable unless proven negligent. The liability clause of homeowners' insurance policies will give protection in some cases. It is wise to ask your insurance representative for details. Some 4-H leaders subscribe to a group accident insurance. If you are interested in a policy of this type, ask your insurance representative, or contact the person in charge of 4-H in your local area.

### Budgeting Your Time

The time you devote as a wood science program leader will vary with the number of members in your group and the extent of your involvement with them, the type of activities you provide, and the goals you and your 4-H'ers establish. It is important that sufficient time be devoted by both adult and teen leaders to operate a safe, effective, educational program. In budgeting your time, consider the following:

1. Beginning leaders should plan to attend leader-training meetings held in their area.
2. Plan adequate time for studying both the leader's guide and the member manuals.
3. Provide sufficient time to plan thoroughly the organization of all meetings, including pledges, inspirational sessions, recreation, and refreshments, if they are appropriate.
4. Plan for "hands on" workshops in addition to other meetings. Ninety-minute workshop-type meetings may be ideal for younger members, while 120- to 150-minute sessions might be more acceptable for older 4-H'ers.
5. Provide sufficient time to help all members individually, particularly those with special needs. In the wood science area, "shortcuts," missing procedural steps, and limited instruction are dangerous and educationally limiting.



6. Provide sufficient time for both leaders and members to exhibit at local fairs, 4-H congresses, conferences, and wherever they have the opportunity.

Schedule meeting times so that members will have an opportunity to plan and participate in “learning” and “doing” experiences. Put forth a special effort to meet the goals of members, teen leaders, and other adult leaders. Finally, plan time with individual members to evaluate their accomplishments and the achievements of the club or group.

## Facilities for Meetings

The facilities necessary for 4-H wood science meetings will vary according to the number in the group, the type of meeting planned, the time of year, and weather conditions. Developing “learning” and “doing” goals can be accomplished in any number of informal, leisure type situations; for example, while sitting in the shade of a tree or in a leader’s basement. Activities such as nail driving contests can be held in similar places. Learning situations such as demonstrating how to drive, pull, and straighten nails with a hammer can be conducted on an old table out-of-doors, or in a garage or basement area.

Ideally, the workshop area should be maintained for 4-H wood science club meetings. It should include work and storage space for materials and equipment for as many youngsters as are in the club. Safety, of course, is foremost in determining the amount of space needed. Younger members working on small items may need only limited space. As both 4-H’ers and their projects grow throughout the year, it may be necessary to expand the work area.

Temporary work benches may be constructed by attaching homemade vises to pieces of plywood securely fastened to the top of sawhorses. One 4’ x 8’ area should provide adequate space for six people by making one station at each end and two on each side. Stop blocks and bench hooks should be provided as holding devices. The bench vises may be attached directly to the plywood. However, many leaders prefer to attach a vise to a smaller piece of plywood and then fasten the assembled unit to the plywood with screws.

## Planning Program Meetings

Initiative, enthusiasm, and organizational ability are good attributes in planning meetings. Many leaders will have grown far beyond the need for the detailed instructions which follow. However, a new wood science program leader may find these suggestions helpful for starting and conducting meetings.

## First Meeting

### Preparation

1. Obtain a list of club or group members, a set of wood science literature for each member, and tools and materials to be displayed in the work area to help generate interest.
2. Decide on the date and time of the meeting (both starting and ending), location of the meeting, method or plan for conducting the meeting, and items the members should provide.
3. Notify members and other project leaders by one or more of the following methods:
  - Announcement at a general club meeting
  - Announcement in the club newsletter
  - Send a card or letter to members and leaders
  - Telephone, with the assistance of junior leaders or older members.

A communications committee will save you many hours of work.

### Conducting the First Meeting

1. Meet the members in a friendly manner. Help everyone involved get acquainted.
2. See that the group is orderly before starting the meeting. After the group has settled, describe the project and activities. Have the members look over the literature.
3. Physical activities provide a good beginning. Consider a nail-driving relay contest. Select two members as team captains and have the 4-H’ers divide into two groups. One hammer to each team and two nails per person is adequate.
4. Regroup the members. Lead them to develop goals for themselves and for the group. Put special emphasis on goals for “learning” and “doing.”
5. Another brief activity might be appropriate. A repeat of the nail-driving contest or some other physical activity will keep the members interested, lively, and help develop their enthusiasm.
6. If the group is to be developed formally, lead the members into electing officers. If the members are strangers, it may be important to have “get acquainted” games and maybe a “biographical” session in order that members may learn leadership qualities of others.
7. Prepare for the next meeting. Invite a few older members to give short informational demonstrations. Have the 4-H’ers and leaders outline what they would like to do at the second session.
8. Set the date and location of the next meeting.
9. Adjourn the meeting.



## Suggestions for Demonstrations and Educational Activities

1. Demonstrate one or more ways to use trace patterns.
2. Illustrate the nomenclature of various tools, including the coping saw, framing square, crosscut and rip saws, wood rasps, multi-blade forming tools, claw hammer, nail set, and other appropriate instruments, such as mitre box or jig.
3. Demonstrate how to saw to a line with a coping saw. Include information on how to select proper blades and to set tension.
4. Show how to square to a mark for sawing.
5. Explain how to read inches and fractions of inches. A yardstick, foot rule, carpenter's tape or zigzag rule would be helpful. If appropriate, discuss the conversion of measures to the metric system.
6. Demonstrate the correct procedure for cutting to a line with a crosscut saw and a rip saw.
7. If a mitre box is available, demonstrate how to adjust the clamp and saw to a line with a mitre saw. A homemade jig may be substituted here.
8. Demonstrate how to form shapes on wood with a rasp, woodfile, or similar tool.
9. Demonstrate how to drive, set, and pull nails with a claw hammer.
10. Provide tools, materials, and equipment for members to begin to experience the procedures shown above. If the club session is brief, 4-H'ers may be instructed to practice their beginning skills at home. If this is an expanded club period, members may begin their tracing, squaring, and sawing during the meeting.

## Home Produced Visuals, Tours, and Speakers

Teach with wood product samples. Secure the help of a forester, carpenter, or wood products salesman. Prepare visuals to show:

- Variety of wood samples from your area or state to help teach wood identification
- Other wood products
- Samples of pulp products (paper types and grades)
- Samples of hardwood products
- Samples of different types of composition, paneling, fiberboard, particleboard, etc.
- Samples of different lumber sizes, species, grades
- Samples of different plywood species and grades, with stamps.

## Activities, Events, and Exhibit Ideas

The creative leader will find an almost inexhaustible source of activities, events, and exhibit ideas for the wood science program. The appendices contained within this leader's guide will provide several possibilities for your consideration.

## Recognition and Awards

4-H'ers, like everyone else, appreciate a pat on the back, a sincere "thank you," and material rewards. They like to earn ribbons, medals, trophies, certificates, savings bonds, scholarships, and other kinds of recognition. In 4-H, such opportunities abound for members, clubs and county groups.

Many people working together through common goals of 4-H make possible this recognition. Among them are parents, 4-H leaders, Extension agents, specialists, state 4-H leaders, and donors of local, state, or national awards. Their interests and personal involvement as well as financial assistance motivate 4-H'ers to achieve even greater accomplishments.

Achievement considered when selecting winners includes: member's participation and accomplishments in the respective program leadership experiences, personal development, community and civic responsibilities, and participation in other 4-H projects or activities.

Selecting and certifying winners of awards, at all levels, is the responsibility of the Cooperative Extension Service, with each state determining its selection process and dates for submitting required materials.

You can help your 4-H'ers get an early start on those all-important 4-H records by having them build a file of project pictures, news clippings, ribbons, correspondences, and other items showing their progress. These will be useful when compiling and submitting records for county and state recognition. Who knows? You may have a future national winner of an educational scholarship.

For current information on national awards that are available in the 4-H wood science program, contact your local or state 4-H office, or write to National 4-H Council, Program Services Division, 7100 Connecticut Avenue, Chevy Chase, Md. 20815.



## Basic Information About Wood

What should you, as a leader, know about wood that will help your 4-H'ers better understand it and its use?

### Where Does Wood Come From?

We all know that wood comes from trees, but where in the trees, and how does it get there? Most of the wood that you and your 4-H'ers will use in your wood science projects will come from the trunks of trees. However, wood from large branches is similar in structure.

Wood, itself, is composed of woody tissue, which is made up of individual wood fibers. An individual wood fiber is very, very small. Tear a piece of paper and look at the torn edge. You should be able to see an individual wood fiber. (You can see it better when magnified.) Paper is made of wood fibers which have been separated from each other and then matted together in a rather random fashion. The original wood grows with these fibers all attached to each other and all aligned in one direction, parallel with the trunk.

If you could look at the end of a piece of wood magnified to 1,000 times its actual size, you would see something that looks quite similar to a box full of soda straws. Each individual straw resembles a wood fiber. Each straw is hollow; so is each individual wood fiber. If you dumped the soda straws out of the box, scattered them about and flattened them, they would look like the magnified surface of paper. Then, if you tore them apart, you could look at one individual straw, just as when you tore the paper, you looked at one individual wood fiber.

What does this have to do with wood science, you may be asking? It is important because so many of the properties of wood are best understood by understanding wood structure.

Wood structure helps explain the strength and weakness of wood. If you wanted to support a concrete block using a couple of boxes of soda straws, you could if you set the soda straws on end. Similarly, you could support a loaded box car with two pieces of wood on end. If you try to support the concrete block with soda straws on their side, you would probably crush them. Similarly, if you tried to support the loaded box car with the wood on its side, you would probably crush it. The point is that wood, like the soda straws, is very strong in the direction of the wood fibers and less strong in the other direction. Many other wood properties depend upon the direction of the wood fibers.

Before leaving the soda straw illustration, there is one additional point which needs to be made. If you took just a few soda straws and stood them on end, they would not support very much weight. If

you glued a few together and stood them on end, they would support more weight, but they would probably bend before they compressed. If you glued many straws together and stood them on end, the structure would be strong enough for you to stand on. You can likewise support a very heavy load with a short section of 2×4 (on end) but a full length 2×4 will not support that same load because it will bend. (If you can somehow keep the 2×4 from bending throughout its length, it will support the heavy load.) This demonstrates that the ultimate strength of wood in its strongest direction often cannot be utilized because of a number of factors.

### Where Wood Fibers Come From

Now that you know wood is composed of fibers, which are essentially parallel to each other and held together, you might wonder how they get that way. Obviously, they grow that way when a tree is forming wood. In temperate climates, trees grow only during the warmer part of the year. The trunk and branches of trees are covered with a layer of bark. All growth of wood fibers takes place at the junction between the wood and the bark. This junction is called the cambium layer. The cambium is the growth layer, and it allows the tree to grow larger in diameter. Each year a sheath of new wood is formed that completely covers all of the older wood in the trunk and branches. Each new sheath fits snugly over the layer of wood formed the year before.

The wood formed during the early part of each growing season (called springwood or earlywood) is usually lighter in weight and coarser in texture than the summerwood or latewood, formed near the end of the growing season. After most trees have reached a moderate age, the wood near the center of the trunk and branches undergoes further changes. It changes from sapwood into heartwood. Sapwood is usually light in color while heartwood is usually darker in color. Early in the life of the tree, the heartwood was sapwood; but, as the tree grew older, the inner sapwood died and turned to heartwood. Heartwood may be more resistant to decay than sapwood. Often a decayed log in the woods will contain all heartwood, the sapwood having rotted away. Very young trees may be all sapwood. But in most species, the band of sapwood which surrounds the heartwood accounts for a relatively small proportion of the total trunk. The rich colors of furniture woods, like cherry and walnut, are the colors of the heartwood of these species.

(Refer to the Unit III 4-H member manual, *Building Bigger Things*, "Structure of Wood.")

### Annual Rings

If a tree is cut by sawing through the trunk just above the ground, the surface of the stump reveals the tree's history. The center of the cross section is called





the pith. It was formed when the seedling sprang up. In concentric rings around the pith, there are alternate layers of springwood and summerwood. Each ring is made up from the springwood and summerwood formed during one growing season, and the total ring formed in one season is called the annual growth ring or the annual ring. If the tree is cut during the growing season, the last annual ring will not be complete. If the tree is cut early in the growing season, the ring will contain only springwood fibers, since the cambium layer is still producing springwood fibers at that time. If the tree is cut later in the growing season, the cambium layer may or may not have already switched to growing summerwood fibers. However, if the tree is cut in the winter, the outermost annual ring will be complete, having both springwood (earlywood) and summerwood (latewood) fibers present.

The number of annual rings accurately tells the age of the tree. The relative thickness in the proportion of springwood to summerwood can tell much about the local climate during the life of the tree. Fast growing trees have wider rings than slow growing trees. Some fast growing trees have rings up to an inch thick, while some slow growing trees take 100 years or more to grow an inch. In general, wood from fast growing trees, which produce mostly springwood, is weaker than wood with more summerwood.

You cannot tell the age of a tree by counting the rings on a cross section of a cut which is some distance above the ground, because you have no way of knowing how many years it took the tree to reach the height at which the cut was made.

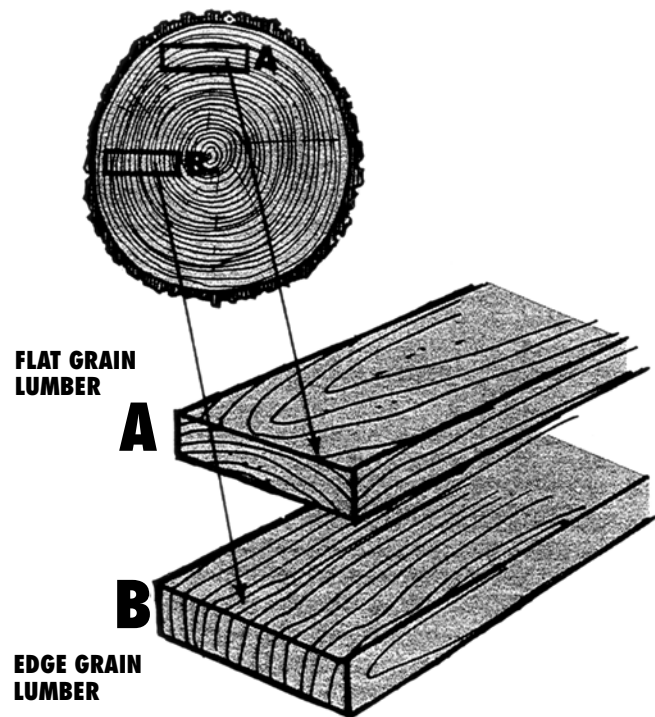
(Refer to the Unit II 4-H member manual, *The Wonderful Wood of Wood*, "Learning to Use Wood"; and to Unit III, *Building Bigger Things*, "Structure of Wood.")

## Boards Cut From Logs

When a tree is cut into logs and the logs cut into boards, it may be cut in several ways. If you cut the log off center, closer to the edge like "A," you will get "flat grain" lumber. The grain on the wide face of the board will be large flat bands, long wavy arches or long patches, depending on how the saw cuts through the annual rings of the log. The grain on the edges will be narrow stripes or lines.

If the log is cut through the center, like "B" in the drawing, you will get "edge grain" lumber. In edge grain lumber the grain goes nearly straight across the board from top to bottom and gives a pattern of stripes or lines on the wide face of the board. Lumber cut near the center of the log will have edge grain.

Knowing this about edge grain and flat grain lumber, you will soon realize that most boards will be something other than pure edge grain or pure flat grain. Few trees are so large that a board cut from the edge will have growth rings that run parallel to the



surface of the board. There may be trees which have a nearly flat surface, but growth rings generally curve because the tree is round, so true flat grain is so rare as to almost not exist. True edge grain is relatively easy to obtain from any tree but only in very limited quantities. You could get additional edge grain by first cutting a log into pie shaped pieces and then cutting these into boards. In actual practice, logs are seldom cut this way because it wastes too much wood and would produce more lower grade boards since defects, such as knots, are most common near the center of the tree (and edge grain boards more likely contain wood from the center of the tree). Generally, logs are sawn so that flat grain boards are cut first.

(Refer to the Unit II 4-H member manual, *The Wonderful World of Wood*, "Learning to Use Wood.")

## Knots

A knot is a section of a branch embedded in the wood. The wood in the trunk of a tree must curve around the wood of the tree's branches. When the trunk and a branch are both living, a sound knot is formed. If the branch dies and the trunk continues to grow around it, the knot and the trunk will not actually grow together, even though the trunk has grown tightly around the knot. This results in a loose knot in a board. Loose knots sometimes become knot holes. Both loose knots and tight knots cause reduction in strength in wood, but loose knots are generally more objectionable. In fact, tight knots are favored for some special uses, such as in knotty pine paneling or furniture.



As a tree grows, the lower branches are shaded by the upper branches and often die, and eventually drop off. As the tree continues to grow in diameter, clear wood grows over the broken off stubs of the branches so that, after time, a tree may have a clear trunk where once there were branches. Even though the surface of the trunk is clear, the wood underneath the surface still contains branch wood from when the tree was smaller. Clear boards are more valuable than boards with knots. Every log contains some knots near the center of the cross section, and some logs contain knots on all surfaces. The grain of the wood in and around knots is irregular and may interfere with woodworking processes.

(Refer to the Unit III 4-H member manual, *Building Bigger Things*, “Knots.”)

## Softwoods and Hardwoods

Softwood lumber comes from trees which have needles. Hardwood lumber comes from trees which have leaves. Generally, softwood lumber is actually softer than hardwood lumber but there are many exceptions. Softwoods, such as southern yellow pine, are harder than hardwoods, such as cottonwood and yellow poplar. A heavier wood, be it softwood or hardwood, is generally harder and stronger than a lighter wood. Most houses are built from softwood. Most furniture is made from hardwood.

(Refer to Unit II, *The Wonderful World of Wood*, “Learning to Use Wood”; and to Unit III, *Building Bigger Things*, “Identifying Hardwoods and Softwoods.”)

## Why Wood is an Important Material

Wood comes in many species, sizes, shapes, and conditions. It has a high ratio of strength to weight and a remarkable record for durability and performance. Dry wood has good insulating properties against heat, sound, and electricity. It can absorb and dissipate vibrations. And, it is used in fine musical instruments, such as violins. Because of the variety of grain patterns and colors, wood is also an aesthetically pleasing material. Its appearance may be easily enhanced by stains, varnishes, lacquers, and other finishes. It is easily shaped with tools and fastens easily with adhesives, nails, screws, bolts, and dowels. When wood is damaged, it is easily repaired. Wood structures are easily remodeled or altered. Wood resists oxidation, acid, salt water, and other corrosive agents. It has a high salvage value. It can be made decay and insect resistant with preservatives and can be treated to resist fire.

## Moisture Content of Wood

Moisture content of wood is defined as the weight of water in wood expressed as a fraction, usually as a percentage of the weight of oven dried wood. Weight, shrinkage, strength, and other properties depend upon

moisture content of wood. In living trees, moisture content may range from 30 percent to more than 200 percent of the weight of wood.

Moisture exists in wood as water or water vapor in the hollow portion of the wood fiber, or as water “bound” chemically within the cell wall. Green wood is wood in which the cell walls are completely saturated with water. Waterlogged wood is wood in which the cell walls and the hollow fibers are completely filled with water. The water contained in the hollow wood fibers adds to the weight of wood but does not affect the other properties very much. The water which is contained within the cell wall greatly influences wood properties. The cell walls in a growing tree are saturated with moisture, and there often is additional moisture inside the hollow wood fibers. Most of the changes that take place in wood due to drying begin to take place as wood dries below 30 percent moisture content, which is the approximate point at which only the “bound” water remains. This is called the fiber saturation point. At moisture contents below the fiber saturation point, wood begins to shrink and gain strength as it loses moisture.

## Equilibrium Moisture Content

The concept of equilibrium moisture content is perhaps the most important wood science concept for a woodworker to know. Equilibrium moisture content is defined as that moisture content at which the wood is neither gaining nor losing moisture. In other words, the wood is in equilibrium with the atmosphere. In actual use, wood almost never reaches a true equilibrium with its surrounding atmosphere, because air temperatures and relative humidities in which wood is used are continually changing.

Wood is constantly either drying or gaining moisture. If you started out with a wet piece of wood and a dry piece of wood of any species and kept them inside an average home, the wet piece of wood would slowly dry to about 8 percent moisture content, and the dry piece of wood would slowly gain moisture to about 8 percent average moisture content. (For the dry Southwest, the figure is closer to 6 percent, and for the humid South and Southeast, it is closer to 11 percent.) The point is that a woodworker should know why it is important to use wood which is already near the moisture content that it will reach while in service or use. This practice should reduce wood shrinkage and swelling by minimizing the change in moisture content of the wood.

## Shrinkage

Wood starts to shrink at moisture contents below 30 percent. It swells until it reaches 30 percent. This shrinking and swelling may result in warping, checking, splitting, or performance problems that



subtract from wood's usefulness. In your home, you may have experienced a drawer or a door that became difficult to open in humid summer weather due to swelling. Shrinking and swelling can be controlled by controlling the moisture content, but wood is often used where it is not practical to control temperature and relative humidity. Protective coatings can retard (but not prevent) the movement of moisture from the air into and out of wood. The adverse effects of changes in moisture content can often be partially offset by good design and careful selection of materials.

How much does wood shrink? The maximum shrinkage, from fiber saturation point to oven dry, varies in three principal directions. Along the grain, such as along the length of the board, the normal shrinkage is very, very little. This is called longitudinal shrinkage. Infrequently, there are individual pieces of wood which exhibit abnormal longitudinal shrinkage, but for the most part, shrinkage along the grain is no problem.

Flat grain boards shrink more in width than edge grain boards, but less in thickness. The across-the-width shrinkage of a flat grain board is called tangential shrinkage (tangent to the growth rings) while the across-the-width shrinkage of an edge grain board is known as radial shrinkage (in the direction that radiates from the center of the tree). Heavier woods generally shrink more than light woods.

Tangential shrinkage is as much as 12 percent for hickory, a very heavy wood, to as little as 5 percent for redwood, a very light wood. Radial shrinkage for hickory is 7 percent and for redwood is 3 percent. Note that this is the total shrinkage from 30 percent moisture content to oven dry. Most wood in use never shrinks this much because most wood does not dry completely.

If left long enough in the equilibrium moisture content conditions in which it will be used, wood will dry to the proper moisture content. However, this may take an excessively long time, especially for some hard-to-dry woods. Left outside (in most regions of the country), wood will never reach the desired moisture content for interior use. Outside humidities are simply too high most of the year.

Most lumber intended for interior use is dried at high temperatures in controlled humidities, in lumber dry kilns. This removes moisture rapidly. The moisture content of lumber in kilns can be accurately controlled. However, proper care of lumber after drying is also important. Just because lumber has once been kiln dried does not assure that it will be satisfactory for your needs when you go to use it, because it could have regained moisture from the air during the storage period after drying.

It is important that a woodworker learn to use lumber that is at the proper moisture content. In

addition to the undesirable shrinkage or swelling which would result from improper moisture content, some other woodworking operations, such as gluing and finishing, can be adversely affected by too much or too little moisture in the wood.

Unfortunately, it is not possible to tell by looking at wood if it is at the proper moisture content. Electrical moisture meters can be purchased to measure moisture content of lumber, but, lacking a meter, the simplest way for a woodworker to check the moisture content of wood is to dry a scrap piece of the wood in an oven.

Measuring moisture content would be a good class exercise. You will need an accurate scale. See the activity called "Measuring the Moisture Content of Wood" in Appendix X ("Suggested Wood Science Experiments") in this leader's guide.

## Specific Gravity of Wood

Specific gravity of wood, like that of any other substance, is its weight compared to the weight of an equal volume of water. None of the domestic woods when dry are as heavy as water, although some foreign woods are heavier than water. Any wood, if wet enough, will sink rather than float. Specific gravities of U.S. woods range from about 0.30 for northern white cedar to about 0.88 for live oak (based on 12% moisture content). In general, the higher the specific gravity, the stronger the wood, and the lower the specific gravity, the easier the wood is to work.

(See the activity called "Specific Gravity and Strength of Wood" in Appendix X ("Suggested Wood Science Experiments."))

## Other Characteristics of Wood

Each wood has some unique working qualities. Woods weather differently. Woods have differing degrees of decay resistance. There are substantial differences in mechanical properties that are not explained by differences in specific gravity alone. The mechanical properties of wood are explained and values given for American species in Chapter 4 of the 1974 U.S.D.A. Wood Handbook (see "Reference Materials").

## Renewability—A Most Important Property

Forests are renewable. Wood products can be produced without expending large quantities of energy. Wood scientists have improved the efficiency in using forest resources so that the same quantity of raw material goes further. Knowledge of how to use wood properly is a scarce resource. Well designed wood products, carefully made, can extend this valuable wood resource even further. 4-H youth can play an important role in this important process.



## Tools and Machines

The beginning 4-H'er should use simple tools. As he or she continues in the wood science program, each should learn to use a wider variety of tools and materials. Simple and easy-to-use tools are described in Unit 1. Additional tools and their uses are described in other project manuals.

Members should be encouraged to acquire their own set of tools; however, inability to do so should not be a deterrent to anyone. Local donors, individuals or groups, probably can be found to purchase tools and materials which will remain club property.

Many leaders will allow members to use their personal tools. Remember, youngsters are active, energetic, inexperienced, and need guidance. Encouraging wise and safe use of tools moves 4-H'ers toward increasing opportunities. Even beginning woodworkers can safely use instruments like the short stroke, finetooth jig saw; the oscillating electric sander; and the light duty quarter-inch drill, if properly instructed and supervised in their use. Other power tools and machinery are illustrated in Units II and III; however, the member may satisfactorily complete his or her project work without the use of power tools.

### Safety Tips for Using Woodworking Tools, Machines, and Processes

1. Dress appropriately for work in the shop. Wear protective clothing and equipment. Eye protection is always recommended, especially when power tools are being used; and, in many states, eye protection is mandatory.
2. Tools such as screwdrivers, wrenches, and chisels should be of the proper shape and size to fit snugly. Worn tools with rounded corners and blunted edges are dangerous.
3. Electrical equipment grounds on power tools should be properly connected before the machines are started.
4. Never depend upon back muscles in lifting heavy objects. Get help, if necessary, and lift with leg and arm muscles.
5. A sharp cutting tool is less dangerous than a dull one.
6. Lay tools on benches in an orderly fashion. Protect cutting edges and keep sharp surfaces pointed away from the work area.
7. Fasten materials securely in a vise when practical.
8. Keep the work area clean, especially the floor. Put waste stock in the scrap box and oily rags in closed metal containers.
9. Maintain order. No running or playing in the work area!
10. Keep the work area well lighted. Fifty footcandles of illumination is recommended for detailed work.
11. Follow directions and instructions for tools, machines, and materials.
12. Be sure members can successfully pass both written and practice tests before operating machines.
13. Take care of accidents promptly. Apply first aid for any cut or scratch. Keep first-aid equipment readily available.
14. Keep up to date on safety information. Secure posters and visual materials from sources such as the National Safety Council, as constant reminders for 4-H'ers.

NOTE: The leader will note the special emphasis placed on safety in each member's manual.



## Criteria for Judging Projects Made from Wood

### I. Skills (Total points 75)

#### A. Quality of Workmanship

##### 1. Cutting

- a. Pieces of proper lengths
- b. Accurate cuts, either squared or beveled
- c. Uniform and smooth saw cuts (some roughness may be appropriate in rustic designs)
- d. Free of chipping, dents, and uncut fibers
- e. On a woodcarving where the knife cuts remain as an element of texture, the cuts should be clean and uniform as an indication of knife control.

##### 2. Assembly

- a. Joints fit snugly
- b. Joints assembled with even edges or uniform overlap
- c. Wood free of clamp marks
- d. Fasteners properly used

#### Nails

- Use common or box nails where strength is more important than appearance.
- Use brads, finishing, or casting nails where appearance is important.
- Nail heads should be flush with the surface of the wood unless set below the surface  $\frac{1}{16}$ " to  $\frac{1}{8}$ " and filled. The filler should match the wood if a clear finish is used.
- Wood should be free of hammer marks and splits caused by nails.

#### Screws

- Should be flush with the surface or countersunk enough to plug the hole

- Rim of the bevel or ovalhead screw flush with surface
- Screwdriver slot should be in good condition.
- Wood should be free of screwdriver marks.

#### Adhesives or glue

- Resorcinol glue should be used for exterior purposes.
- Casein or plastic resin glue should be used for wood turnings.
- Wood surfacing should be delayed several days after gluing to prevent glue line depressions.
- Wood should be free of glue stains.
- Dowels used in end grain to side grain butt joints

### B. Surface Preparation and Finish

1. Free of pencil marks, scratches, and dents (unless of rustic design)
2. Furniture-like items free of planer marks and cross grain sanding marks
3. Finish should be dry, smooth and uniform and free of dust specks, brush bristles, runs and sags.

### C. Difficulty of Construction (number of skills and operations involved)

1. A well made, complex item should rank higher than a well made, simple item.
2. A perfectly made, small and simple item should rank higher than a poorly made, complex article.

### II. General Characteristics (Total Points 25)

#### A. Attractive and Well-proportioned

#### B. Can Adequately Serve the Purpose for Which Item is Intended

#### C. Proper Selection of Wood According to Use. For example:

1. Exterior grade plywood used for areas subject to wetting
2. Heartwood of decay resistant lumber or treated lumber used for lawn and garden furniture

## Appendix I Judging Score Card

		Identification of Article			
I. Skills (Total 75 points)					
A. Quality of Workmanship—cutting, assembly, etc.	<b>(30)</b>				
B. Surface Preparation and Finish	<b>(25)</b>				
C. Difficulty of Construction and Level of Skills Involved	<b>(20)</b>				
II. General Characteristics (Total 25 points)					
A. Attractive and Well-proportioned	<b>(10)</b>				
B. Utility Value	<b>(10)</b>				
C. Selection of Woods and Materials	<b>(5)</b>				



## Appendix II Nail-driving Activity

### Objectives

- To develop eye hand coordination
- To gain the skill of driving nails safely, accurately and efficiently into wood

### Equipment and Supplies

- Safety goggles for each participant
- A hammer for each participant or team, depending on how the contest is conducted
- Pieces of dimension lumber, such as a 2×4 or 2×6
- Nails shorter than the thickness of the lumber
- Nail driving blocks
- A watch with a second hand (optional)

### Leader Responsibilities

The leader sets the rules:

- Sets the amount of time for the activity
- Determines if the activity will be competitive or noncompetitive
- Decides if the activity will be individual or a team effort

Organizes the activity:

- Selects teams and team captains, if necessary
- Distributes goggles, nails, hammers, and driving blocks
- Starts and times the event
- Scores the event

### Scoring

For individual learning or self competition, have each individual record his time and try to improve it the next time. For group or team competition, the team with the highest combined score wins. (Time minus 30 seconds for each bent nail and 10 seconds for each hammer mark.)

### Hints

This activity can be used to put action into a discussion meeting. It can generate enthusiasm and create interest. You can modify this activity by having both a piece of hardwood and a piece of softwood and both heavy- and thin-shanked nails. A requirement could be that one thin shank and one thick shank be driven in both the hardwood and the softwood. Teen leaders or older teen members may be of assistance to the leader. Get them to help whenever needed.



## **Appendix III**

### **Wood Products, Tools, and Fasteners Identification Activity**

#### **Objectives**

- To identify common types of hardwoods and softwoods used in your area
- To identify different types and kinds of fasteners (nails, screws, glues, etc.)
- To identify various kinds of woodworking tools
- To help 4-H'ers feel satisfaction and accomplishment in wood science activities

#### **Equipment and Supplies**

- Samples of hardwood and softwood
- Samples of different kinds of fasteners in different sizes
- Samples of woodworking tools

#### **Leader Responsibilities**

- Plan the activity and set the rules
- Assemble the wood samples, fasteners, and tools
- Score the event

#### **Scoring**

Scores depend upon the rules of the game. Consider the members' ability to identify samples of wood, tools, nails, etc.

#### **Note**

Identification of wood products, tools, and fasteners can be done in various ways. Use your creativity to plan an event keeping in mind the objectives of the activity.



## **Appendix IV**

### **Hand Sawing Efficiency Activity**

#### **Objectives**

- To use sawing equipment properly and safely
- To gain skills in sawing techniques
- To provide recognition for the 4-H member

#### **Equipment and Supplies**

- Square
- Carpenter's tape or rule
- Coping saw and several blades
- Crosscut saw
- Marking pencils
- Sawhorse or workbench of proper height
- Lumber

#### **Leader Responsibilities**

(See responsibilities under Nail-driving Activity, previous page.)

#### **Scoring**

(See scorecard on page 13 for an idea.) When developing your scorecard, consider accuracy, safety, and care of tools.

#### **Note**

Praise or a pat on the back can give recognition for a job well done.





## Appendix V Measuring Activity

### Objectives

- To learn to read various measuring tools properly
- To understand standard sizes of wood materials
- To develop skills in measuring lumber accurately

### Equipment and Supplies

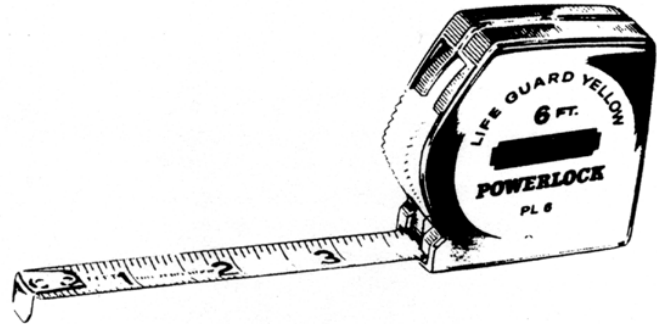
- Carpenter's tapes
- Utility squares
- T square
- Pieces of dimension lumber of different sizes (find pieces and label them according to size)
- Pieces of plywood and particleboard

### Leader Responsibilities

- Prepare a list of pieces to be measured to specification. Have members demonstrate their skills in measuring.
- Arrange a task of determining the amount of lumber necessary to build a specific item, such as a dog house, etc.

### Scoring

- Methods of scoring will depend on the rules of the activity.





## **Appendix VI** **Wood Finishing Activity**

### **Objectives**

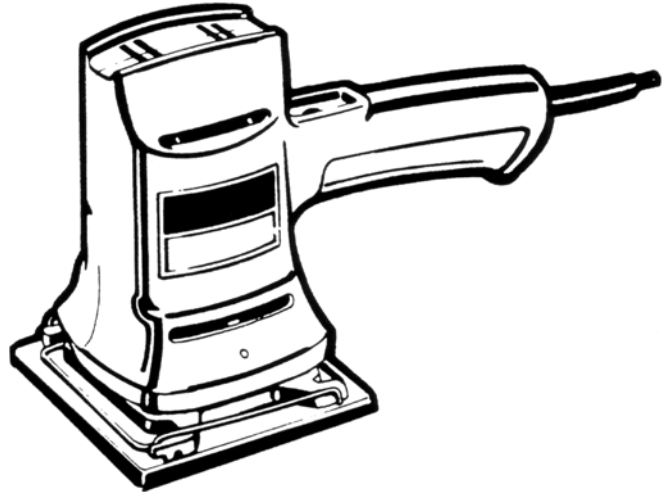
- To use good finishing techniques and application of a suitable finish
- To develop skills in finishing wood
- To refine skills in the use of wood finishing tools, abrasives, fillers, etc.

### **Equipment and Supplies**

- Several grades of wood sanding paper
- Steel wool
- One or more types of rasps
- Several types of suitable finish
- Different species and kinds of wood
- Applicators and cleaners

### **Leader Responsibilities**

- Secure a box of scrap lumber samples of hardwoods and softwoods, all unfinished. (Members will select a piece of wood, select a finish and the supplies and equipment needed to complete the finish. In a given time allotment, the 4-H'er will complete a small area for showing.)
- Evaluate the finished product. Consider safety and care of tools. Also consider suitability of the finish selected, especially as it affects function or use of the item.





## Appendix VII Wood Knowledge Contest

Listed below are sample questions that can be used in a wood knowledge contest. Any 4-H leader can design a similar type of contest for his or her club. The same type of questions, with wood samples, can be used in other ways, such as a 4-H Wood Science Bowl.

Instructions: Circle one answer in the right hand column.

1. There are literally hundreds of specialty wood products and by-products. Which one of these is not a wood product? (no sample displayed)  
**A. Rayon thread B. Turpentine C. Cooking oil**..... A B C
  
2. Which one of these groups of tree species is common to the Northwest Christmas tree industry? (no sample displayed)  
**A. Austrian Pine, Blue Spruce, Hemlock B. Scotch Pine, Douglas-fir, Noble Fir**  
**C. Balsam Fir, White Pine, Giant Sequoia**..... A B C
  
3. This sample is from a group of different tree species with one common lumber trade name. It is  
**A. Spruce B. Pine C. Hem Fir** ..... A B C
  
4. I'm used for flooring, furniture, and wedges, and I'm not a common forest species in (your state or area). I'm  
**A. Spruce B. Oak C. Maple (change samples for your area)** ..... A B C
  
5. Of the three samples of plywood shown here, which one would be subject to the least warpage and surface checking? (display your own samples) ..... A B C
  
6. This wood product is known in the building trade as a  
**A. Shake B. Shingle C. Miter** ..... A B C
  
7. This wood product, made by cooking wood chips and then compressing and drying into sheets, is known as  
**A. Fiberboard B. Particleboard C. Chipboard**..... A B C
  
8. This piece of plywood, generally sold with no grade stamp and often used in cabinet shops, is called  
**A. C D plywood B. Shop or void plywood C. Marine plywood** ..... A B C
  
9. My wood is quite soft and fine grained, and I'm from a five-needle Pine. My wood is used for interior finish, lumber, and woodworking. I'm  
**A. Western White Pine B. Shore Pine C. Ponderosa Pine** ..... A B C
  
10. The wood for this pencil is commonly made from  
**A. Alaska Cedar B. Pacific Yew C. Incense Cedar** ..... A B C

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11. This is a chunk of one of the most common hardwood fireplace woods. I am  
A. Maple B. Red Alder C. Douglas-fir ..... A B C
12. In the lumber business, this collection of samples would be called  
A. Boards B. Dimension C. Timbers ..... A B C
13. Which sample, when used in home building resting on concrete or near the soil, is required by most building codes?  
A. Cedar 2×4 B. P.T. 2×4 C. Douglas-fir 2×4 ..... A B C
14. This sample is from a western tree that produces most of the strongest (group 1) plywood. My common species name is  
A. Engleman Spruce B. Douglas-fir C. Western Hemlock ..... A B C
15. Plywood that is made with a waterproof adhesive and can generally be used anywhere is called what grade plywood?  
A. Interior B. Exterior C. Veneer ..... A B C
16. Examples of primary processing include  
A. Cardboard boxes B. Particleboard C. Paper shopping bags ..... A B C
17. Which group of words (factors) are used in the Christmas tree grading standards?  
A. Producer, wholesaler, retailer, marketer B. Balance, foliage, taper, density, deformities  
C. Bevel, plane, miter, prune ..... A B C
18. This sample, whose actual measurement is  $\frac{3}{4}'' \times 3\frac{1}{2}''$ , has a "normal size" classification of  
A. 1×3 B. 1×4 C. 2×4 ..... A B C
19. Wood can be smoothed and leveled using which tool?  
A. Bevel B. Miter C. Plane ..... A B C
20. This sample of dimension lumber is from what tree species?  
A. Hem Fir B. Douglas-fir C. Pine ..... A B C
21. You are selecting plywood to make a natural finish, top quality display cabinet. These pieces represent four sheets of plywood. You are to compare and rate these sheets. How did you place the four pieces?

- | 1st choice   | 2nd choice | 3rd choice | 4th choice |
|--|------------|------------|------------|
| 22. This sample from a broadleaf hardwood, used in furniture and for making other items, is<br>A. Alder B. Big Leaf Maple C. Oak ..... A B C |            |            |            |
| 23. This sample is called<br>A. Chipboard B. Particleboard C. Fiberboard ..... A B C   |            |            |            |



## **Appendix VIII**

### **Exhibit Ideas**

#### **Division A: Wood Science (Display Samples)**

- Labeled specimens of hardwoods common to your area
- Labeled specimens of softwoods common to your area
- Different products of dimension lumber
- Different plywood species
- Different hardwood plywoods
- Hardwood products
- Pulp products
- Stages in paper making
- Chemical process products of wood
- Seasoning woods for cooking

#### **Division B: Woodworking: Articles Made from Wood (Display Samples)**

- From Unit I: tie rack, letter holder, note holder, picture frame, art design, bird nest shelf, puzzle, game, etc.
- From Unit II: key holder, cutting board, birdhouse, bookends, footstool, book rack, tool box, games, etc.
- From Unit III: toy, door knocker, sandbox, shoeshine box, step stool/chair, saw horse, garage door creeper, barn medicine cabinet, etc.



## Appendix IX Wood Science and Wood Scientists

You as a leader may be asked for a definition of wood science or an explanation of what wood scientists do. We hope that you will encourage youth in the 4-H Wood Science Project to learn more about wood and wood science.

Wood Science is a relatively new profession. It is a materials engineering science. Graduates of university wood science programs have a comprehensive knowledge and understanding of wood as a raw material. This knowledge includes the anatomy, physical, chemical, mechanical, and biological properties of wood. In addition, they receive extensive training in the major wood processing operations such as drying, machining (including sawmilling and veneering), gluing, finishing, and treating wood. Additional areas of study often selected are industrial engineering, business administration, marketing, personnel relations, economics, civil engineering, and chemistry.

A wood scientist must know chemistry, physics, mathematics, and other sciences. However, he or she is distinguished from the chemist, physicist, mathematician, engineer, and forester in that the wood scientist knows wood. He or she knows wood as a biological product of the forest, as a raw material, as a material for construction, and as a part of our civilization. He or she knows why it acts the way it does and what to look for when it doesn't.

Wood scientists are expanding the broad scientific base for wood science through educational and research efforts. The behavior of wood is often explained by its peculiar structure and organization. Very few materials in the field of construction are as complex as wood, yet wood has been, and still is, being used by those who know nothing of its complex properties.

Because wood is such a common and easily used material, many users do not even know that wood has unique properties. Much of the difficulty encountered when working with wood is due to misinformation or the lack of information regarding its properties and behavior. A wood scientist can help you and your 4-H'ers better understand the properties of wood and how they affect the use of wood.

Wood scientists have organized as professionals into a Society of Wood Science and Technology (SWST). The Society publishes a quarterly journal called *Wood and Fiber Science* which began in 1983. Prior to that were two publications, *Wood and Fiber* and *Wood Science*, which merged. Libraries may have copies of each up through 1982. The new publication (*Wood and Fiber Science*) contains technical information about wood. In addition, there are numerous trade publications which deal specifically with harvesting, processing, furniture manufacturing, and pulp and paper.

Information about the Society and careers in wood science is available from SWST, P.O. Box 5062, Madison, Wisconsin 53705.

Another publication, *The Forest Products Journal*, is published monthly by the Forest Products Research Society, 2801 Marshall Court, Madison, Wisconsin 53705.



## Appendix X Suggested Wood Science Experiments

The youth who are enrolled in this project will learn a great deal about wood and woodworking tools as they progress through each Unit. You can help them even more by conducting some simple experiments. These experiments will help 4-H'ers learn to better use wood. And you, as a leader, may even discover something you didn't know about wood.

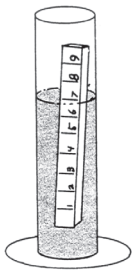
Here are a few suggestions. There are many other possibilities. Feel free to pick and choose those which best suit the needs of your 4-H members. Your reward will be to see your members build better products from wood because of what they have learned through their experiments and experiences with you as a leader.

### Specific Gravity and Strength of Wood

Specific gravity tells how heavy wood is compared to water. Most wood is lighter than water, so it has a specific gravity of less than one.

You can do a reasonably good job of finding the specific gravity of wood by floating a piece on end and measuring the proportion of it that gets wet. Do it quickly before the wood gets so wet that it sinks further than it did when dry. If half gets wet, its specific gravity is 0.5, which means that it is half as heavy as water.

Better yet, dip it in hot paraffin or paint it first. Cut a 10-inch piece of uniform cross section ( $\frac{3}{4}$ " $\times$  $\frac{3}{4}$ " or  $1\frac{1}{2}$ " $\times$  $1\frac{1}{2}$ " ) from a board or a 2 $\times$ 4. Draw a line at each inch. Float it on end. Count the number of spaces that get wet. Divide by 10. That gives the specific gravity. (You can estimate in between the spaces to be more accurate).

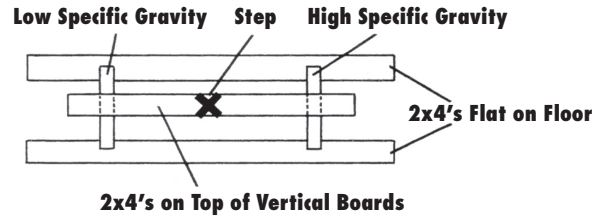


$$\frac{6.5}{10} = 0.65 \text{ SPECIFIC GRAVITY (because 0.65 of sample is under water)}$$

Note: You will need to support the wood gently in order to get it to float on end rather than float on its side. If in supporting it you accidentally push down or pull up, that will change the level at which the wood floats and, therefore, give an inaccurate reading of its actual specific gravity. A tall glass tube just large enough for the sample works best, but if you do not have one, a paper milk carton will work quite well.

You can demonstrate that a heavyweight wood is stronger than a lightweight wood by using two

pieces the same size. Use the two that have the greatest difference in specific gravity. Set them across supports (2 $\times$ 4's laid flat on the floor) and support a third 2 $\times$ 4 on top of them as shown below. Ask progressively heavier members to stand near the center of the third 2 $\times$ 4 until one piece breaks.



### Thermal Properties of Wood

You'll need a plastic bag filled with ice cubes, any long metal rod or bolt, and a piece of wood the same length. Stick the rod and wood in the bag of ice cubes at the same time and have the group feel them both from time to time. Note that the rod feels cold while the wood does not. Wood is a good insulator; poor conductor. (You could demonstrate the same property using hot water instead of ice.)

### Strength of Nails, Screws, Bolts, Glue

You will need short pieces of 2 $\times$ 3's or 2 $\times$ 4's, all about the same length, each with one end cut at a 45-degree angle. (Making these might be a group exercise.) You will need a variety of fasteners, such as short nails, long nails, modified shank nails, wood screws, bolts, and glue. Fasten two pieces together to form a V at the top.

Hold an old baseball bat, table leg, or pipe in the V notch and have the lightest to the heaviest member pound on or jump on the bat, or hit it with different weights of hammers. Write the pounds force or some qualitative measure on the broken piece (such as, it took Bob to break it; it took James and Lynn). List the fasteners tested, from the weakest to the strongest.

### BB Driving Contest

You'll need a hammer, some BB's or ballbearings, one softwood board, and one hardwood board. Have members drive the BB's first into the softwood board and then try to drive them into the hardwood board. Try to drive them in both the sides and the ends of the boards, and then find out which was the easiest and which was the most difficult.



## The Tug of War

All you need is one long, smooth board (a furring strip, about ¾×1 would be good). Choose two members approximately the same weight or divide the group into two teams, if the board is long enough. Have the two pull and tug on the board. No matter how hard they pull, as long as they pull straight, they will probably not be able to pull the board apart. (Caution: be sure it is a smooth board and wear gloves for protection from splinters.) This demonstrates the strength of wood in tension.

If the piece of wood is expendable, demonstrate how easily it can be broken by the two smallest students bending it against a post. (Be careful of sharp ends when it breaks.) Cut off any sharp ends. Fasten the two pieces together with a nail or screw. Pull again. This demonstrates that it is hard to fasten wood and have strength equal to the original wood.

## Distortion of Wood Upon Swelling

Paint one side of a flat, dry board and both sides of another. Mark the center on each. Measure the board lengthwise from center to end. Soak both boards in water. Again, measure the boards from center to end. Note that the board painted on one side curves because it swells first on the unpainted side, but it flattens out later when both sides have swollen.

Repeat, but first dry the boards in an oven just before painting. Then allow them to pick up moisture from the air, rather than soaking them. You will see that coatings delay swelling but do not prevent it, yet coating both sides is a good practice to prevent uneven swelling.

## Measuring the Moisture Content of Wood

Weigh a small wood sample taken at least 20 inches from the end of a board (the ends dry more rapidly, so a sample from the end may not indicate the true moisture content). Weigh the sample accurately right after it is cut. Dry it in an oven set at 225 to 250 °F until the sample reaches a constant weight (this might take 12 hours). This is the **oven-dry weight**. Subtract the oven-dry weight from the weight of the sample when cut. The difference is the weight of water removed in drying. Divide the weight of water removed by the oven dry weight and multiply by 100. This gives percent moisture content. Note that it is traditional among wood scientists to use the oven-dry weight as the denominator when expressing moisture content. (Engineers often use the wet weight as the denominator. This results in a slightly lower value for moisture content in dry wood, and a much lower value in wetter wood.)

Here is an example: If a small sample of wood weighs 220 grams when cut, and 200 grams after drying, it has lost 20 grams of moisture. The percent moisture content equals:

$$\frac{\text{weight when cut minus oven-dry weight}}{\text{oven-dry weight}} \times 100 =$$

$$\frac{220 - 200}{200} \times 100 = \frac{20}{200} \times 100 = 10\%$$

**(Note: If weight when cut was used as the denominator:**

$$\frac{220 - 200}{220} \times 100 = \frac{20}{220} \times 100 = 9\%)$$





## Appendix XI Suggested Plans for Woodworking Projects

### Nine Block Puzzle

#### Materials needed

- Use ¼-inch plywood for sides and base. Use 1-inch lumber (actual thickness ¾ inch) for the blocks. See illustration for the dimensions.
- Glue
- ½-inch brads

#### Tools needed

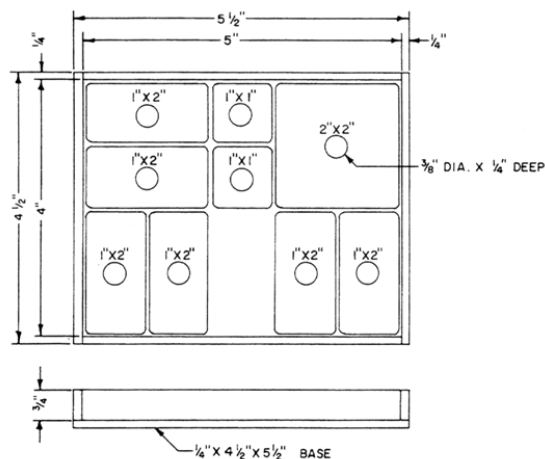
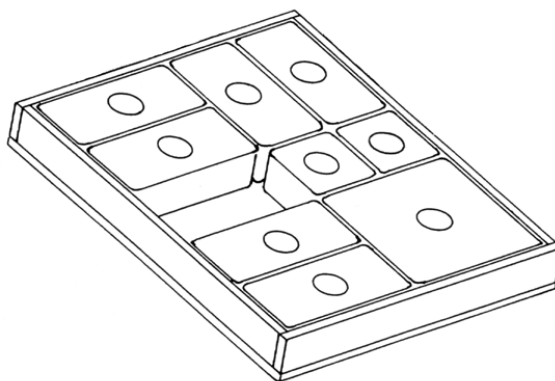
- Tack hammer
- Saw
- Drill with ⅜" countersink bit
- Sandpaper
- Paint or stain and varnish

#### Instructions

1. Cut all pieces to size.
2. Glue and nail frame together and then glue and nail to base.
3. Drill a shallow countersink hole in the middle of the nine blocks so they can be moved easily.
4. Sand all pieces and round corners so they will move easily in frame.
5. Finish as desired.

#### Playing instructions

Start from position shown. The object of the game is to move the large block from the upper right corner to the upper left corner. This takes a minimum of 47 moves.





## Bed for Dog or Cat

### Materials needed

- 1 piece lumber 1" × 8" (actual size ¾" × 7½") × 18" for back
- 2 pieces lumber 1" × 8" × 12" for ends
- 1 piece lumber 1" × 8" × 10" for front
- 1 piece lumber 1" × 8" × 2" for front
- 2 pieces lumber 1" × 2" (actual size ¾" × 1½") × 18" for floor supports
- 1 piece ½" plywood 11¼" × 18"
- 6d finishing nails

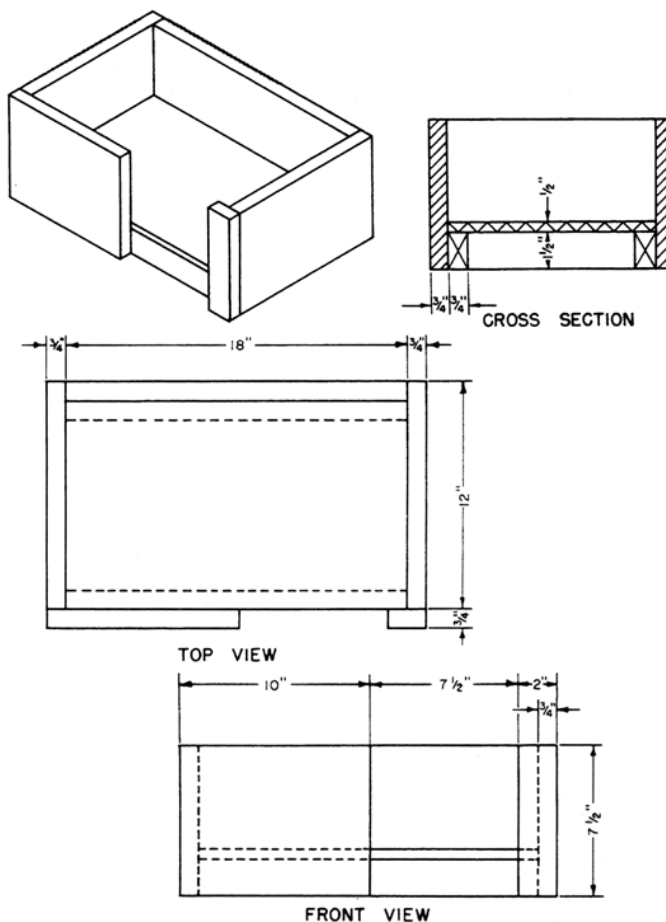
### Tools needed

- Saw
- Hammer
- Sandpaper
- Shellac or paint

### Instructions

1. Cut pieces to size.
2. Nail ends to back.
3. Nail front pieces to ends.
4. Set floor supports in place and nail through end pieces into ends of supports.
5. Nail floor to supports.

Note: If pet is larger or smaller, dimensions can be changed accordingly.



## Nail & Tool Box

### Materials needed

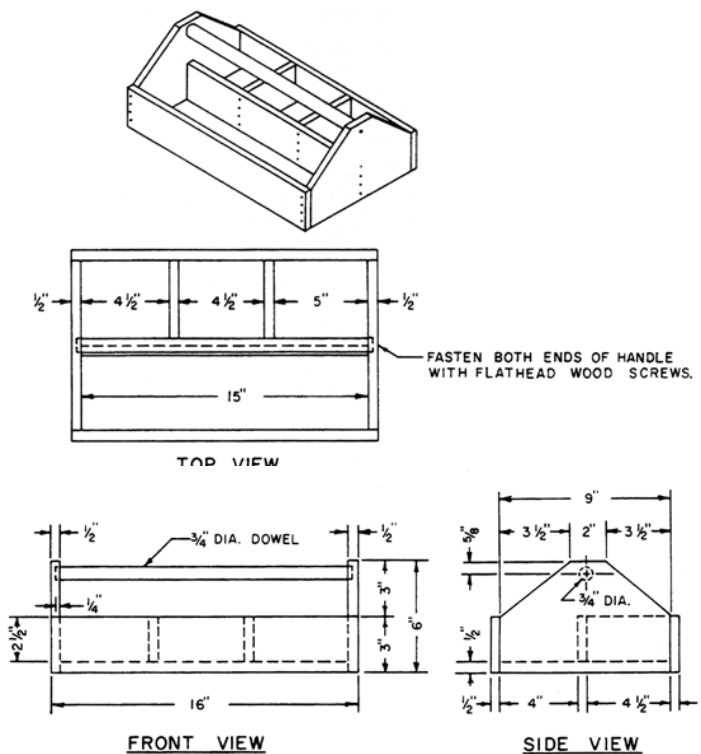
- 1 piece wood ½" × 24" × 24" (use exterior plywood)
- 1 piece of ¾" dowel stock, 15½" long
- Finishing nails 1¼" or 1½"
- 2 No. 8, 1" flathead wood screws
- Glue

### Tools needed

- Hammer
- Saws
- Screwdriver
- Drill with ¾" bit
- Sandpaper
- Paint or shellac

### Instructions

1. Cut pieces to size.
2. Drill end pieces ¼" deep for dowel.
3. Sand all pieces before assembly.
4. Glue and nail partitions to base.
5. Glue dowel between ends and fasten with screws.
6. Fit end/handle section over base. Glue and nail.
7. Glue and nail side pieces to unit.
8. Apply finish.





## Firewood Basket

### Materials needed

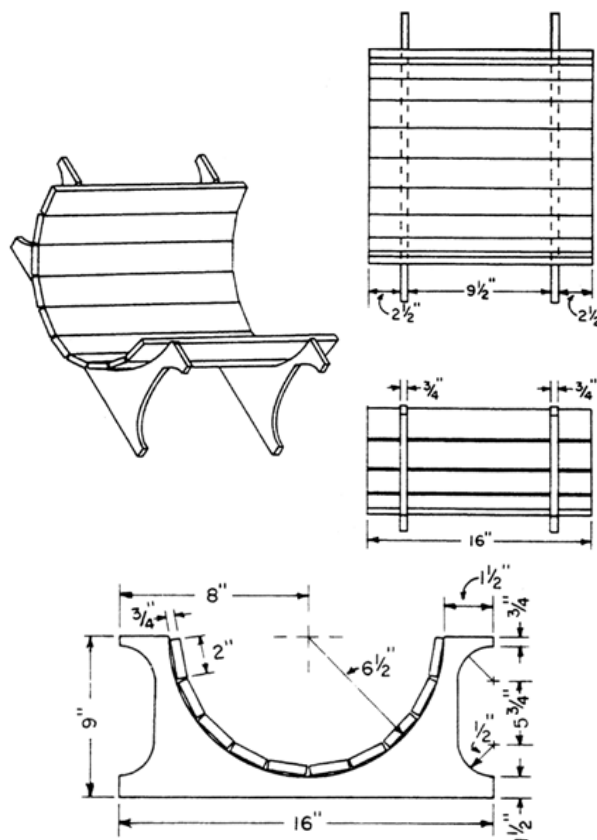
- 2 pieces of  $\frac{3}{4}$ "  $\times$  9"  $\times$  16" plywood for ends
- 10 pieces lumber 1 $\times$ 2 (actual size  $\frac{3}{4}$ "  $\times$  1 $\frac{1}{2}$ ")  $\times$  16" for slats

### Tools Needed:

- Table saw or hand saw
- Jig saw or saber saw
- Hammer
- Hand plane
- Sandpaper on block
- 50 6d box nails

### Instructions:

1. Leave ends of plywood square. (Note: If notched out, keep notch shallow or nails will stick through.)
2. Find center on plywood pieces.
3. Use compass on a string and pencil to lay out semi circle to be cut out for basket ( $6\frac{1}{2}$ " radius).
4. Smooth all surfaces.
5. Cut 10 pieces  $\frac{3}{4}$ "  $\times$  2" for slats.
6. Start at top of semi circle to nail on slats. Keep at 90° angle while nailing. Alternate nailing on slats, first one end then the other.
7. Paint to preference or finish as desired.



## Lawn Stool

### Materials needed

- 2 pieces lumber 2 $\times$ 3 (actual size  $1\frac{1}{2}$ "  $\times$  2 $\frac{1}{2}$ ")  $\times$  2'6"
- 6 pieces lumber 2 $\times$ 3 (actual size  $1\frac{1}{2}$ "  $\times$  2 $\frac{1}{2}$ ")  $\times$  1'4"
- 2 pieces of 1" dowel stock, 19 $\frac{1}{4}$ " long
- Waterproof glue
- 8 No. 12, 2 $\frac{1}{2}$ " flathead screws
- 16 No. 12, 1 $\frac{1}{2}$ " flathead screws
- About 23' of  $\frac{3}{8}$ " manila rope
- Foam rubber or other waterproof cushioning material

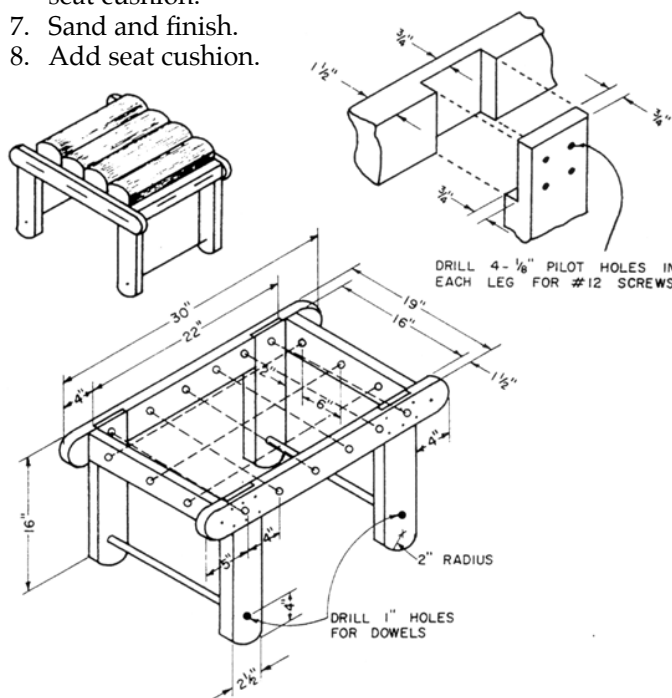
### Tools needed

- Saw
- Drill with 1",  $\frac{7}{16}$ ",  $\frac{1}{8}$ ",  $\frac{3}{8}$ ", and countersink bits
- Screwdriver
- Knife
- Wood file
- Sandpaper
- Exterior paint or stain and exterior varnish

### Instructions

1. Cut pieces to size. Round corners as shown with wood file.
2. Glue rails to legs.
3. Drill 1" holes in legs and glue dowels in place.
4. Drill  $\frac{1}{8}$ " pilot holes through legs into rails and fasten with No. 12, 1 $\frac{1}{2}$ " screws (4 per joint).

5. Glue braces between rail ends. Drill  $\frac{1}{8}$ " pilot holes and fasten with No. 12, 2 $\frac{1}{2}$ " screws (2 per joint).
6. Drill  $\frac{7}{16}$ " holes in frame (6 per side and 3 per end) for rope, as seen in illustration. Weave rope through holes, forming a webbed support for the seat cushion.
7. Sand and finish.
8. Add seat cushion.





## Book Shelf

### Materials Needed:

- 1 piece of  $\frac{3}{8}'' \times 40'' \times 41\frac{1}{2}''$  interior plywood for back (A)
- 2 pieces of  $\frac{3}{4}'' \times 15\frac{3}{8}'' \times 41''$  interior plywood for sides (B)
- 1 piece of  $\frac{3}{4}'' \times 10'' \times 40\frac{1}{2}''$  interior plywood for shelf (C)
- 1 piece of  $\frac{3}{4}'' \times 12\frac{1}{2}'' \times 40\frac{1}{2}''$  interior plywood for shelf (D)
- 1 piece of  $\frac{3}{4}'' \times 15'' \times 42''$  interior plywood for bottom (E)
- 4 pieces of lumber 2x2 (actual size  $1\frac{1}{2}'' \times 1\frac{1}{2}''$ ) x 7" for legs (F)
- 1 piece of lumber 1x2 (actual size  $\frac{3}{4}'' \times 1\frac{1}{2}''$ ) x 29" for rail (G)
- 2 pieces of lumber 1x2 (actual size  $\frac{3}{4}'' \times 1\frac{1}{2}''$ ) x 9" for rails (H)
- 8 12d finishing nails
- 6d finishing nails
- Glue
- Wood filler

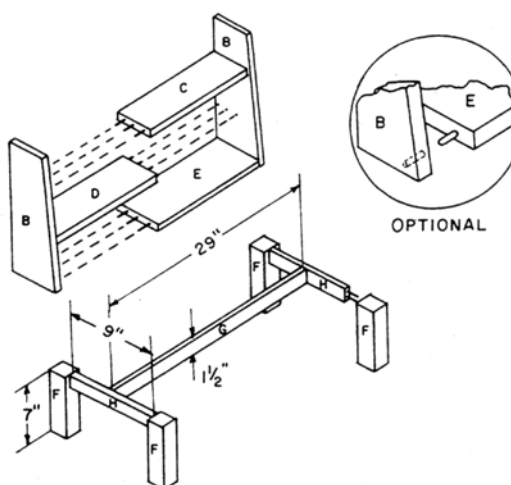
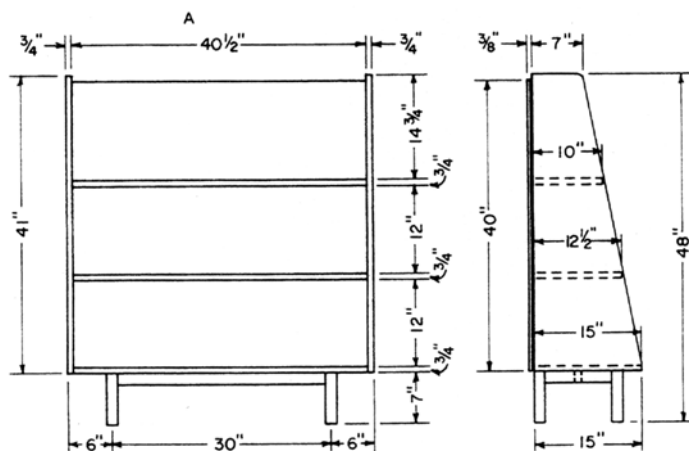
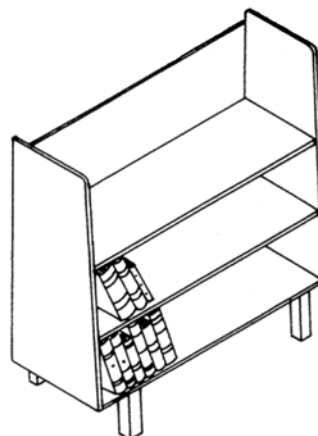
### Tools needed

- Saw
- Hammer
- File
- Nail set
- Sandpaper
- Stain and varnish

### Instructions

1. Cut pieces to size. Round front top corners of side pieces with file.
2. Glue and nail shelves (C, D) and bottom (E) to one end piece (B). Note: Wood dowels may be used in place of nails.
3. Glue and nail other end (B) piece to shelves and bottom.
4. Glue and nail back (A) in place.
5. Glue and nail legs (F) to rails (H) using two 12d nails per leg.
6. Glue and nail end/leg unit to each end of rail (G).
7. Set shelf unit on stand unit and glue and nail in place.
8. Sand and finish.

Note: An optional way to join the rail/leg assembly and put the shelving in is to use dowel pins (see circled diagram).





## Revolving Tie Rack

### Materials needed

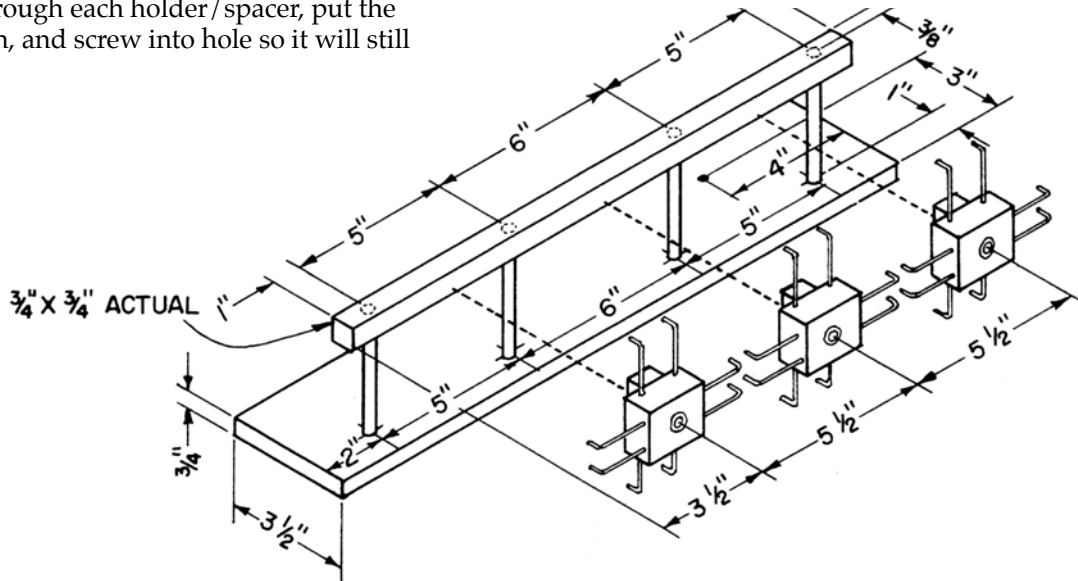
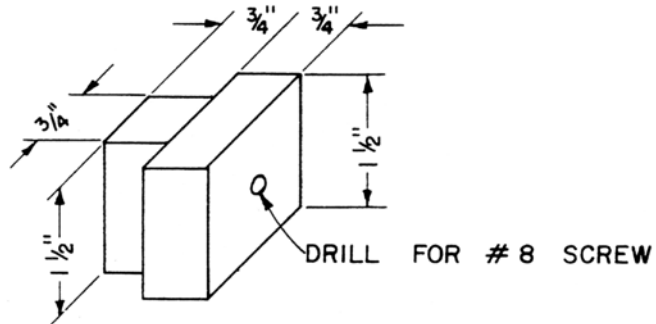
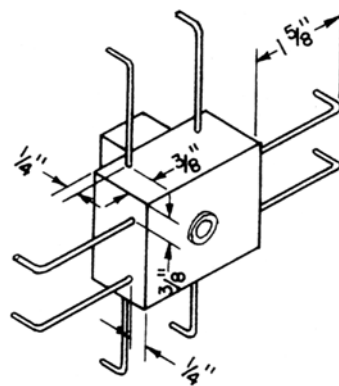
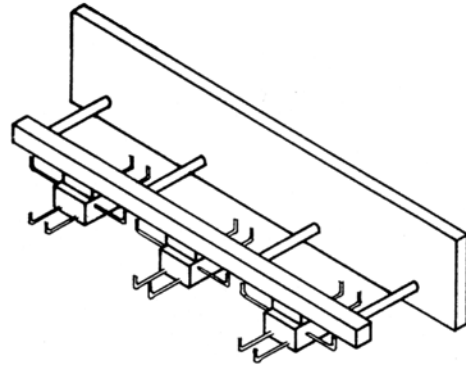
- 1 piece of lumber 1×4 (actual size  $\frac{3}{4}$ " ×  $3\frac{1}{2}$ " ) × 20" for back
- 1 piece of lumber  $\frac{3}{4}$ " ×  $\frac{3}{4}$ " × 18" for bar
- 3 pieces of lumber 1×2 (actual size  $\frac{3}{4}$ " ×  $1\frac{1}{2}$ " ) ×  $1\frac{1}{2}$ " for hook holders
- 3 pieces of lumber  $\frac{3}{4}$ " ×  $\frac{3}{4}$ " ×  $1\frac{1}{2}$ " for spacers
- 4 pieces  $\frac{1}{4}$ " dowel stock,  $3\frac{1}{2}$ " long
- 24 metal screw hooks,  $3\frac{1}{2}$ " long
- 3 No. 8 roundhead woodscrews 2" long
- 6 washers for No. 8 screws
- Glue

### Tools needed

- Drill press or drill with stop gauge and  $\frac{1}{4}$ ",  $\frac{1}{8}$ ", and  $\frac{1}{32}$ " bits
- Screwdriver
- Sandpaper
- Stain and varnish

### Instructions

1. Cut pieces to size.
2. Drill  $\frac{1}{4}$ " holes in bar,  $\frac{1}{2}$ " deep. Use drill press or drill with stop gauge for uniform depth holes.
3. Drill  $\frac{1}{4}$ " holes in back.
4. Drill  $\frac{1}{32}$ " pilot holes for screws in the bottom of bar.
5. Drill  $\frac{1}{8}$ " mounting holes in back, 4" in from ends and 1" from top edge.
6. Center spacers on hook holders and glue in place.
7. Drill a hole through the center of each holder for the No. 8 screw. Holder should turn free on screw.
8. Sand all pieces.
9. Drill pilot holes in holders for hooks, install hooks leaving them protruding about  $1\frac{5}{8}$ ".
10. Mount the bar to the back using the four dowels. Be sure holes for screws are on bottom side of bar.
11. Attach holders to the bar by putting a screw with a washer up through each holder/spacer, put the other washer on, and screw into hole so it will still turn.
12. Apply finish.





## Shop Tool Rack & Shelf

### Materials Needed:

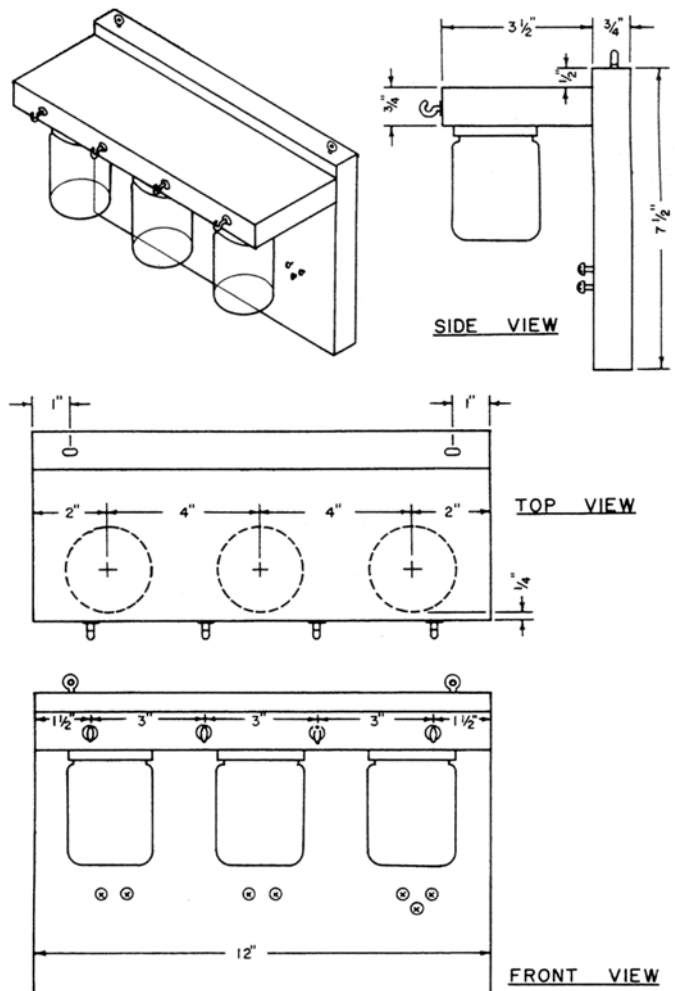
- 1 piece of lumber 1×8 (actual size  $\frac{3}{4}$ " ×  $7\frac{1}{2}$ " ) × 12" for back
- 1 piece of lumber 1×4 (actual size  $\frac{3}{4}$ " ×  $3\frac{1}{2}$ " ) × 12" for shelf
- 3 baby food (or similar) jars with screw type lids
- No. 6,  $1\frac{1}{4}$ " round head wood screws
- 3 Round head wood screws  $\frac{1}{2}$  inch long
- 4 small cup hooks
- 2 screw eyes
- 3 No. 6 finishing nails
- Glue

### Tools needed

- Screwdriver
- Hammer
- Sandpaper
- Shellac

### Instructions

1. Cut pieces to size, sand, and finish before assembly.
2. Punch a hole in each jar lid (center) and fasten the 3 lids to one side of shelf.
3. Glue shelf to back and nail.
4. Locate screws in front to hold tools desired.
5. Put screw hooks on front edge of shelf.
6. Put screw eyes in top edge of back.
7. Fasten to wall with nails or screws through eyes.



## Shadow Box

### Materials needed

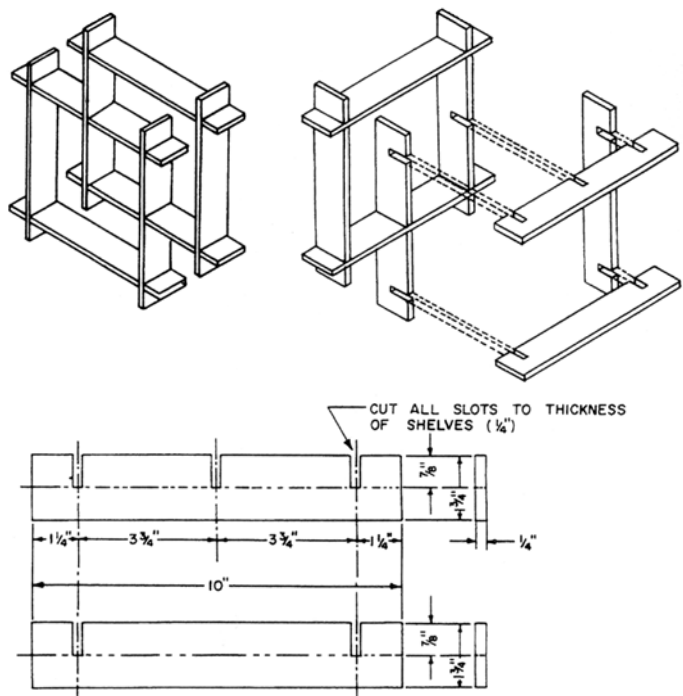
- 8 pieces of interior plywood,  $\frac{1}{4}$ " ×  $1\frac{3}{4}$ " × 10" each
- 2 screw eyes for hanging

### Tools needed

- Table saw, bench saw, or fine hand saw
- Square
- Wood file
- Sandpaper

### Instructions

1. Cut 4 boards to width and length.
2. Lay out slots to be cut, using small square.
3. Use miter saw, bench saw, or fine hand saw. Be sure to make cuts very accurate. Note: Half of the boards have 3 seats. Others have 2.
4. Sand all surfaces smooth.
5. Try fitting pieces together.
6. Finish boards with stain and clear varnish or, enamel before final fitting.
7. Use two screw eyes to mount shadow box on wall.





## Picnic Table with Bench

### Materials needed

#### Table

- 3 pieces lumber  $2 \times 4$  (actual size  $1\frac{1}{2}'' \times 3\frac{1}{2}''$ )  $\times 3'6''$
- 4 pieces lumber  $2 \times 4 \times 2'6''$
- 2 pieces lumber  $2 \times 4 \times 4'$
- 11 pieces lumber  $2 \times 4 \times 7'$
- 2 pieces lumber  $2 \times 4 \times 6'4''$

#### Bench

- 3 pieces lumber  $2 \times 4 \times 3'$
- 4 pieces lumber  $2 \times 4 \times 1'5''$
- 2 pieces lumber  $2 \times 4 \times 1'$
- 2 pieces lumber  $2 \times 4 \times 1'3''$
- 2 pieces lumber  $2 \times 4 \times 1'4''$
- 12d galvanized nails for frame or  $\frac{3}{8}'' \times 4\frac{1}{2}''$  carriage bolts
- 20d spikes

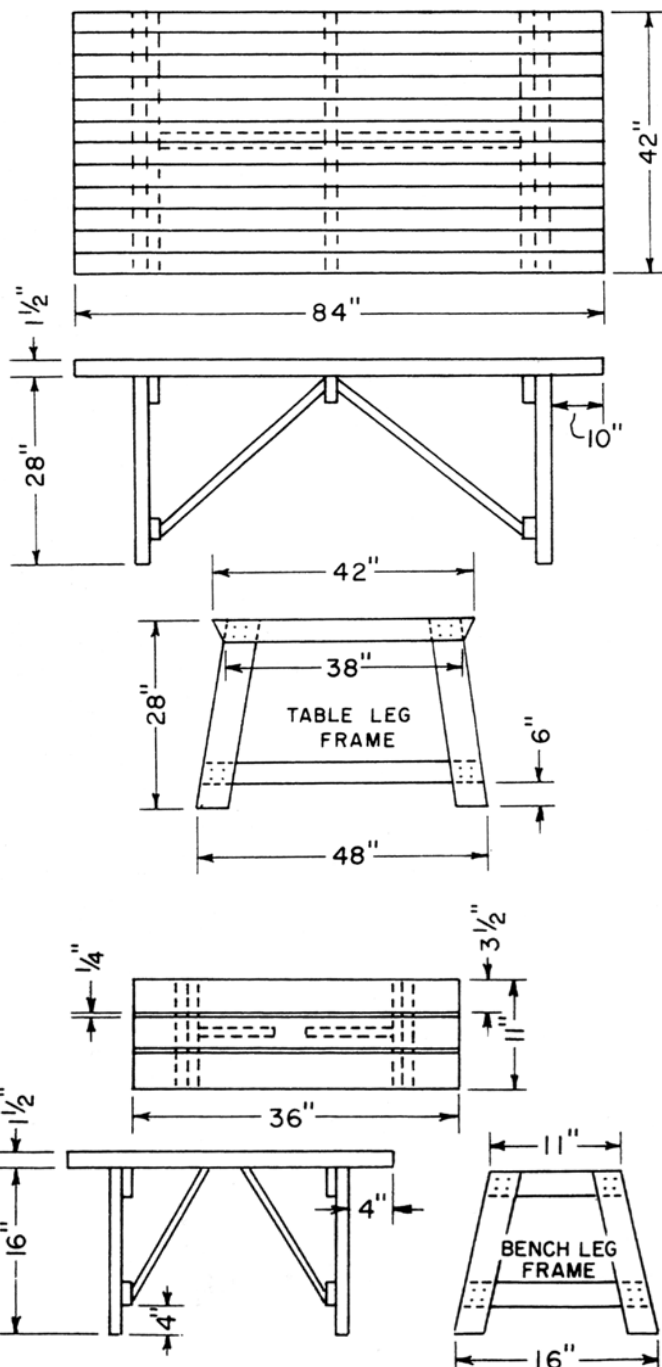
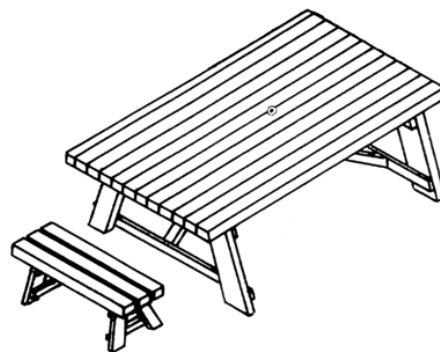
### Tools needed

- Saw
- Wood file
- Hammer
- Sandpaper
- Exterior paint or stain and varnish

### Instructions:

1. Cut pieces to size.
2. Make 2 table leg frames as shown in drawing. Fasten together using 12d nails.
3. Lay the twelve top pieces flat on the floor. Nail a piece of scrap across them at each end to hold them temporarily; this is removed after table is assembled.
4. Set the leg frames upside down on the top, 10" from either end, and toenail cross members of frames to each top board using 12d nails.
5. Toenail center cross member in place. Mark off diagonal braces and nail them in place with 12d nails.
6. Set table right side up and nail each top board to the cross members of the leg frames using 20d spikes.
7. Use wood file to round rough edges and corners.
8. Bench is made in the same fashion as the table except that the top cross member of each leg frame doesn't extend past legs (i.e., it isn't tapered out).
9. Sand and finish bench and table.

Note: For maximum durability, especially if the table and bench are to remain outdoors, use preservative-treated, decay-resistant lumber.





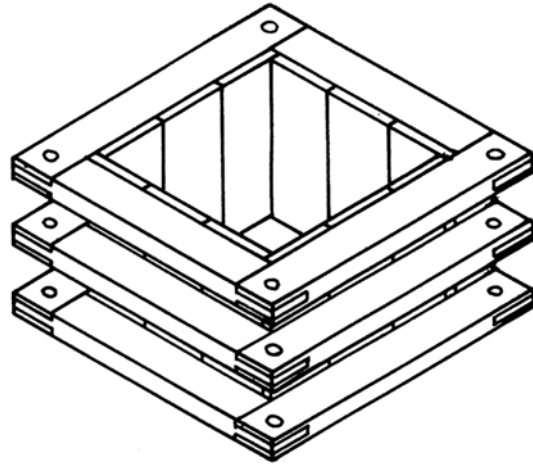
## Planting Box

### Materials needed

- Redwood or cypress
- 12 pieces lumber 2 × 4 (actual size 1½" × 3½") × 26" for frames
- 12 pieces lumber 1 × 6 (actual size ¾" × 5½") × 12" for sides
- 2 pieces lumber 1 × 10 (actual size ¾" × 9½") × 18" for bottom
- 1 piece of ½" dowel stock, 24" long
- Waterproof glue
- 6d aluminum nails

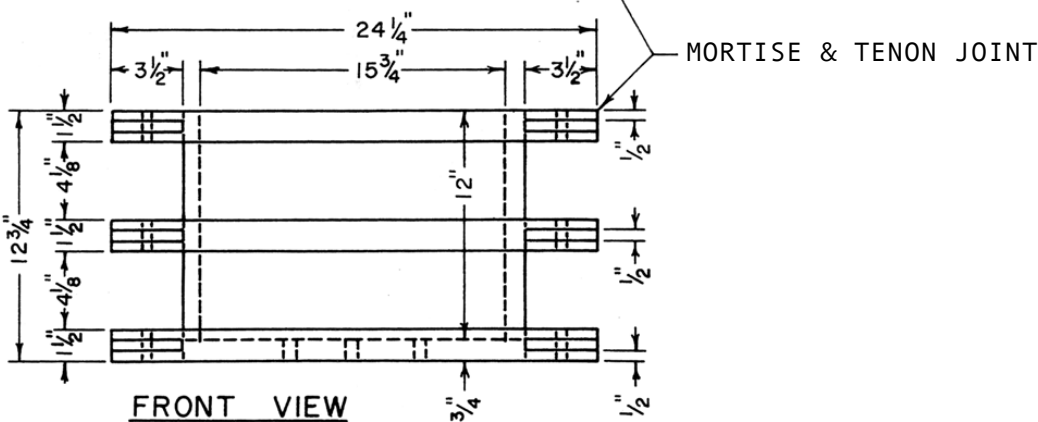
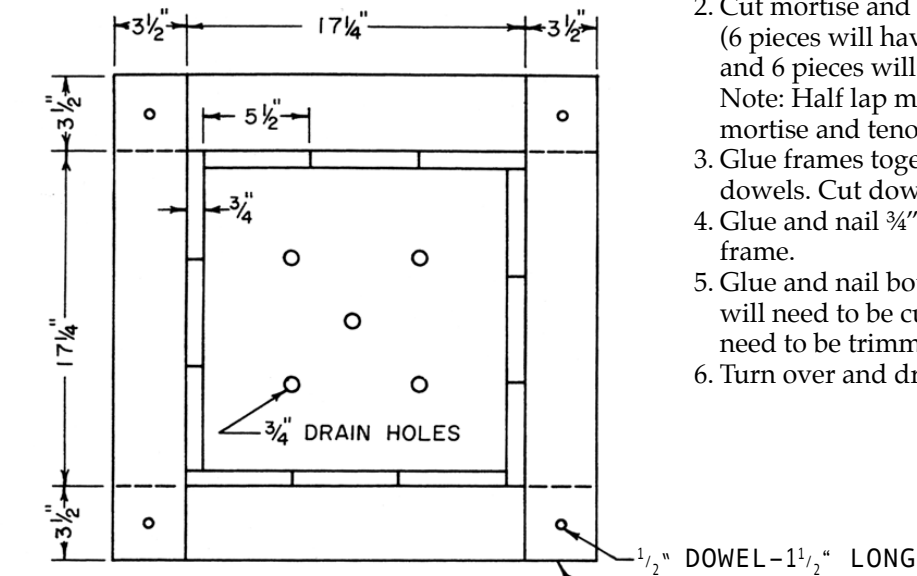
### Tools needed

- Hammer
- Drill with ½" and ¾" bits
- Saw



### Instructions:

1. Cut all pieces to size as illustrated.
2. Cut mortise and tenon on corners of frame pieces (6 pieces will have female type joint on both ends and 6 pieces will have male type joint on both ends). Note: Half lap may be used as an alternative to mortise and tenon.
3. Glue frames together and drill holes in corners for dowels. Cut dowel pieces 1½" and glue in each hole.
4. Glue and nail ¾" × 5½" × 12" pieces to inside of frame.
5. Glue and nail bottom in place. Note: Bottom boards will need to be cut to 17¼" long, and one board will need to be trimmed to 7¼" wide.
6. Turn over and drill ¾" drain holes in bottom.







## Portable Shelving

### Materials needed

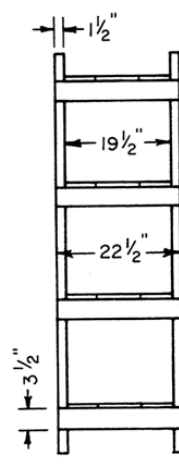
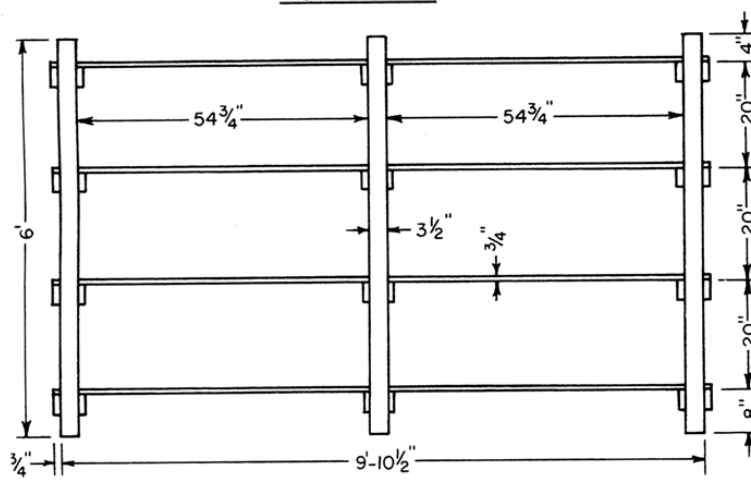
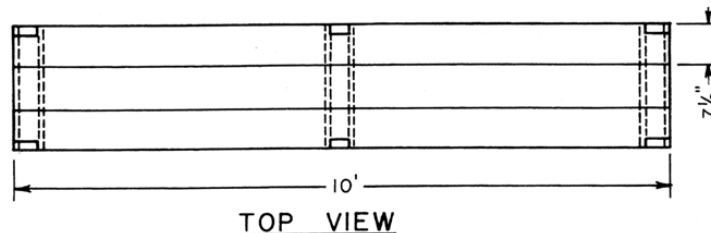
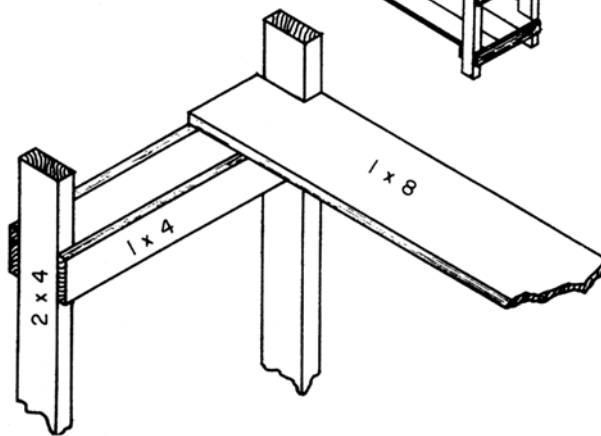
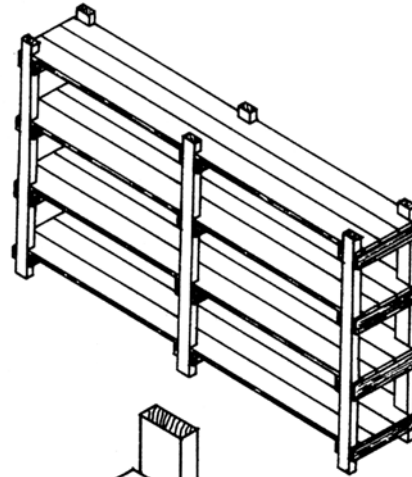
- 6 pieces of lumber 2 × 4 (actual size 1½" × 3½") × 6' for ladder posts
- 12 pieces of lumber 1 × 8 (actual size ¾" × 7½") × 10' shelving
- 24 pieces of lumber 1 × 4 (actual size ¾" × 3½" × 22" for shelving supports (rungs of ladders)
- 96 8d common nails
- 3d and 5d nails for shelving supports

### Tools needed

- Saw
- Scale
- File
- Hammer
- Marking pin
- Chisel

### Instructions

1. Cut six posts to size, 6 feet long, using 2 × 4 pieces.
2. Measure 8" from one end on each post and draw a line on the narrow edge using the square. Repeat process at 28", 48", and 68". These mark the tops of the rungs.
3. Cut the rungs 22" long from the 1×4 boards. Nail in place with 8d common nails. Now check the "ladders" to be sure they stand level.
4. Cut the shelves from the 1×8 boards, 10 feet long each. There will be three of these per level (12 total). Notch out side edges to fit around posts. The two outside shelves need to have three notches cut in them, one at each end and one in the center. These notches should be 1½" × 3½" in size (see illustration).
5. Assemble shelving with 3d and 5d nails. Check for any wobble. If it does not stand level, trim ends of posts to level it.





## Reference Materials

The following are suggested references for the 4-H wood science leader. They may be helpful in providing additional information about woodworking, finishing tools, wood science and technology, and related materials.

These references are not listed in any of the member manuals, so it is up to you to suggest to your group those references that you would like them to use. Some of the items listed here may be appropriate for youth and may be available at your local library.

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- Projects in Wood Furniture*. Douglass, Harvey J. (gr. 7 up, rev. ed., illus.) Bloomington, IL: McKnight Pub., 1967.
- What Wood is That? A Manual of Wood Identification*. Edlin, Herbert L. (illus.) New York, NY: Viking Press, 1969.
- Wood As A Building and Hobby Material: How to Use Lumber and Wood Base Panels and Round Wood Wisely in Construction for Furniture and as Fuel*. Kubler, Hans. New York, NY: John Wiley & Sons, 1980.
- Wood Handbook: Wood As An Engineering Material*. USDA Forest Products Laboratory. Agriculture Handbook #72. Washington, DC: Government Printing Office, 1974.
- Wood Materials and Processes*. Feirer, John L. (illus.) New York, NY: Charles Scribner's Sons, 1976.
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- Wood Structure and Identification*. Core, Harold A. et al., (pap. txt., illus.) Syracuse, NY: Syracuse University Press, 1979.
- The Woodworker's Pocket Book*. Hayward, C. and R. Lento. (illus.) Englewood Cliffs, NJ: Prentice-Hall, 1982.
- Woodworking for Kids*. Torre, Frank. (gr. 3–7) New York, NY: Doubleday & Co., 1978.
- Woodworking for Kids*. Starr, Richard (illus.) Newtown, CT: Taunton Press, 1982.
- Working With Wood*. Background Information. Parker, Sheila. Science 5–13 series (illus.) Milwaukee, WI: Raintree, 1977.
- Working With Wood*. Stages 1 & 2. Parker, Sheila. Science 5 13 series (pap. txt., illus.) Milwaukee, WI: Raintree, 1977.



## Magazines

The following magazines may have dimensioned plans for woodworking projects and are usually available at your local magazine stand or library.

*The Family Handyman*

*Fine Woodworking*

*Popular Mechanics*

*Popular Science*

*Woman's Day*

*Workbench*

## Other Sources of Educational Aids

The following sources may have literature and/or audiovisuals available to help. Some items may be free; others may be available at cost. Write for a guide or catalog to what's available.

American Plywood Association, P.O. Box 11700, Tacoma, WA 98411. "Plywood Publication Index." It covers films, pamphlets and plans that are available.

American Forest Institute, 1619 Massachusetts Ave., N.W., Washington, D.C. 20036. Guide to forest industries, educational materials, movies, and slide show rentals.

American Wood Council, 1619 Massachusetts Ave., N.W., Washington, D.C. 20036. Pamphlet, "Some Little Known Facts About Wood." Leaflet, "A Reader's Guide to Wood Products."

American Paper Institute, 260 Madison Ave., New York, NY 10016. Guide to literature and audiovisuals.

Craft Patterns Studio, 2200 Dean Street, St. Charles, IL 60174. Write for information on woodworking plans and craft patterns.

Directions Simplified, Inc., P.O. Box 215, Briarcliff Manor, New York 10510. Write for a catalog and order form for patterns and books. Audiovisuals may also be available.

Hardwood Plywood Manufacturers Association, 1825 Michael Faraday Dr., Reston, VA 22090. A list of hardwood plywood literature and plans is available.

Mastercraft Plans, Box 631, Park Ridge, IL 60068. "Popular Plans & Patterns."

National Forest Products Association, 1619 Massachusetts Ave., N.W., Washington, D.C. 20036. Write for information on free and inexpensive literature.

National Particleboard Association, 2306 Perkins, Silver Spring, MD 20910. Write for information on free and inexpensive literature.

Southern Forest Products Association, P.O. Box 52468, New Orleans, LA 70152. Write for a copy of "Everything You Always Wanted To Know About Southern Pine and Ought To!"—a catalog of consumer, technical, and educational literature, films, and services.

Southern Forest Institute, 3395 Northeast Expressway, Suite 380, Atlanta, GA 30341. Booklet: "How Paper Comes From Trees"; also other aids.

Stanley Tools, Educational Department, 600 Myrtle Street, New Britain, CT 06050. Write for information on woodworking plans and safety charts.

Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Write for information on literature related to wood science, woodworking, and forestry.

Weyerhaeuser Company, Box A, Tacoma, WA 98401. Write for information on literature and audiovisual aids relating to wood science and woodworking.

Hand Tool Institute, 707 Westchester Avenue, White Plains, NY 10604. Write for information on the "Hand Tool Safety Guide to Selection and Proper Use"; also ask for information on any other related aids that are available.



## Glossary of Woodworking Terms

### A. General Terms

**d**—the abbreviation for “penny” in designating nail size; for example, 8d nails are 8 penny nails, 2½” long.

**fiber**—A general term used for any long, narrow cell of wood or bark, other than vessels.

**grain direction**—The direction of the annual rings showing on the face and sides of a piece of lumber.

**hardwood**—Wood from a broad leaved tree and characterized by the presence of vessels. (Examples: oak, maple, ash, and birch.)

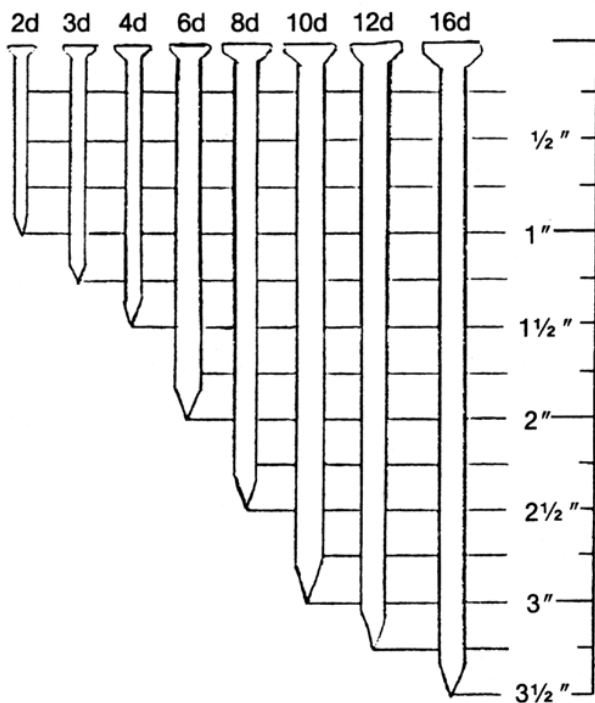
**heartwood**—The older, harder, nonliving portion of wood. It is usually darker, less permeable, and more durable than sapwood.

**kiln dried**—Wood seasoned in a humidity and temperature controlled oven to minimize shrinkage and warping.

**sapwood**—Wood immediately inside the cambium of the living tree that contains living cells. This wood is more permeable, less durable, and usually lighter in color than heartwood.

**softwood**—Wood from a coniferous or cone bearing tree and characterized by having needles, such as pine.

**vessel**—A series of cells having fused together to form a long tube. They extend longitudinally in the stem.



### B. Terms Used in the Lumber Industry

**boards**—Lumber less than 2 inches in nominal thickness and 1 inch and wider in width.

**board foot**—A measurement of wood. A piece of wood that is 1 foot long by 1 foot wide by 1 inch thick. It can also be other sizes that have the same total amount of wood. For example, a piece of wood 2 feet long, 6 inches wide, and 1 inch thick; or a piece 1 foot long, 6 inches wide, and 2 inches thick would also be 1 board foot. To get the number of board feet in a piece of lumber, measure your lumber and multiply Length (in feet) x Width (in feet) x Thickness (in inches). The formula is written:

$$T'' \times W' \times L' = \text{Board feet} \quad \text{or} \quad \frac{T'' \times W' \times L'}{12} = \text{Board feet}$$

$$\text{or} \quad \frac{T'' \times W' \times L'}{144''} = \text{Board feet}$$

**dimension lumber**—Lumber 2 to 5 inches thick and up to 12 inches wide. Includes joists, rafters, studs, planks, girders, and posts.

**nominal**—Refers to the size of lumber by which it is known and sold in the market. Nominal size often differs from the actual size.

**timbers**—Lumber that is 5 inches or more in its least dimension. According to use in construction, they are classified as beams and stringers, girders, purlins, and posts.

**veneers**—A thin slice of wood cut from a log with a knife or saw. Veneers are also produced in a giant lathe, by turning a log on a horizontal axis against a long knife cutting the log into thin wood slices.

Note: Also refer to the glossary in each of the member manuals.

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# 4-H Wood Science Project Record

(Use with all Wood Science units)

Year \_\_\_\_\_

Member's name \_\_\_\_\_ Age \_\_\_\_\_ County \_\_\_\_\_

Address \_\_\_\_\_ Zip Code \_\_\_\_\_

Units of Wood Science completed this year \_\_\_\_\_  
(Name of project manual – Unit)

1. Write a short story about the new things you learned this year regarding wood and its use. (Attach an extra sheet of paper.)
2. List the item(s) you made, refinished, repaired, etc. Indicate total cost of materials used for each and the value of the finished product. Estimate the number of hours you spent on each item. (You should keep a separate itemized list of materials and costs for each woodworking item that you complete. In some states, it may be necessary to attach it to your project record sheet.)

Item	Total cost of materials	Value of product	Hours spent

3. List the primary tools and procedures used in this project.  
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\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
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4. Describe the safety precautions you observed in your woodworking activities or safety precautions you learned about for the first time.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

5. When making items from wood, did you use the blueprints/ plans provided in the 4-H manual, blueprints from another source, or make up your own plans? (Check as many as apply.)

- Blueprints in 4-H manual       Blueprints from another source       Made my own blueprints

6. Note any problems you encountered, if any, while making, refinishing, or repairing items from wood. If you could do the same item again, what would you do differently?

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7. What additional items would you like to learn how to make in future project work?

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8. What tools and skills would you like to utilize in wood science?

Tools	Skills

9. List any demonstrations, speeches, talks, news articles, radio or TV appearances that you were involved in related to your project work.

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10. What leadership and citizenship activities did you do as an individual and/or in a group?

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(Note: You may attach an extra sheet of paper for answering questions, if necessary, but try to be brief and concise with all answers.)