Introduction

Engineering models are not new. For centuries, humans have used scale models to communicate thoughts and ideas. The tombs of Egypt, for instance, contained many exciting models that showed what life was like in that country thousands of years ago. From these models we learned how the Egyptians harnessed their horses, rigged their ships, armed their warriors, and buried their kings.

Modern engineering modeling started after World War II. Since then it has had a great impact on everyday life. It has helped in the engineering of food-processing plants, chemical and plastics plants, power plants, hydraulic structures and systems, oil refineries, and nuclear reactors.

Types of Models

Many types of models can be constructed to serve different purposes. Hobbyists build model aircraft, cars, trains, boats, houses, furniture, and other items in miniature simply because they are fun to make.

This model of a submarine was used in the 1989 movie "The Hunt for Red Ocober."

Other models have special uses in business and industry. Automobile manufacturers, for instance, often use models to test the *aerodynamics*, or wind resistance, of vehicles. Filmmakers use models to achieve breathtaking special effects in movies. Engineers use models in designing dams and flood-control structures. Furniture designers use models to help make chairs and tables more attractive and comfortable. Other uses for professional-quality models are listed in the section of this pamphlet that discusses modelmaking as a career.

For requirement 4, you are to build one of the following types of models used in business and industry:

- *Architectural*—a model of a house
- *Structural*—a model showing corner construction of a wood-frame building
- *Process*—a model of the plumbing system in a house
- *Mechanical*—a model of a mechanism that does some kind of work
- *Industrial*—a model of a passenger-carrying vehicle

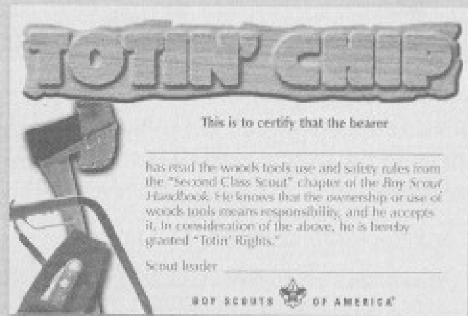
Before choosing which type of model to build, be sure that you get your counselor's advice. Although only one model is required for this merit badge, you may want to build more than one.

Use tools only under the watchful eye and close supervision of a responsible adult.

Safe Use and Care of Hand Tools

These instructions are a basic guide to tool safety and care. Use tools safely to avoid accidents, reduce injuries, prevent damage to the tools, and improve your model. In addition, taking proper care of your tools will help ensure their usefulness for many years to come.

If you have earned a Totin' Chip for knife and ax safety, you already know how important it is to use tools safely. If you have not, begin learning the basics of woods tools safety by completing the requirements for the Totin' Chip. Boy Scouts earn this recognition to get good, basic information on knife safety. The Totin' Chip is like a driver's license for carving. You need it to participate in many Scout activities and functions, so carry it with you at all times.

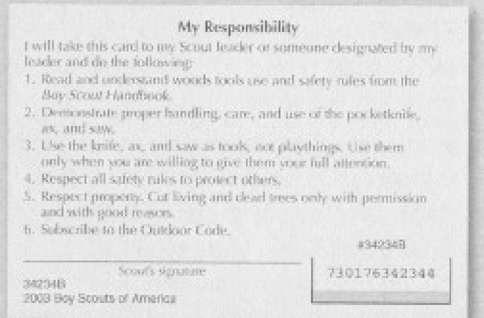

TOTIN' CHIP

This is to certify that the bearer

has read the woods tools use and safety rules from the "Second Class Scout" chapter of the *Boy Scout Handbook*. He knows that the ownership or use of woods tools means responsibility, and he accepts it. In consideration of the above, he is hereby granted "Totin' Rights."

Scout leader ______________________

BOY SCOUTS OF AMERICA


My Responsibility

I will take this card to my Scout leader or someone designated by my leader and do the following:

1. Read and understand woods tools use and safety rules from the *Boy Scout Handbook*.
2. Demonstrate proper handling, care, and use of the pocketknife, ax, and saw.
3. Use the knife, ax, and saw as tools, not playthings. Use them only when you are willing to give them your full attention.
4. Respect all safety rules to protect others.
5. Respect property. Cut living and dead trees only with permission and with good reason.
6. Subscribe to the Outdoor Code.

#34234B

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Scout's signature

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2003 Boy Scouts of America

General Tips

There are a lot of dos and don'ts to keep in mind when using hand tools.

- Never work alone when using tools.
- Take good care of tools. Keep them clean, oiled, and sharp. Return them to your toolbox when you are finished with them.
- Use each tool for what it was made to do—never for anything else. For instance, use hammers only to hammer in or remove nails.
- Use only tools that are in good working condition. Broken tools could cause injury or damage your model.

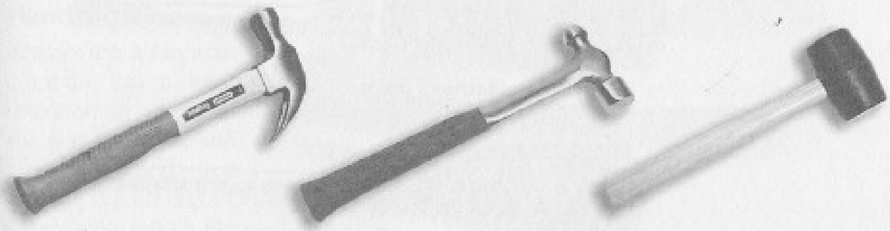
Face Shields and Goggles

Whenever necessary, wear protective equipment over your face and on your hands. Using the proper equipment will prevent most accidents, but be prepared for the unexpected. Make sure the face shield headband fits properly (follow the manufacturer's instructions on proper fit), and be sure to clean or wipe the goggles after use.

Hand Tools

Hammers and Mallets

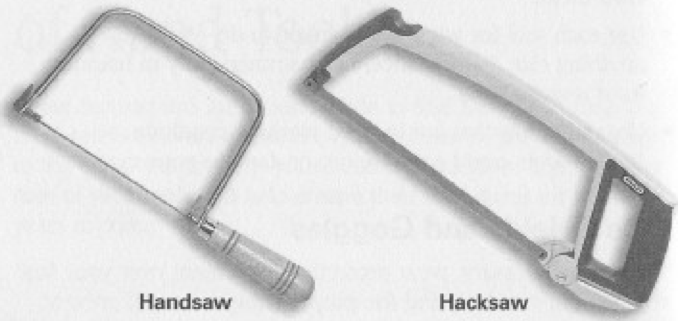
Always use the face of the hammer when striking an object, and use only the amount of force needed. Use the claw of the hammer only on wood and only for removing nails; a ball-peen hammer is for metal.



Claw hammer **Ball-peen hammer** **Mallet**

Handsaws

Use a vise to secure the material being sawed. To prevent buckling or breaking, adjust the blade tension and make sure blades are installed in the correct position. While working, provide enough clearance so that, in sawing, the point of the saw will not strike any object. Use even, steady strokes

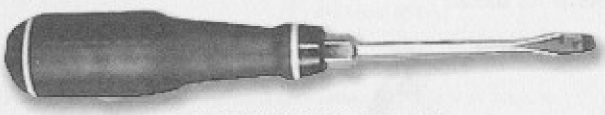


Handsaw Hacksaw

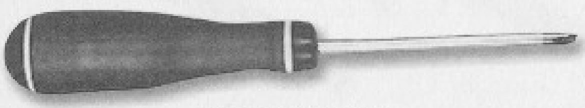
without bending the blade. Saws cut on a forward stroke, so make sure to apply pressure on the appropriate stroke. When you are done, wipe the blade clean and store the saw safely in a tool rack. Make sure other tools are not on top of the blade.

Screwdrivers

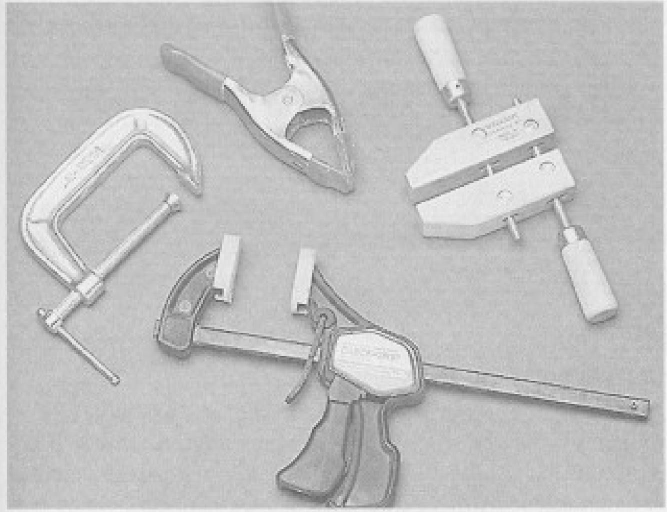
Choose the correct size when using a screwdriver. Keep the handle directly over the screw head and turn with smooth, even strokes while applying steady pressure toward the screw.



Flathead (slotted) screwdriver



Phillips screwdriver



Use vises and clamps to help keep your project in place while you work.

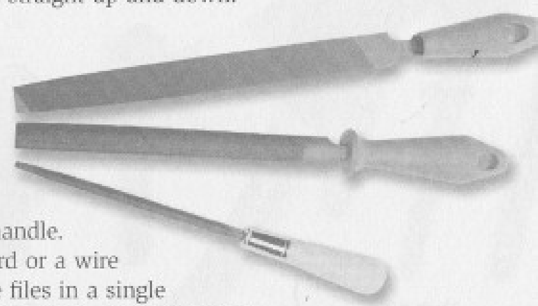
Clamps (C Clamps, Bar Clamps)

Use the proper size clamp, and make sure the clamp is not overtightened. Always keep clamps clear of drilling equipment while you are drilling.

Bench Vises

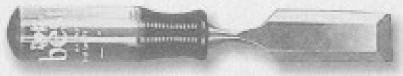
Always attach the vise to a firm work stand and use the vise—never your hands—to secure materials. Use just enough pressure to hold materials securely. Remain clear of the vise body during drilling or cutting operations. When you are done, close the vise and leave the handle straight up and down.

Hand Files

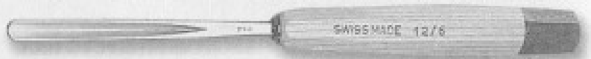


Always use a file with a handle. Cut in the direction for which the file was intended, and keep hard objects from striking the file teeth or handle. Clean a file with a file card or a wire brush after use, and store files in a single layer—never on top of each other—in a dry place.

Have a professional sharpen or regrind your tools. Improper maintenance could permanently ruin your tools.



Chisel



Gouge

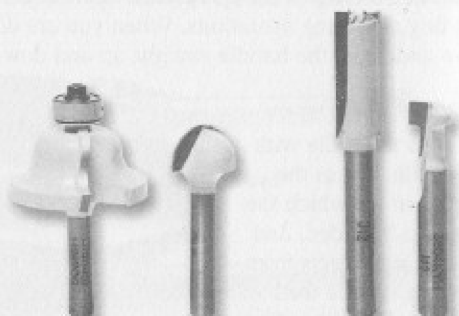
Chisels and Gouges

Always wear safety goggles when carving, and use tools big enough for the job. Use the chisel or gouge on metal only if it is a "cold chisel" meant for metal, and use only wooden mallets to hammer on chisels and gouges. Before you begin, clamp the material securely to a bench vise. Chip toward the stationary jaw of the vise, using the blade, not the point or corner. When you are done, cover the blades and store your carving tools in a dry area.

Drills and Drill Bits, Countersinks and Router Bits

Tighten the shank of the twist drill securely in the chuck. Avoid taking heavy cuts through material, and run routers and drills at the correct speed for the material. While working, keep the twist drill away from any clamping device. Cut only materials for which the router bits were intended.

Drill bits



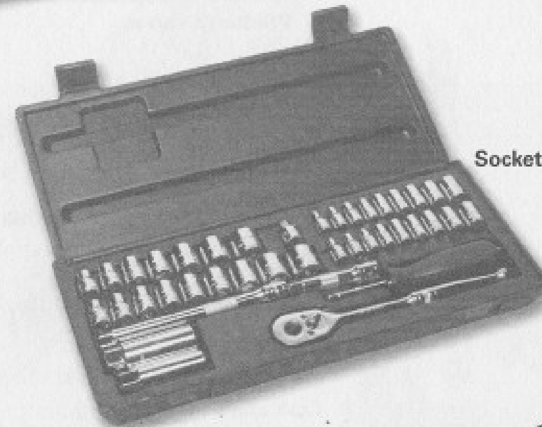
Router bits

Wrenches (Open-ended, Adjustable, Socket)

Use the correct size. Pull the wrench toward you, not away from you. Tighten bolts so they are secure but not too tight. It is not necessary to use extension bars on wrenches when tightening or loosening bolts.

Adjustable wrench

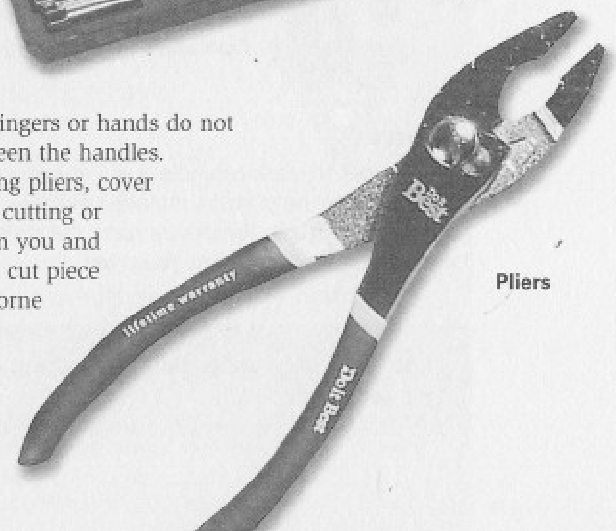
Open-ended wrench



Socket wrench set

Pliers

Watch that your fingers or hands do not get pinched between the handles. When using cutting pliers, cover the piece you are cutting or point it away from you and other people. The cut piece may become airborne after it is cut.



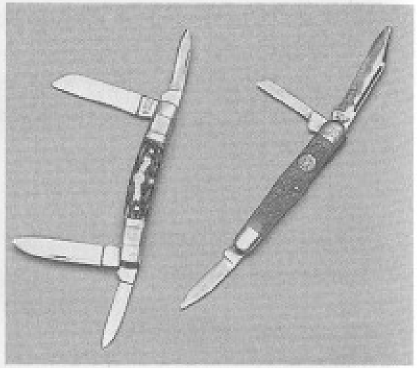
Pliers

Knives

Use sharp blades that do not have any nicks. Cut away from the body.

When you are done, cover the blade and put the knife away.

A dull tool is a dangerous tool.



Whittler's knives

Craft knives

Utility knife

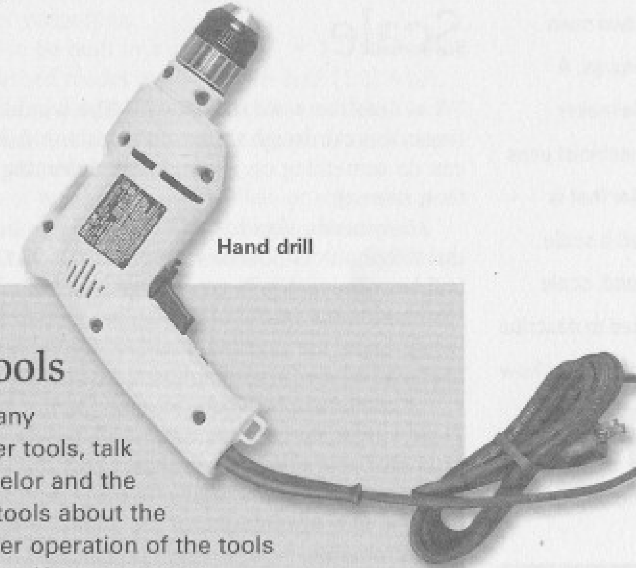
Scribers

Use a scriber to mark centerlines or cut lines on plastic material. Use the scriber only for its intended purpose, not as a center punch, pry, or pick. When you carry the scriber, hold it by the handle with the point away from you.

Use tools only under the close supervision of a responsible adult.

Hand Drills

Use a vise or clamp to secure the material being drilled. Never use pliers to tighten a twist drill in the chuck. Do not force a drill into the work, and never hit the handle with a hammer or mallet. Always use sharp bits. As you work, use a brush to sweep away chips.



Hand drill

Portable Power Tools

Before using any portable power tools, talk to your counselor and the owner of the tools about the safe and proper operation of the tools you plan to use. Here are some simple guidelines to remember.

- When unplugging a power tool, grasp the plug head and pull straight out from the wall socket or extension cord.
- Use portable tools only for the work for which they are meant to be used. Ask your counselor if you think you might need to use a more heavy-duty tool.
- Carry a portable power tool by its handle, not its cord.
- Arrange the cord so that it will not be in the way of the operation.

In the engineering and modeling world, *scale* has two main meanings. A modelmaker or machinist uses a ruler that is called a scale. Second, scale is used to describe *proportion*, or how the size of one thing compares to another.

Scale

What does the word *scale* mean? The word has many definitions. You can weigh things on a scale. A fish has scales. You can do something on a grand scale, meaning larger or bigger than normal.

If someone says to you, "I'm going to build a model of this telephone to double scale," this means the finished model will be twice as big as an average telephone. If someone said, "I'm building a model of this automobile to half scale," you would know the finished model of the car will be only half as big as a real car. That would still be one big model!

A model might be double size (2:1) or half size (1:2). The relationship between the model and the original is expressed as a *ratio*, which shows how the size of one thing relates to the size of another. The first number represents the model's scale in multiples of the original's size, which is the second number. A scale might be changed to three times as large (3:1) or one-third as big (1:3) as its original. As the modeler, you decide based on what you want the final size of the model to be.

There are two basic number systems used for measurements. The *foot-and-inch system* is also known as the imperial system. The *metric system* uses the meter for the basis of all length measurements. In this pamphlet, we will use the foot-and-inch system. When we talk about scale from now on, we will talk about the proportions of models or plans as they relate to a one-foot, zero-inch ruler. Let's examine the one-foot ruler as a basis for model scales:

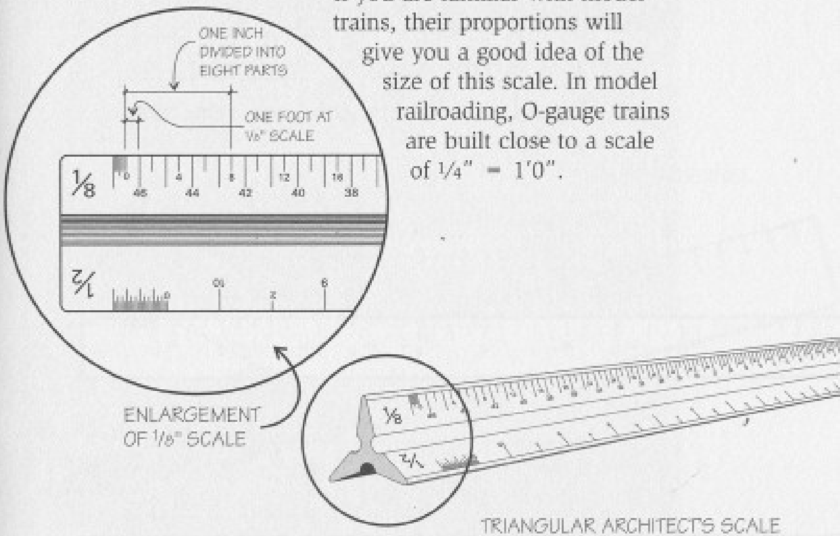
- It has 12 equal parts, each of which is called an inch.
- It can easily be divided into two, three, four, six, or 12 parts:
  —Two parts equals 6".
  —Three parts equals 4".
  —Four parts equals 3".
  —Six parts equals 2".
  —Twelve parts would each be 1" long.

In the above example, the 6" part is said to be one-half (1:2) scale or proportion. The 4"-long part is said to be one-third (1:3) scale or proportion.

If a model is to be built to a scale of 6" = 1", you would know that the finished model would be one-half (1:2) scale, or one-half the size of the real thing. A replica modeled to a scale of 3" = 1'0" would be built to one-fourth (1:4) scale, or one-fourth the size of the original.

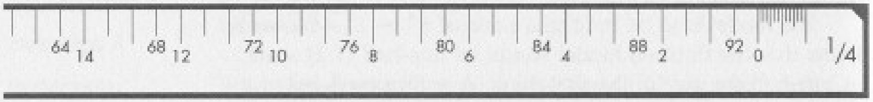
Most models of buildings, automobiles, or stage sets, for instance, are built to an even smaller scale. For instance, a model built to a scale of 1/4" = 1'0" would be only 1/4" long or high for each foot of the "real" item. The proportion would be 1:48, or 1/48 the item's real size. That's because a one-foot ruler has 48 pieces that are 1/4" long.

If you are familiar with model trains, their proportions will give you a good idea of the size of this scale. In model railroading, O-gauge trains are built close to a scale of 1/4" = 1'0".



A wonderful tool called an architect's rule, or scale, helps a modeler build a model to almost any scale. This triangular ruler displays 11 common scales and a regular one-foot ruler.

Let's see how the ¼″ = 1′0″ scale looks on the architect's scale. Some people like to think of each ¼″ section as a miniature foot-long ruler. The illustration here shows how the first ¼″ is divided into 12 small spaces. Each little space is to be used as a guide for 1″ at the ¼″ scale.



The ¼″ = 1′0″ scale, shown actual size

Reading an Architect's Scale

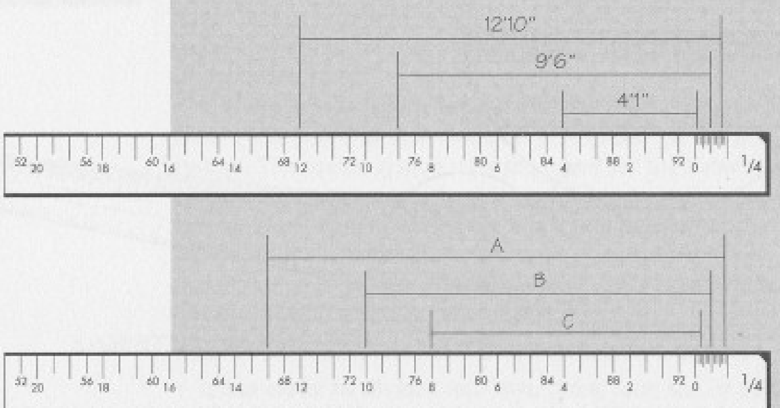
The following examples show how to read the ¼″ = 1′0″ scale on an architect's scale.

How long is dimension A? ______________

How long is dimension B? ______________

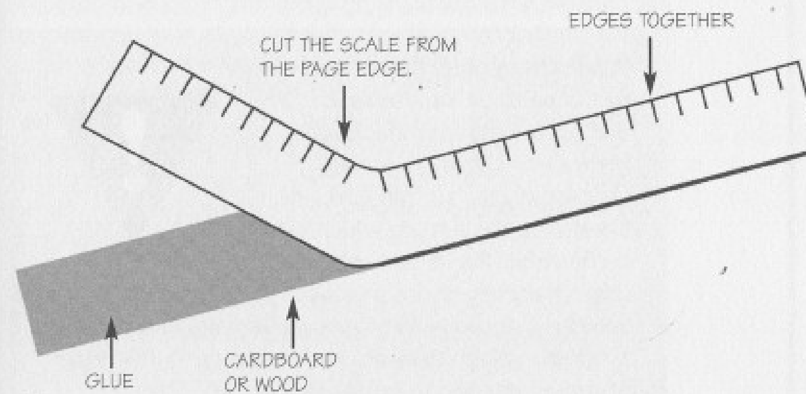
How long is dimension C? ______________

Check your answers with your merit badge counselor.



Each scale on an architect's scale is read in a similar way. As an example, look at the ¾″ = 1′0″ scale. There are 16 pieces measuring ¾″ in a foot-long section, which means the ratio will be 1:16, or 1/16 size. Every foot of the real, finished part would be 16 times larger than the model. Another way to say it is that each "real" foot vertically or horizontally would be modeled as ¾″ long.

You won't need to buy an architect's scale to build your model. The edges of some right-hand pages in this pamphlet are printed to duplicate the 11 scales on the architect's scale. When you choose a scale to build your model, simply cut the edge of the page off and glue it to a piece of cardboard or wood. Glue it so that the marks line up with the edge of the cardboard.



Glue the scale from the edge of the page to a cardboard or wood backing.

Materials and Finishes

Modelmakers are experts on materials and finishes. They use all sorts of surprising things for making models. A trip to a local, well-equipped model supply store will give you many ideas. This section offers ideas about where to find modeling materials. The trick is to use things found around the house to come up with a unique model.

Glue and Paint

Some types of models require supplies such as glue or paint. Be sure to use materials that will not damage your model. Some glues and paints contain solvents that can eat away the finish or materials of your model. Test the glue or paint by dabbing a little on a scrap piece and see what happens. Your counselor also can help you choose the right supplies.

> When using glue, epoxy, paint, or thinners, be sure to read and follow the manufacturer's instructions. Work in a well-ventilated area so that you won't breathe in the fumes, which can be harmful. Avoid skin exposure when handling these products. In fact, you may want to use protective latex gloves. Be sure the products you choose are compatible with the types of materials used in your model.

Wood and Polystyrene Foam

Wood probably is the most common material used for models. Softwoods such as balsa, pine, or basswood are ideal. Thin sheets of wood such as those from orange crates and other packing boxes also work well. Wood can be nailed or glued with model-airplane cement, and it sands well for a nice finish. Some models are made from larger blocks of wood and are carved or sawed to the shape desired. Large blocks of dense polystyrene foam work well, too.

Cardboard

Another common material in model building is cardboard. Thick corrugated cardboard is the material used to make most moving boxes and packing boxes. Thinner cardboard such as that used to make the backs of writing tablets, shoeboxes, and gift boxes also can be used. Manila file folders, an everyday office supply, are a source for very thin cardboard.

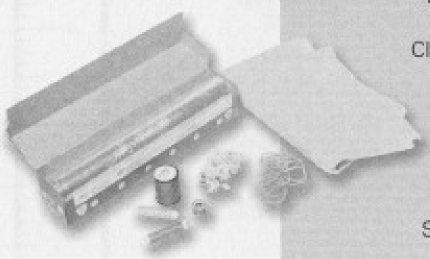
> Adhesive tape can be used on cardboard, but white glue and rubber cement work better and are more permanent.

If you have a little money and want to use a material that many architects use to build models, try foam core. You can find it at art supply stores. Foam core is a piece of plastic foam sandwiched between two sheets of poster board. This product costs more than cardboard, but it's more effective for creating curves. You cut foam core with a utility knife, which gives you more precision on the cuts.

> Remember to be careful when using knives. (See the chapter "Safe Use and Care of Hand Tools.")

Materials and Uses

The following list will help you get started collecting materials for your modelmaking project.



Material	Use on Model
Tongue depressors, craft sticks	Wood or metal beams, house siding, links in a breadboard or 3-D mechanical model
Straws, uncooked spaghetti, dowel sticks, coat hanger wire, pencils, matchsticks	Pipes and columns, axles, push rods, dowels, fence posts, telephone poles
Plastic foam meat tray (flat bottom)	House wall sections, inside walls, floors and other flat surfaces, staircases
Straight pins, thumbtacks	Indicators of valve locations on straw pipes, temporary fasteners to hold plastic foam in place while gluing, pivot points for breadboard models
Sandpaper (different colors)	Rooftops, blacktop driveways, textured surfaces
Twigs from shrubs	Trees
Cotton, lichens, sponges	Shrub and tree foliage
Plaster of paris	Irregular shapes
Soup or vegetable cans, oatmeal canisters	Tanks on a process model, rollers, large pipes
Rubber bands	Belt or chain drives
Cloth or canvas	Coverings for irregularly shaped surfaces
Clear bread wrappers, plastic wrap	Window glass
Sewing thread	Cables, telephone wires
Sawdust sprinkled over wet rubber cement	Grass and painted green

Selection

As you choose the materials for your model, be sure the material you select is strong enough to hold up. For instance, you would not use a piece of thin cardboard or plastic foam as a push rod in an engine model. The cardboard would buckle and the foam might crunch. You would need something stronger, like wood or metal. Or, if you used coat hanger wire for a long push rod it probably would bend. If you used it for a short rod, it might work fine.

Craftsmanship

Consider craftsmanship when you assemble your model to make it look its best. In business and industry, models often are used to test how the real product will work, to help sell an idea, or to explain a mechanism or process to a client. So, apply all your materials so that your model looks polished and professional.

Remember, choose your project first and get your counselor's input and approval. A good Scout uses his resources wisely.

Architectural Models

Architecture is the art of designing buildings. Architects and engineers often use models to see how the buildings they design will look, in miniature, before construction begins on the full-scale structure. Models are important design aids because even the most carefully made drawings and blueprints will not include all the details that can be shown in a model.

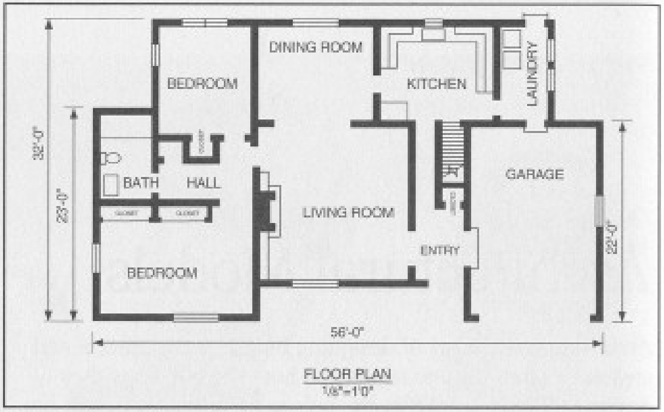
Drawings are flat, or two-dimensional, while a model shows a structure in three dimensions.

You do not have to be an architect or an engineer to design and build a model. For requirement 4, you can make a model of your family home, a fantastic home of the future, perhaps, or living quarters inside an orbiting space station. Your model could be of an elaborate tree house, a frontier fort, a castle, or some famous building like the White House or the Taj Mahal.

Plans and Materials

To begin, draw a *floor plan* of the building you plan to model. If you are making a model of an existing structure, take careful measurements of it and draw a floor plan based on your measurements. As a guide, use the sample floor plan provided. Or you can base your design on a floor plan printed in a book or magazine. Check your local library or a do-it-yourself type of building-supply store for ideas.

Experiment with creative types of construction and unique styles. Some hobbyists build elaborate model houses using materials such as plastic, foil, or polystyrene foam. Use your imagination.



Sample floor plan and elevation

Note that the sample plan is drawn to a scale of ⅛" = 1'0". Thus, the outside dimensions of the house—32" by 56"—are drawn on the plan as 4" by 7". The height of the house is not shown, but for a typical one-story house you can assume a standard height of 8' from the top of the foundation to the *eaves* (the overhanging edge of the roof). Usually there is another 4' from the eaves to the peak of the roof. Requirement 4 specifies that the model be built to a scale of ¼" = 1'0". Based on the sample floor plan, your model would measure 8" by 14" and would be 3" high from foundation to roof peak.

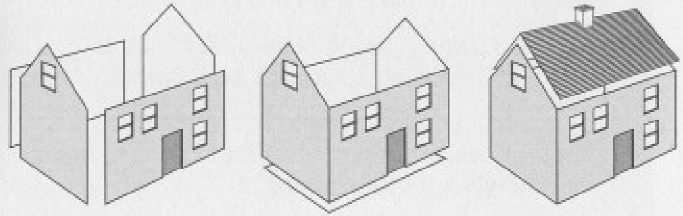
> The cardboard tubes can be used to create castle towers or round rooms in a modern office building or transfer tunnels in a space station.

Use the floor plan's dimensions in measuring and marking the building materials for your model. You may use wood or cardboard. Cardboard is inexpensive, easy to get and use, and durable if treated with reasonable care. Wood is strong and attractive, but heavier and more difficult to manipulate.

> If you choose wood, consider buying some *lattice wood.* Lattice wood is ¼"-thick wood and comes in long strips in a variety of widths, from about ¾" to 3" wide. An 8" strip of lattice wood 1½" wide costs very little and can provide a good part of the material required for a fair-sized house model.

Steps in Assembly

The following drawings illustrate some basic steps in modeling a simple building.



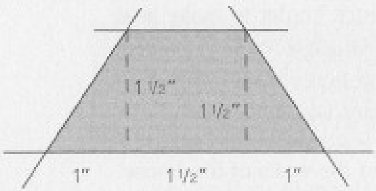
Step 1 Step 2 Step 3

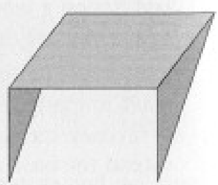
Basic steps in assembling a house model

1. Construct the base of the house first. This will allow you to see the width of the walls. Measure the base by placing a copy of the floor plan over your base material. Make sure it is to scale, then cut out the dimensions for the base.
2. Measure and cut out the exterior walls. Draw and cut out the window and door openings. (It's easy to cut out door and window openings at this stage, while the walls can be laid flat on a work surface. It is much harder to make neat openings after the walls are fastened together.)
3. Apply glue to the edges and assemble the walls. Glue the walls to the base. If you plan to later add a porch, walkway, shrubbery, trees, or other outside features (be creative!), extend the base far enough beyond the walls of the house to allow room for the additions.
4. Make a peaked roof from one large piece of cardboard, scored and folded at the peak. To *score* cardboard, make a shallow groove by running a dull knife blade along the line where the fold is to be. A butter knife works well. Use a ruler as a guide so that the score and the fold will be straight. Make the score on the inside of the fold—in this case, on the underside of the roof. If you want a detachable roof, to look inside the model or to add interior walls later, don't glue it down. Cut the roof so that it hangs over slightly on the ends and sides.

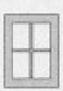
To make this basic house model more realistic and attractive, add some architectural details:

- Cut and fold cardboard to form a front porch and steps, or make them from blocks of wood.
- Use thin strips of wood or cardboard to add shutters, window frames, and door frames.
- Use clear plastic or transparent adhesive tape for window panes. Glue colored tissue paper or fabric behind windows for curtains.
- Attach an extra room or shed simply by adding a box to the main structure.
- To add a chimney, first fashion a small box. Then cut an angled notch from the bottom of opposite sides of the box to fit the slope of the roof.
- Add interest to a large, unbroken expanse of roof by attaching dormer windows as shown in the drawings.

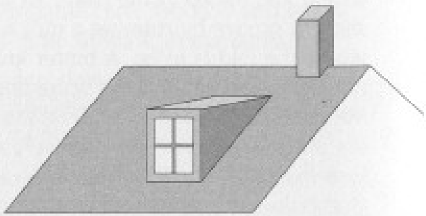




Measure and cut out the dormer. The proportions can be changed to fit your model's size and style. Score and fold along the dotted lines.



Make the window separately and fit it into the dormer opening.



Dormer windows

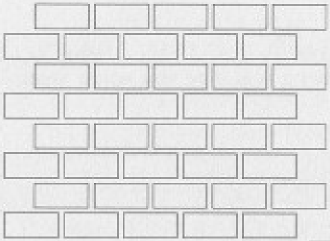
Outside Treatments

Finish your architectural model with an interesting surface texture or treatment. The following will give you some ideas for wall and roof finishes.

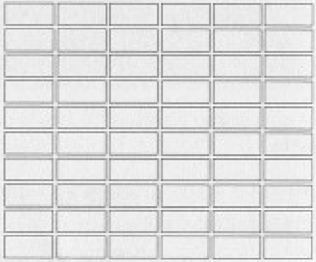
When you choose your materials, try to choose finishes such as paint or varnish that can be used on several different parts of your model, preferably all of them.

Walls

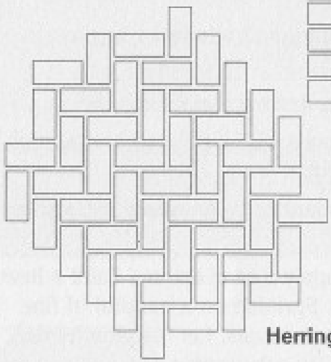
- Paint or stain shutters and door and window trims a contrasting color.
- Draw light pencil lines to look like wood siding.
- Scribe shallow, parallel grooves with a pointed tool to look like tongue-and-groove siding.
- Glue on strips of thin cardboard or balsa wood to resemble clapboard siding.
- To create a concrete effect, apply a sand texture. Paint a heavy layer of glue onto the walls. Sprinkle on a handful of fine sand, such as that used in aquariums. Let the glue harden, then tap off the extra sand. Try substituting sawdust or ashes for sand to create unusual surface textures and finishes. Use these methods before the walls are glued together so that you can lay the walls flat on your work surface.
- For a stucco effect, brush a little water over each unattached cardboard wall section and apply an even layer of white glue. Sprinkle generously with plaster-repairing powder. Tap off the extra powder. Lay the wall facedown on a clean piece of cardboard and rub the back to make the treated surface smooth. Turn the wall faceup and let the glue set.
- To color the walls, use spirit-based wood stain, shellac, or paint. When the paint has dried, back each wall with a piece of thick cardboard for extra support.



Running bond



Stacked bond



Herringbone

- Apply individual cardboard "bricks." Cut small rectangles from gray or colored cardboard and glue them onto the walls. To keep the rows of brick even, draw guidelines or glue graph paper onto the walls. Spread enough white glue over a section of wall to lay about three square inches of bricks at a time. Position each brick with the point of a knife. To get a red-brick look, paint the walls with a wash of mahogany wood stain. Use shellac to imitate yellow bricks.

> Sand, stucco, and brick effects should be done before the walls are glued together so that you can work with the walls laid out flat.

Roof Surfaces

- Lay cardboard tiles. Cut individual roof tiles from very thin cardboard. Mark guidelines on the roof to help you keep the rows even as you glue on each tile, using the point of a knife to accurately position each one. Cap the peak of the roof with ridge tiles. To make ridge tiles, cut out a narrow strip of thin cardboard. Score it down the middle and then cut the strip into individual tiles. Fold each tile in half along the score line and glue it onto the roof ridge. Color the roof with a wash of mahogany wood stain. Or, to resemble roofing slates, color with gray, blue, and white washes.

> For the most realistic effect, overlap and stagger each row of tiles.

- Use masking tape to resemble wooden shingles. Cut rectangles from strips of masking tape and apply the tape shingles in the same way as cardboard tiles.

> Use wood stain to color the roof and to dull the shine of the masking tape.

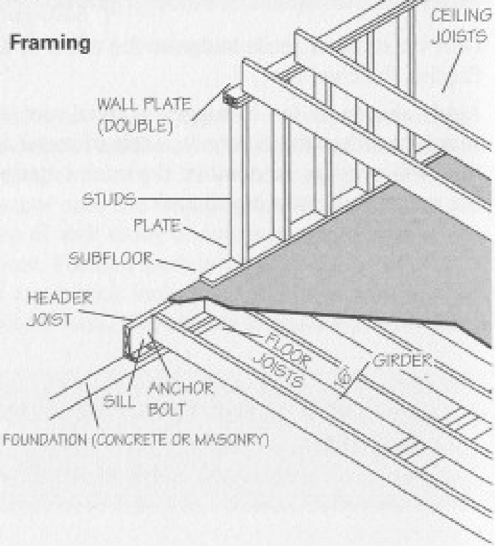
- Glue on straw or reeds to create the effect of a traditional English thatched roof.
- Apply aluminum foil to suggest a metal roof. Include the seams to reflect the different panels of metal and show how they will overlap. Remember, the more detail you add to the model the better it will look.

Structural Models

An architectural model shows what a building will look like, but it doesn't necessarily show how the building will be constructed. The walls and roof in an architectural model might be little more than flat sheets of cardboard or wood. A structural model, however, shows details of construction. The individual pieces that make up floor, wall, and roof structures are reproduced in miniature.

An option for requirement 4 is to build a model showing corner construction of a wood-frame building. If you have never helped build a house or watched one being built, you will need to understand some basic elements and terms before you can build an accurate model showing corner construction. The following outlines basic steps in framing a home's floors, walls, and roof supports.

Framing



Wood-Frame Construction

In wood-frame construction over concrete or masonry block foundation walls, the first wooden member of the structure is the *sill*. Sills are placed flat (horizontally) on top of the concrete foundation walls all around the structure and are secured to the foundation with anchor bolts. The material usually used for sills is 2"-by-6" lumber (known to builders as 2 X 6s).

> Regional building codes may require the doubling of the sill plate due to heavy winds or the threat of earthquakes.

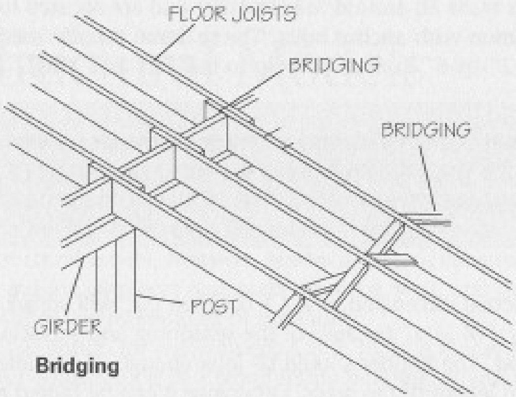
The actual dimension of a 2 X 6, when cut, will shrink to around 1 1/2" X 5 1/2" because of the seasoning and surfacing of the wood. The lumber should be long enough, if possible, to run the full length of the walls. Otherwise it can be butted end to end.

> *Seasoning* refers to the natural drying of fresh-cut lumber, and *surfacing* is the smoothing of any rough edges after cutting.

Floor joists are horizontal members of the structure, placed on edge, that span the foundation walls. Joists run parallel to one another and are evenly spaced between the sills. In house building, the spacing of joists is fairly standard at 16" from the center of one joist to the center of the next, but the spacing can vary greatly depending on the load or weight the joists will be carrying. The depth of the floor joist can vary according to the length of the span. For your purposes in designing a structural model, you may assume that the joists are 2 X 6s spaced 16" apart, with a span of 12'.

Because the span is only 12'—not far enough to reach the entire distance between the exterior walls—the joists will need supports, called beams or *intermediate girders*. The ends of the girders rest on the exterior walls in special pockets provided for them. The girders are themselves supported between the exterior walls on posts. Girders can be solid blocks of timber.

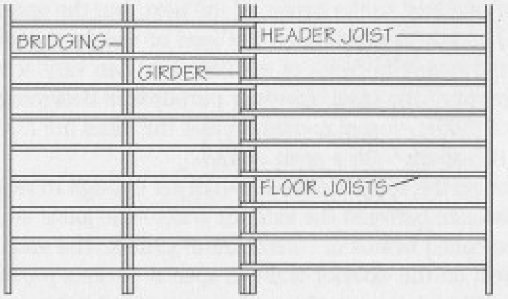
More commonly, they are built up from two or more layers of 2"-thick lumber. For your purposes in modelmaking, assume that the girders are 4 X 6s (that is, they are built up from two layers of 2 X 6s) and are spaced 6' apart.



Bridging

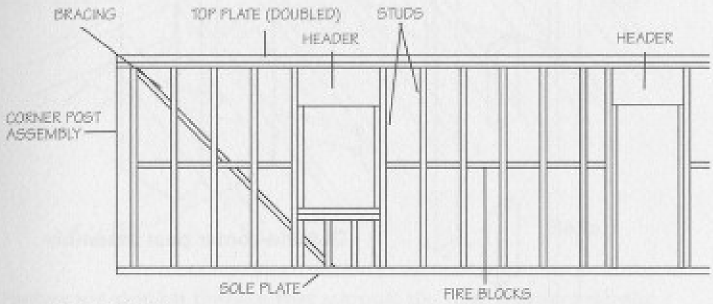
Floor joists that are too short to run the entire length of the structure must be pieced together. They are overlapped where they cross the girder. Solid *bridging*, rows of diagonal braces, can be nailed between them for support or installed at other points between joists to keep them fixed and straight. A common system of bridging uses pieces of 1 X 3 or 1 X 4 lumber set between joists as shown in the illustration. The bridging should be in a straight line at a spacing of 8' or midway between the foundation wall and the girder as shown in the illustration.

Floor frame



Floor joists are boxed in by *headers* that run across the ends of the joists. The headers are attached to the sills.

On top of the floor frame formed by the joists and headers, common 1" boards or 5/8" plywood sheets are placed to form the *subfloor.* The subfloor adds rigidity to the structure and acts as a base for the final, finished floor.



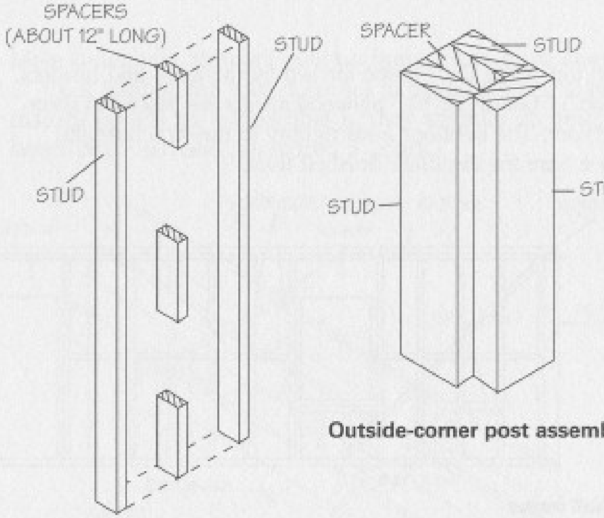
Wall frame

Wall frames are installed next. They support upper structures like ceilings and roofs and act as bases on which the builder can fasten exterior and interior wall coverings. Inside the wall frames between the coverings, there is room for other house essentials such as electrical wiring, telephone cables, water and gas pipes, heating ducts, and insulation.

The lowermost member of the wall frame is the *sole plate,* a long piece of 2 X 4 lumber placed flat and nailed along the edge of the subflooring. *Studs* are the upright or vertical members of the wall frame. Studs usually are 2 X 4s, but 2 X 6s may be used if a thicker wall is desired. Studs are nailed to the plate. Usually they are spaced either 16" or 24" apart.

> If 2 X 6 studs are used, the sole plate also will be of 2 X 6 lumber.

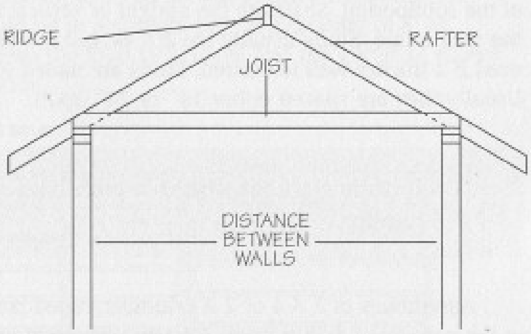
Assemblies of 2 X 4 or 2 X 6 lumber called *posts* are used at the corners of wall frames. A basic post design uses two studs and three spacers nailed together to form a solid unit. When the post is for a corner, a third stud is added as in the illustration shown here.



Outside-corner post assembly

The *top plate* is a doubled 2 X 4 (or 2 X 6 if the wall frame is of 2 X 6 studs). "Doubled" means that two pieces of lumber are used to create a double thickness.

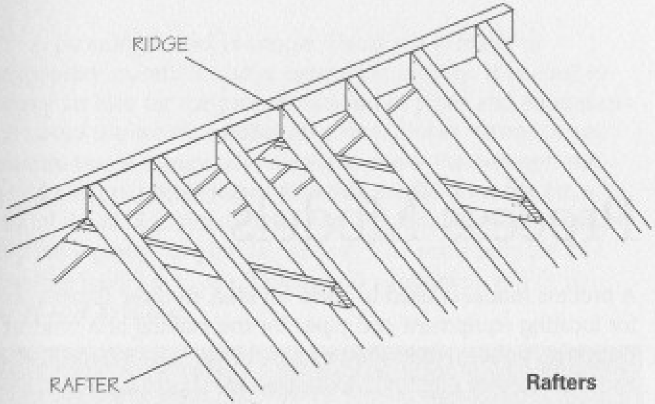
Ceiling joists top wall frames. Like floor joists, they are horizontal members of the structure placed on edge. They run parallel to each other and are evenly spaced, usually 16" apart.



Ceiling joist

Ceiling joists act as ties between opposite walls and support the ceiling.

Unlike floor joists, ceiling joists have no headers around the edges.



Rafters

***Rafters* are sloping timbers that support the roof. Rafters typically are spaced 16" to 24" apart.**

Building to Scale

The structural model for requirement 4 is to be built to a scale of 1½" = 1'0". At this scale, 2 X 6 lumber would be represented by strips of wood ¼" thick by ¾" wide. To model a 2 X 4, use a strip ¼" thick by ½" wide.

Before beginning to build your model, prepare a supply of miniature 2 X 4s and 2 X 6s. Also prepare the other necessary building materials to the same scale. You might need small pieces to use for bridging and cardboard or flat sheet wood stock for flooring. Although nails or screws would be used to hold the various parts together in full-scale construction, you may use glue in making your model.

Study the illustrations carefully to see how the subfloor, wall, and roof structures in a wood-frame building work together to support the building. In constructing your model, work slowly and let the framework dry between steps. If you rush the project, you could end up with a messy pile of wooden sticks instead of the strongly built, accurately scaled, and professionally constructed model you want.

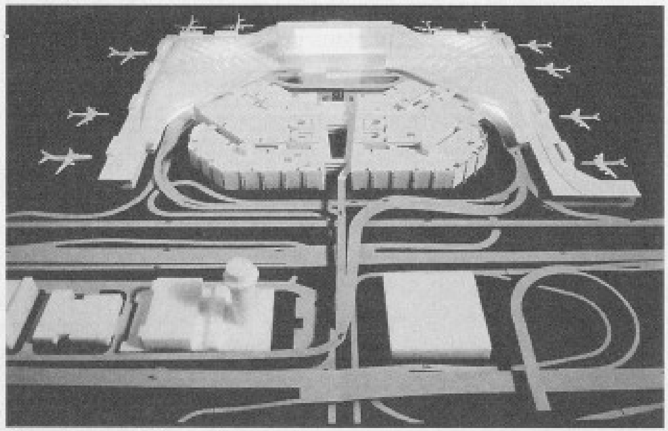
Process Models

A process model is used to show an idea, in three dimensions, for locating equipment and pipes for the making of a product. Engineers build process models to show on a small scale what a manufacturing plant will look like when constructed. A model of such a plant can be easily understood by its viewer because it is almost like looking at the real thing, except it is much smaller.

Models are used in designing process plants. For example, such models are used by pharmaceutical companies that make vitamins, aspirin, and other medicines; by companies that process and package foods and beverages; and by chemical companies that make inks, dyes, and paints.

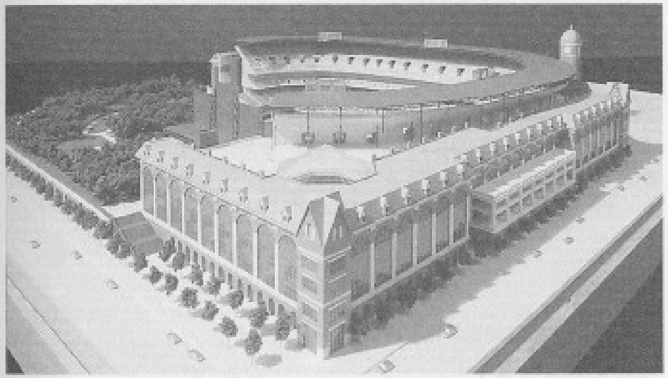
Types of Process Models

There are two types of process models: *planning models* and *final construction models* from which construction workers actually build the full-size plant.



Planning model

A planning model is simple. Usually it is made of inexpensive materials and is assembled quickly. It is used to convey an idea for the general location of pipes and equipment. You could use wood, cardboard, string, blocks, foam, or any material that is handy. The idea is to show the concept, not the details, so a preliminary planning model does not include a lot of detail. Equipment is shown as plain blocks and usually only large groups of pipe are shown. The main purpose of a planning model is to see if pipes and equipment will fit into the spaces available.



Final construction model

A final construction model is much more complex, accurate, and expensive. It shows far more detail than the planning model. Equipment is modeled in exact detail and with great accuracy. Instead of showing pipes as blocks of materials, each pipe is shown individually and cemented into place.

Advantages of Models

Building a model before beginning actual construction has many advantages. During the design stage, a model allows you to see problems easily. For example, you might spot places where two different things will try to take up the same space or notice a piece of equipment that sticks out into an aisle or hits a tank.

A **tank** is a tub used to store a liquid, a gas, or a product.

Because a three-dimensional model shows the length, width, and height of equipment, layouts can be judged better. Engineers can decide the best locations for welding, for pipe and equipment supports, for water-hose stations, for lights, and for items such as valves. Items such as safety showers (where operators accidentally splashed with acid can be drenched with water) are easily placed on a model.

> **Fire protection** can include fire hydrants, hoses, and sprinklers used to put out fires.

One of the most important advantages of a process model is that architects, piping engineers, and machine designers can get together and use the model to work out problems. All the engineers can coordinate their work through the use of the model. When the process model is complete, it is used not only for construction purposes, but also, in many cases, to train the workers who will operate the final plant after it is constructed.

What Process Models Show

You have learned what a process model is, who uses process models, and the advantages of building one. Now consider in more detail what is shown on a process model.

Building Structure

After the size (scale or proportion) and shape of the model have been decided, the modeler makes the structure of the building to enclose the plant. The building structure can be made of wood, plastic, cardboard, or any material available that will do the job. Beams and columns are usually shown to the largest outside dimensions or, to be more realistic, sometimes the actual shape is shown.

> **Structure** refers to the building or framework used to enclose the process.

The modelmaker might want to show the walls in some material only partially. Modelmakers call this "dodging in" a wall. Partial sections are used because the modelmaker wishes to leave access to actually work on the model. If the walls are put in completely, no one could get hands or tools in to work on the model.

Equipment Layout

Equipment should be placed in the model in its exact location, taking care to ensure that it is accurately positioned and that there is enough space left in which to get around the equipment. A good rule is to allow a 36" minimum access around each piece of equipment. (Remember, at a scale of $^{3}/_{4}$" = 1', $^{3}/_{4}$" X 3 = $^{9}/_{4}$" = $2^{1}/_{4}$". That is, the modelmaker would need to leave a space of $2^{1}/_{4}$" around each piece of equipment in the model to represent the 36" minimum access required in the actual plant.)

> Equipment can be modeled to any degree of detail desired. It can be made of wood, cardboard or plastic boxes, cardboard tubes, or any material that is easily adapted to the shape needed. The chapter "Materials and Finishes" lists other materials useful in building models.

> **Instrumentation** is a term for automatic devices used to operate valves, take readings, show temperatures, etc. A **valve** is a device, such as a faucet in a bathroom, that controls the flow of a liquid or gas through a pipe.

Piping

Piping takes careful thought and planning before installation. When many pipelines are to be shown, the modelmaker must consider their order of placement, the size of the pipes, how they will be supported, and how a worker would reach any valves that might control the pipes. In positioning pipes, designers and engineers must try to use the minimum number of fittings required to get from one point to another. Unnecessary fittings increase the cost of materials and increase labor costs to install them.

Piping is hollow tubing used to move a liquid, a gas, or a product from one place to another. A **tee** is a pipe fitting used to branch off of a pipe to go in another direction. An **elbow** is a pipe fitting used to change the direction of a pipe.

Other things to consider are head clearances and *sloped lines*. Sloped pipelines are those that must drain by gravity. In basements you will see sloped sink and toilet drainpipes.

Pumps can be equipment used to force a product through a pipeline.

HVAC stands for heating, ventilating, and air-conditioning.

Heating and Ventilating

Another important feature of a process plant that can be shown on a model is the heating and ventilating equipment and ductwork. Heating and ventilating equipment does just that: It heats and cools the building and provides good ventilation. Ductwork is the system of tubes through which warm or cold air travels. Equipment and ductwork must be installed so that pipes, electrical wires, and other equipment do not interfere with the ducts.

Instrumentation and Electrical Conduits

Most equipment needs electricity to operate. Much of the equipment used in process plants is made to operate by electrical signals from different types of instruments. These can include automatic valves, switches, transmitters, and recording devices. Therefore, it is important that electrical conduits and instruments are properly installed.

Building a Process Model

Now that you know what kinds of things can be shown on a big industrial process model, you're ready to build a similar, though simpler, model of your own. One kind of process almost everyone is familiar with is the water system in a house. Water is piped into a house; some of it is left cold and some is heated, and then the water is distributed throughout the house.

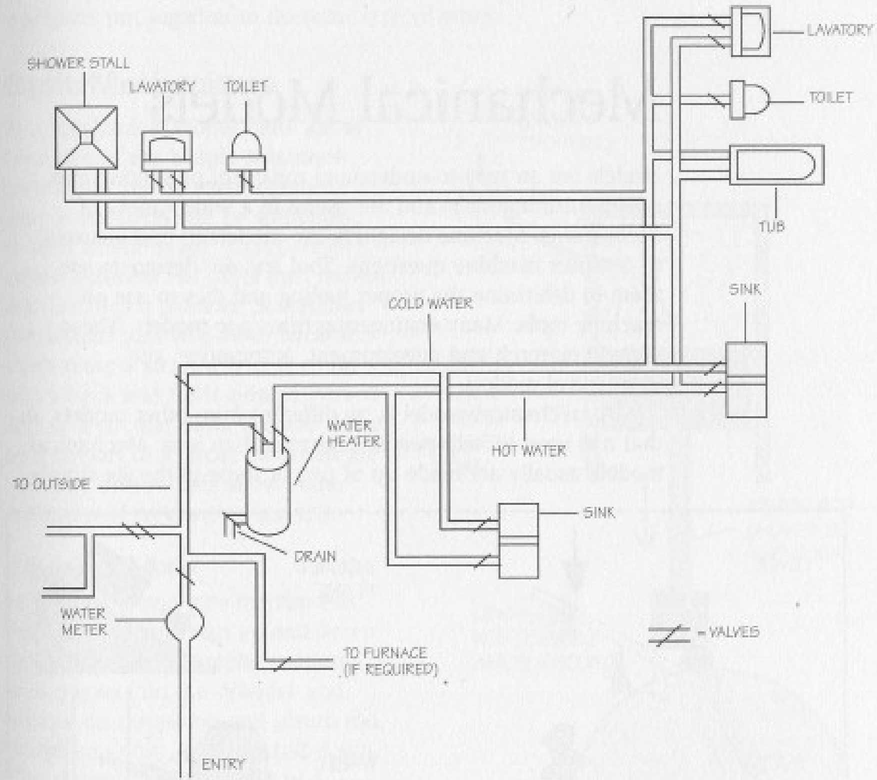


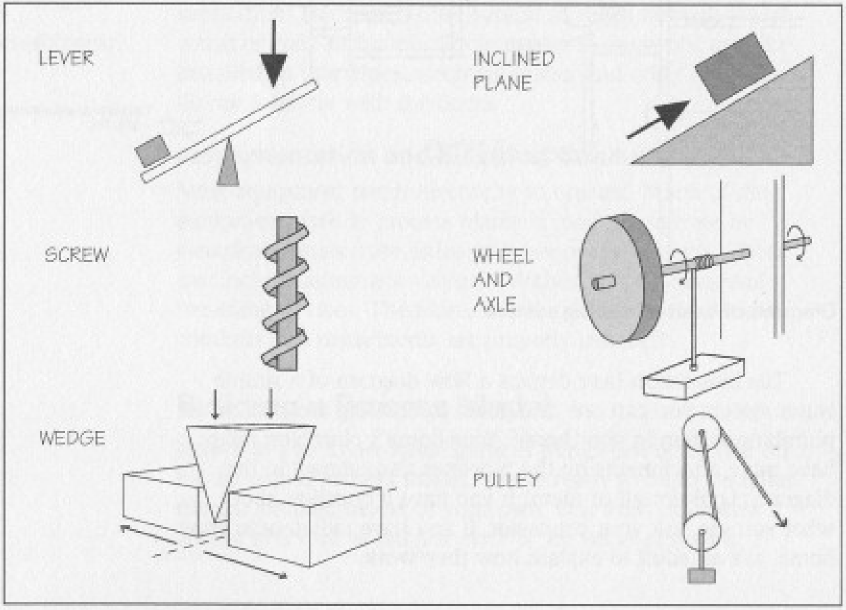
Diagram of basic plumbing system

The illustration here depicts a flow diagram of a simple water system you can use as a guide in building a model of the plumbing system in your home. Your home's plumbing might have more attachments on the pipelines than shown in the diagram. Look for all of them. If you have a question about what you see, ask your counselor. If you have radiators in your home, ask an adult to explain how they work.

Mechanical Models

Models are an easy-to-understand means of presenting and communicating ideas and are useful in a wide variety of occupations. Machine designers use models to find answers to complex machine questions. Tool and die designers use them to determine the proper tooling and dies to use on machine tools. Many engineering firms use models. These include research and development, automotive, and mechanical models.

A mechanical model is no different from other models, in that it is used to help people understand an idea. Mechanical models usually are made up of two or more of the six simple machines you learned about in science class: wheel and axle, lever, wedge, inclined plane, screw, and pulley. When model designers and engineers think about a mechanical model or mechanism, they know it is a combination of these simple machines put together to do some type of work.



Six simple machines

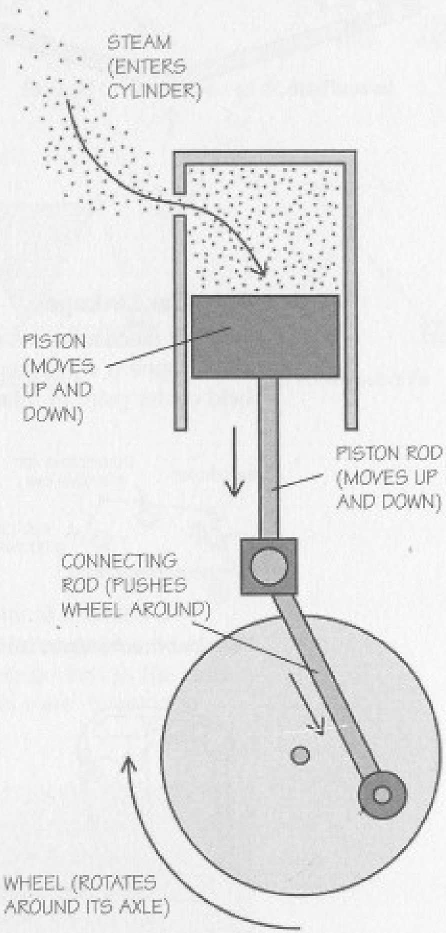
Basic Mechanisms

In a mechanical model there are at least two of the simple machines mentioned above, used together. One of the parts will be stationary, or held in one place. That part is called a *driver.* The other part moves and is called a *follower.* Sometimes the second part will move back and forth along a straight line. It could move back and forth along a curved line or a circular path; it could move only in part of a circle, called an arc.

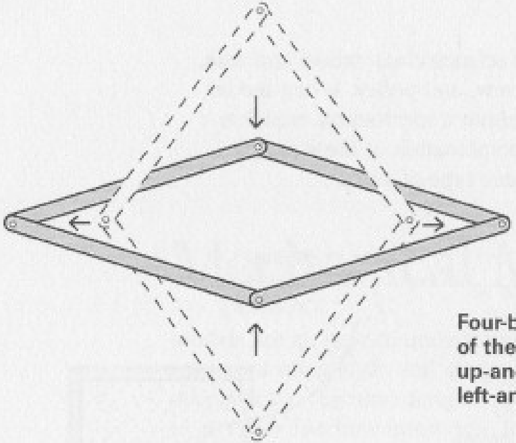
The illustrations show some examples of mechanical models.

Wheel and Axle

In the wheel and axle mechanism, the piston changes an up-and-down movement into a circular motion. Steam goes into the cylinder and pushes on the piston and piston rod, which can only move up and down. The piston rod is attached to a connecting rod, which pushes the wheel around on its axle as the piston moves up and down. Most steam engines and gasoline engines work on this principle.



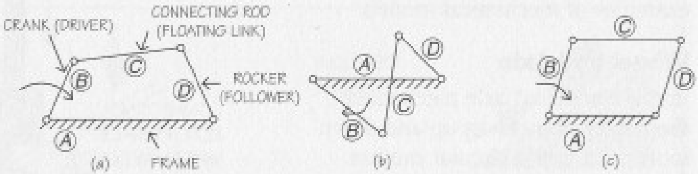
The piston's up-and-down movement is changed into circular motion.



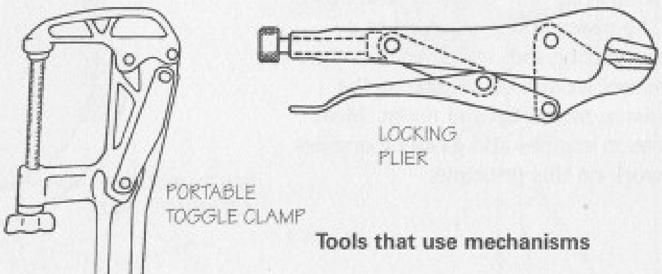
Four-bar linkage—the linkage of the four bars converts up-and-down motion into left-and-right motion

Four-Bar Linkage

Another mechanism often used is the four-bar linkage. See what happens when the arm (b) is rotated about its solidly held center point of rotation.



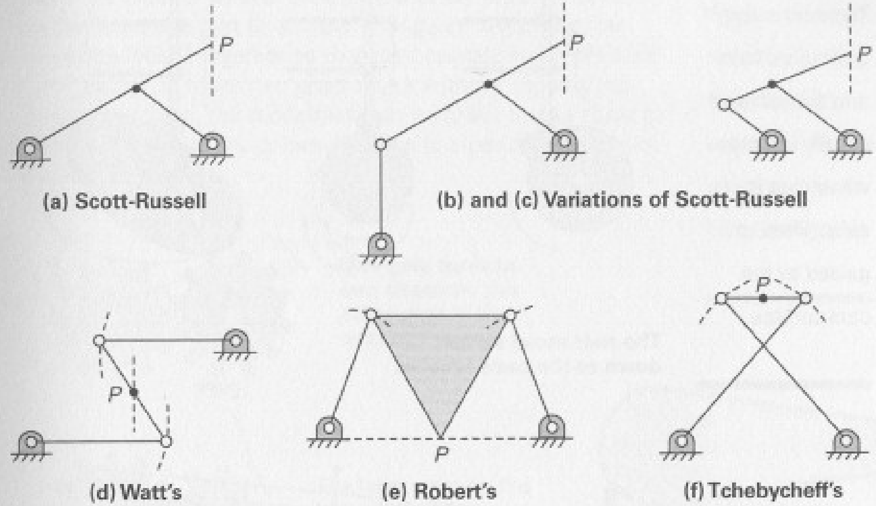
Four-bar mechanisms: (a) open, (b) crossed, (c) parallel



Tools that use mechanisms

The locking plier is an example of four-bar linkage with the fixed link made adjustable by turning the end screw.

Straight-line mechanisms



P=point traveling in straight line

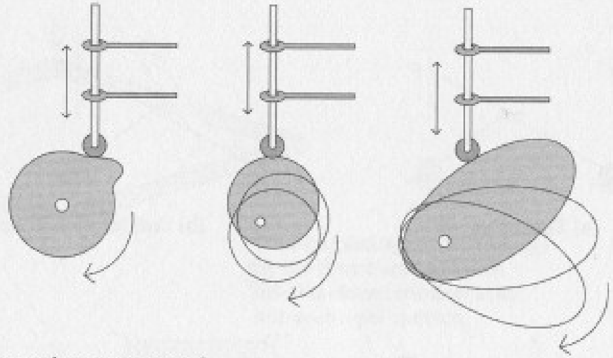
 **= fixed pivot**

Straight-Line Mechanisms

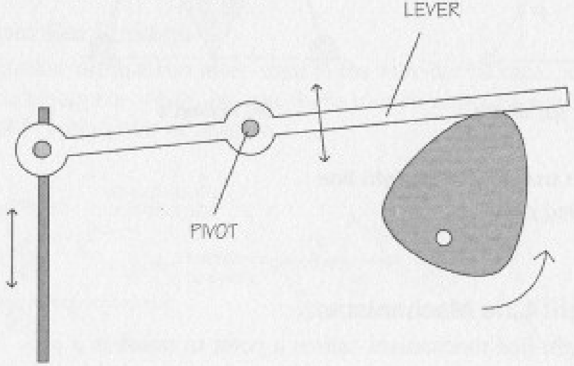
A straight-line mechanism causes a point to travel in a straight or nearly straight line, without being guided by a plane surface. Such mechanisms were important in the early days of machinery before machine tools were invented to make smooth plane surfaces.

> James Watt, a Scottish inventor and mechanical engineer, had a great need for a mechanism that would guide the joint between the piston rod and the drive beam along a straight line in his steam engine.

The *cam* is any guiding surface and the *follower* usually is a little wheel that is either lifted or guided by the cam surface.



The rods move up and down as the cams revolve.



Examples of cams

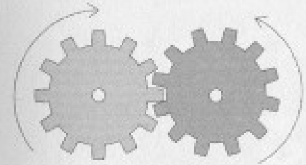
Cams

Cam mechanisms provide a simple means of getting unusual or irregular motions that would be difficult, if not impossible, to obtain with other types of mechanizing. Cams with irregular or unusual shapes can be used to achieve a desired motion. In other cases a simple round or oval wheel mounted so that it revolves off center will guide the follower in the desired motion. Cams are the heart of such automatic devices as automatic machine tools. They also are found in all internal-combustion engines.

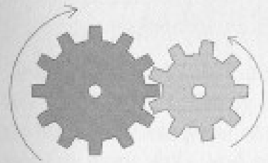
Gears

Gears are toothed wheels used to accurately transmit circular motion from one part to another. The gears' teeth keep the two gears locked together so that they operate smoothly without slipping. To make two gears rotate without slipping but without touching, the modelmaker or engineer uses a chain to connect the two gears. A bicycle chain is a perfect example of this arrangement.

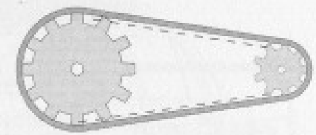
When referring to a chain drive, the designer or engineer calls the gears *sprockets* instead of gears.



One gear turns in one direction, the other gear in the opposite direction.



The large gear on the left will turn more slowly than the small gear on the right.



Gears

Building a Mechanical Model

Models of mechanisms, or mechanical models, are used in the first stages of design to ensure that the design will do what it is supposed to do. A flat, or two-dimensional, *breadboard* model is a very simple type of mechanical model that is easy to make. It can be cut out of cardboard, poster board, or paper. The cardboard or paper pieces can be fastened to a backing board with thumbtacks and can be made to move or remain stationary. Because the materials used are rather flimsy, this type of model has limited usefulness.

A *prototype* model is the first mechanical or working model of a design and is usually three dimensional and full scale. It can be made of wood, plastic, metal, or another material. Design information gained from such models can be of real value.

When choosing a mechanical model to build, you might consider making a model of a two-wheel bicycle chain drive, a new kind of lock mechanism, or a big model of the squirting mechanism on a bottle of window cleaner (maybe you could even make it squirt water). Use your imagination.

Before you start making your model, be sure to discuss your ideas with your counselor.

Industrial Models

Almost all products—cars, appliances, toys, furniture—begin as models. As you have learned, models are used to see how something works or looks before it is manufactured or built. You may complete requirement 4 by building an industrial model. Be sure to get your counselor's approval before you begin.

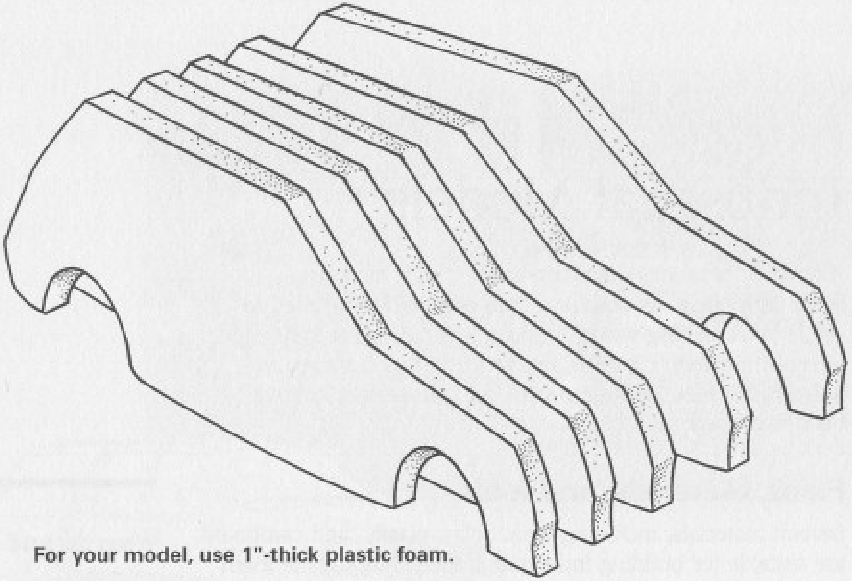
Plans, Materials, and Tools

Several materials, including wood, clay, plastic, and cardboard, are suitable for building industrial models. Polystyrene foam or foam core are good choices for a car. They are inexpensive, easy to work with, and can be found at most hobby and art-supply shops. If you use foam, you also will need a water-soluble white glue (not plastic model cement), spackling paste (commonly used for patching cracks in plaster walls), a sharp knife, sandpaper, and paint.

Before you start, you must first select a design. It can be a copy of an existing car or one of your own creation. If it is a copy, be sure it is a car that will be available for reference as you build your model. If the design is your own, keep it simple. Most things are easier to draw than they are to build.

Next you will need to draw your design. Start your drawing with a side view to a scale of 1" = 1′0". Your drawing should include overall dimensions and important reference points. Working from front to back, these might include the distance from the ground to the bumper, the length of the hood, the distance from the ground to the roof, and so on. The drawing also should include front and rear views.

When you have completed your drawing, show it to your counselor. Discuss any questions and review the next steps. With your counselor's approval, you are ready to start building the model.



For your model, use 1"-thick plastic foam.

Transfer the outline of the side view to 1"-thick Styrofoam. Cut out five or six layers, depending on the overall width of the car. Each layer will be identical except for wheel openings in the outside layers. Glue the layers together.

Making the Model

Transfer the outline of the side view from your drawing to the foam. This is best done by making a paper pattern and tracing around it. If the foam is 1" thick, you will need five or six layers, depending on the overall width of the car. Each layer will be identical except for wheel openings in the outside layers. Cut out all of the layers and glue them together with white glue. Let them dry for several hours.

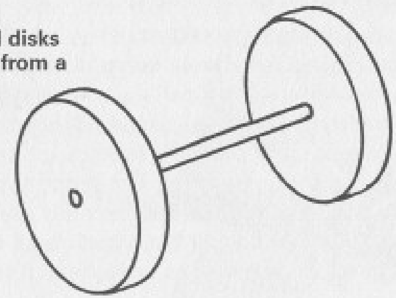
> Do not use plastic model cement on foam. The foam will melt and the layers will not bond.

When the glue has dried, the block can be carved. This step is intended to give the model its basic form, not its detail. An ordinary kitchen knife and a hacksaw blade make perfect carving tools.

After you have finished carving the shape, spread a layer of spackling paste over the foam. It will take several hours for the paste to dry, so set the model aside until the next day.

When the paste is thoroughly dry, lightly sand the model with fine sandpaper. Then use a pointed tool and a fine file or piece of sandpaper to shape the details of the model. Scribe the outlines of window frames and windows, doors, hood, trunk lid, headlights, taillights, and so forth.

Wheels made of wood disks mounted on axles cut from a coat hanger



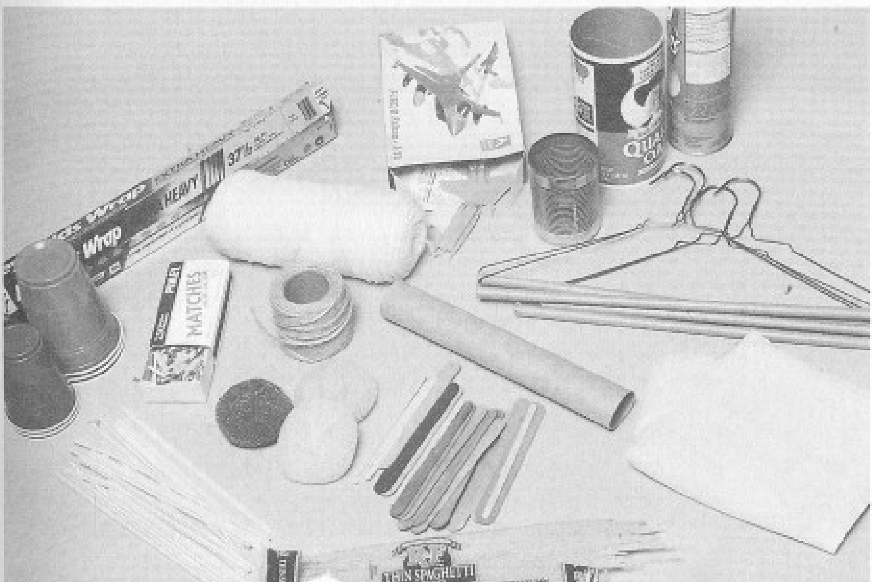
Make wheels and tires from disks of wood. Glue the disks into the wheel openings. For a more realistic effect, mount the wheels on axles of coat hanger wire or a similar material so that the car will roll.

Paint your model. When the base coats are completely dry, you can add details such as racing stripes and whitewall tires. Use a fine-bristled, pointed brush for painting stripes, body side molding, numbers, and other delicate paintwork.

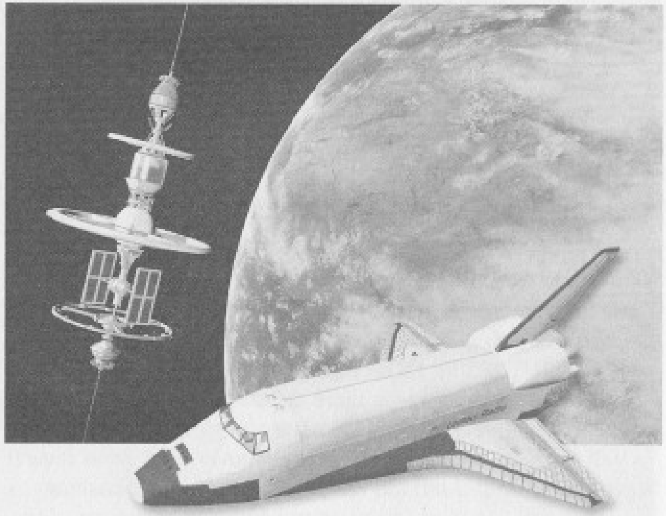
Kit-Bashing

Thousands of hobbyists use kits to create their models. In these kits the design, parts, and accessories are provided. All the hobbyist has to do is follow the instructions and put the parts together. But for those who want to go one step beyond kits, there is kit-bashing—a more creative approach that uses parts from two or more kits to create an original design and model. Most kit-bashing projects use leftover parts from several kits and items from around the house. In short, kit-bashing allows you to use your imagination plus take advantage of the convenience of premade parts.

To get started, study different designs of aircraft, ships, and submarines. Your local library and the Internet (with your parent's permission) will offer plenty of resources. Look around



To complete requirement 5, you will try your hand at kit-bashing to design a spacecraft. The scope and detail of this project is up to you, using some general guidelines. The project should reflect what you have learned about designs and models so far—and your imagination.



The most difficult part of your project may be coming up with a design idea. Give yourself plenty of time to think of what your spacecraft will look like and what materials you could use. Organization will be key, since you are working without a set of instructions. You will make your own instructions as you go along.

your home for interesting materials to use. Also gather leftover pieces from other models you have made in the past.

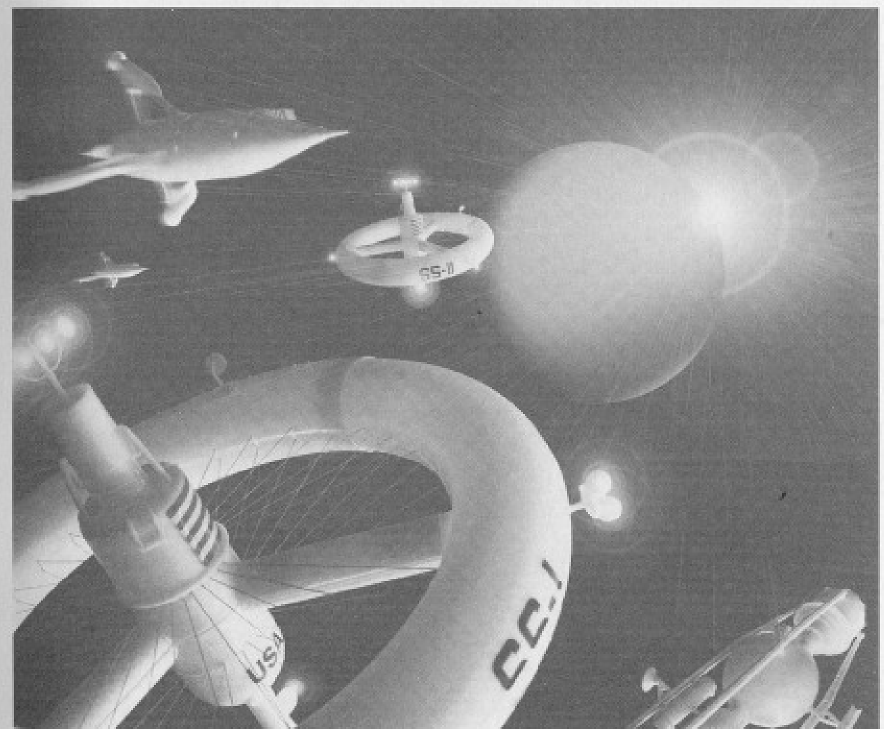
You could visit an interior-design shop and research different surfaces and materials. You might be able to get free samples to use in your model. Visit a hardware store to research various storage compartments. Watch television programs about space exploration to find out about spacecraft components. You might also request information from NASA through its Web site or the mail.

When you are ready to design, first determine the model's scale based on your materials. You will want the spacecraft to look realistic—it is to be used in a movie production. List the tools you will need. Cut pictures or shapes out of catalogs, newspapers, or magazines to use as detail on the spacecraft.

Now, using what you have learned in this pamphlet, begin creating your design. Make detailed drawings of the craft, remembering your scale at all times. Think of how the model will look from different angles. Make sure all the parts fit together. There should not be any gaps between pieces.

Once you have completed the model, write a short essay explaining why you chose your design and how you engineered it. Explain how you came up with your design and made it a reality. Tell what you learned from the project, what challenges you encountered, and how you overcame them.

Part of being a Scout is adapting what you have learned and using it in everyday life.

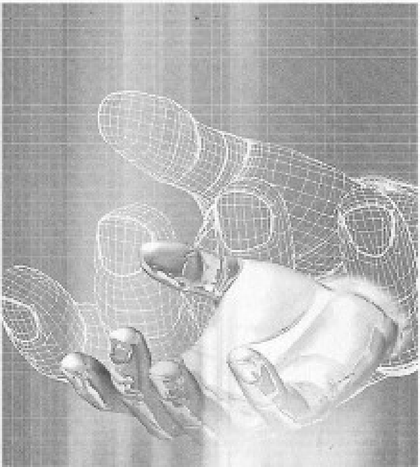


Modelmaking as a Career

Industrial modeling can be a rewarding career. Modelmaking skills are used in a wide variety of industries. In the movie industry, for example, designers use modelmaking skills to create sets and special effects. Architectural and graphic design firms also use models. Models have long been important in the automobile-manufacturing industry.

Computer modeling and animation is a fast-growing career field. Computers are making it possible to "build" and display intricate models on-screen. Although such models have no physical form, they can be studied and manipulated on computer monitors much as scale models in three dimensions.

Industry's need for trained technicians is growing yearly. Industrial modeling is not only profitable but also enjoyable for those who pursue this occupation. The resource section of this pamphlet lists a number of colleges and vocational training schools that offer associate degree programs in modeling technology. Your merit badge counselor, teacher, or school counselor can also help you find information about training opportunities near your home.



In the future, computer models might replace scale models for some design purposes, but industry will continue to need and use a variety of detailed, three-dimensional models.

Business Area	How Models Are Used
Automobile industry	Sales, wind-resistance testing, safety design
Toy industry	Development and sales
Chemical and petroleum industries	Process piping design, offshore drilling rigs, ship design, dry materials handling
Office equipment manufacturing	Design, sales, human factors engineering
Film and theater industry	Stage sets, robots, spaceships, cities, planets, makeup
Machine tool industry	Movement and force studies
Building and construction (architectural/structural) industries	Buildings and houses, office layouts, site studies, urban planning, site reconstruction, and historical landscape effects
Environmental and civil engineering	Topography studies, pollution studies, river flows, dams, spillways
Sales	Backdrops, booths at conventions
Law	Crime-scene re-creations
Museum and park industries	Caves, physics demonstrations, historical rooms, artifacts, planetary systems, historical sites
Aeronautics	Wind-resistance studies, destructive testing, displays
Energy industries	Coal handling, solar-energy systems
Amusement parks	Rides, park layouts
Underseas and naval industries	Water-resistance studies, internal piping layouts, human environments, harbor studies
Medicine and science	Human and animal anatomy, molecular structure

Model Design and Building Resources

Scouting Literature

Architecture, Art, Auto Mechanics, Aviation, Engineering, and *Railroading* merit badge pamphlets

Books

Bridgwater, Alan. *Making Wooden Mechanical Models: 15 Designs with Visible Wheels, Cranks, Pistons, Cogs, and Cams.* Popular Woodworking Books, 1995.

Covert, Pat. *Building Better Scale Model Cars and Trucks: Detailing Tips and Techniques.* Kalmbach Publishing Company, 1998.

FineScale Modeler. *Scale Model Detailing: Projects You Can Do...* Kalmbach Publishing Company, 1995.

Hamilton, Ken. *How to Build Creative Dioramas for Your Scale Auto Models.* Kalmbach Publishing Company, 2001.

Hooker, Saralinda. *The Art of Construction: Projects and Principles for Beginning Engineers and Architects.* Chicago Review Press, 1990.

Jackson, Rick. *Spaceships at the Final Frontier: Building Star Trek Models.* Kalmbach Publishing Company, 2000.

Johnson, Gene. *Ship Model Building.* Cornell Maritime Press, 1998.

Kalmbach Publishing Company, editors. *Scale Model Detailing.* Kalmbach Publishing Company, 1995.

Levy, Raymond. *Making Mechanical Marvels in Wood.* Sterling Publications, 1991.

Sutherland, Martha. *Modelmaking: A Basic Guide.* W. W. Norton and Company, 1999.

United States Bureau of Naval Personnel. *Basic Machines and How They Work.* Dover Publications, 1971.

Magazines

FineScale Modeler
P.O. Box 1612
Waukesha, WI 53187
Toll-free telephone: 800-533-6644
Web site: *http://www.finescale.com*

Model Airplane News
P.O. Box 428
Mt. Morris, IL 61054
Toll-free telephone: 800-877-5160
Web site:
http://www.modelairplanenews.com

Modeltec Magazine
P. O. Box 9
Avon, MN 56310
Telephone: 320-356-7255
Web site: *http://www.4w.com/modeltec*

Scale Auto
P.O. Box 1612
Waukesha, WI 53187
Toll-free telephone: 800-533-6644
Web site: *http://www.scaleautomag.com*

Organizations and Web Sites

Academy of Model Aeronautics
5151 East Memorial Drive
Muncie, IN 47302
Toll-free telephone: 800-435-9262
Web site: *http://www.modelaircraft.org*

International Plastic Modelers' Society USA
P.O. Box 2475
North Canton, OH 44720-2475
Web site: *http://www.ipmsusa.org*

North American Model Engineering Society
36506 Sherwood
Livonia, MI 48154
Web site:
http://www.modelengineeringsoc.com

Colleges and Vocational Schools

Bemidji State University
1500 Birchmont Drive NE
Bemidji, MN 56601-2699
Toll-free telephone: 800-475-2001
Web site: *http://www.bemidjistate.edu*

Community College of Allegheny County
800 Allegheny Ave.
Pittsburgh, PA 15233-1895
Telephone: 412-323-2323
Web site: *http://www.ccac.edu*

Genesee Community College
1 College Road
Batavia, NY 14020
Telephone: 585-343-0055
Web site:
http://www.sunygenesee.cc.ny.us

Macomb County Community College, South Campus
14500 East 12 Mile Road
Warren, MI 48088
Toll-free telephone: 866-622-6624
Web site: *http://www.macomb.cc.mi.us*

Mission College
3000 Mission College Blvd.
Santa Clara, CA 95054
Telephone: 408-988-2200
Web site: *http://www.missioncollege.org*

Traviss Technical Center
3225 Winter Lake Road
Lakeland, FL 33803-9709
Telephone: 863-499-2700
Web site: *http://www.travisstech.org*