Joints

How should we fasten this structure together? That is a critical decision because structures are often weakest where their parts are joined together.

Mobile joints are joints that allow movement. Door hinges, elbows, and the pins in a bicycle chain are examples of mobile joints. They hold parts together while still allowing some movement. Their complicated shapes are tricky to make, and they must be coated with a lubricant (a slippery substance) so that they move smoothly. Without lubrication, door hinges squeak, bicycle chains wear out, and human joints, as in Figure 13.19, develop arthritis and similar painful diseases.

Rigid joints fasten parts firmly together, but they, too, can be weak points in a structure. Chair legs and table legs become wobbly as wooden parts shrink, glue ages, or nails, screws, and bolts loosen. Flexible materials are even harder to join securely. Clothing comes apart at seams where it is sewed together. Tape comes loose. Zippers and Velcro™ stop working.

People have invented an amazing number of rigid joints, but they all fit into just five groups: fastners, ties, adhesives, melted joints, and interlocking joints.

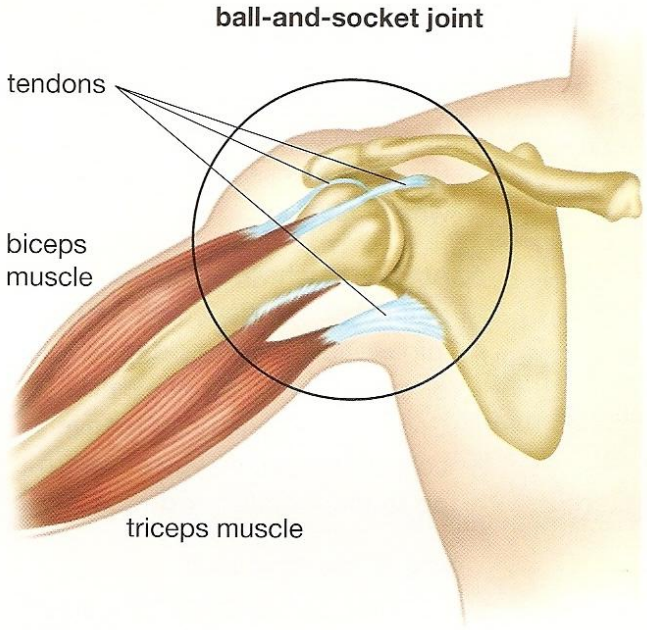


Figure 13.19 This ball-and-socket joint holds parts of the body together while still allowing movement. Such joints are lubricated by a substance called synovial fluid.

Fasteners

Nails, staples, bolts, screws, rivets, and dowels (shown in Figure 13.20) are used to hold many structures together. Unfortunately the holes that fasteners make also weaken the materials they fasten. Staples and nails are usually forced into the parts they join, and this can crack and separate the material. Drilling holes for bolts, screws, and dowels does not weaken the material as much, but the holes are time-consuming to position and cut.

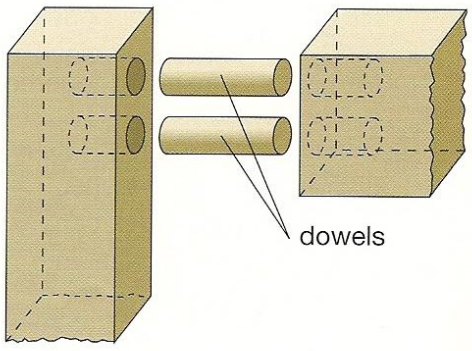


Figure 13.20 Dowelled joints are used by cabinetmakers to hold pieces of furniture together.

Attaching parts with just one fastener allows the parts to twist around it when they are pushed or pulled. Several fasteners make a more rigid joint, but the extra holes weaken the material more. So making a strong joint does not mean simply pounding in a bunch of big nails! Both the kind and number of fasteners must be carefully planned.

Ties

Thread, string, and rope can also fasten things together. Shoes are tied with laces. Jacket hoods are tightened with drawstrings. Seams in clothing are "tied together" with a sewing machine. Figure 13.21 shows how the needle and bobbin thread are intertwined to tie the seam in place.

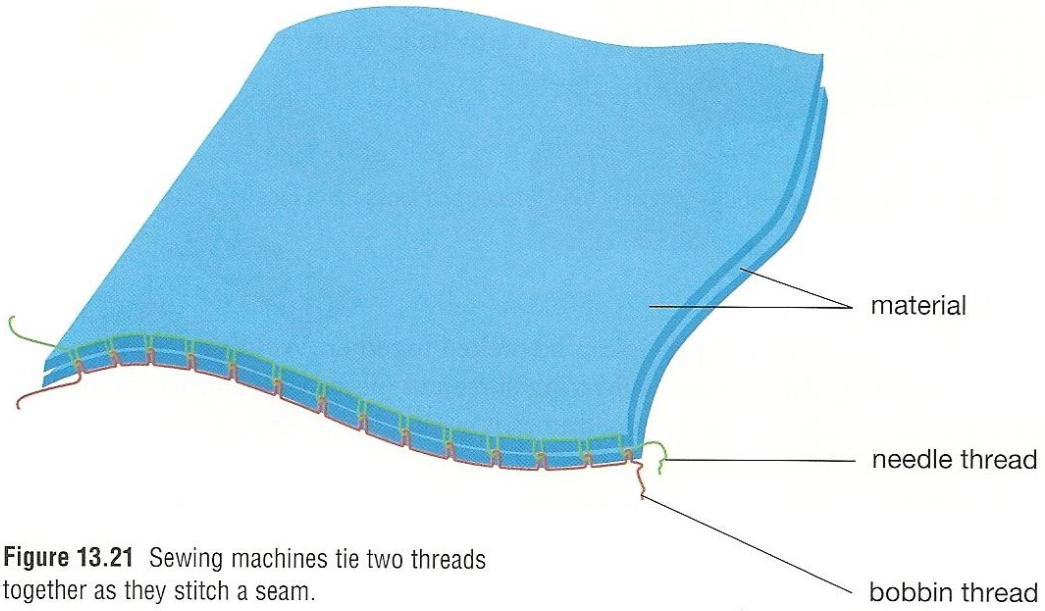


Figure 13.21 Sewing machines tie two threads together as they stitch a seam.

Adhesives

Sticky substances, called **adhesives** or glues, can hold things together. Figure 13.22 on page 400 shows how glue flows into tiny rough areas on the surface of the pieces it joins. When the glue hardens, it locks the pieces together. *Thermosetting glues* like those used in glue guns harden when they cool. *Solvent-based glues* harden as they dry out. The strongest glues also create a special kind of force between the tiniest particles of the pieces being joined. Because of these forces, epoxy resins and super glues are strong enough to hold pieces of car bodies together.

Even the strongest glued joints fail under extreme conditions. Glues may soften in water or under very hot conditions. If a glue is stronger than the substances it joins, the material next to the joint may break.

Adhesives can be a health hazard. Some glues start to harden as soon as they touch moisture. If a drop gets on your fingers or in your eye, it can stick your fingers or eyelids together almost instantly. Other glues, such as those used to make plywood and particleboard, release powerful chemicals into the air as they harden. These gases collect between walls, in basements, and in other places that have poor air circulation. If people with asthma and allergies live or work in these areas, the gases may trigger breathing difficulties, skin problems, headaches, and other health problems. Some people experience very sudden, serious reactions, but it is more common to feel just a little bit ill as long as exposure to the chemicals continues.

DidYouKnow?

Chemist Spence Silver was supposed to develop a super powerful glue. He tried many recipes. One recipe made a not-very-sticky substance that definitely did not meet specifications. It held papers together temporarily, but the joint could easily be pulled apart. Silver kept experimenting for almost ten years, sure that his glue could be useful somehow. Finally, in 1974, a co-worker, Arthur Fry, suddenly thought of a use for the temporary adhesive — sticky bookmarks that would not fall out of place! Post-It™ notes were the result, and they were an instant success.

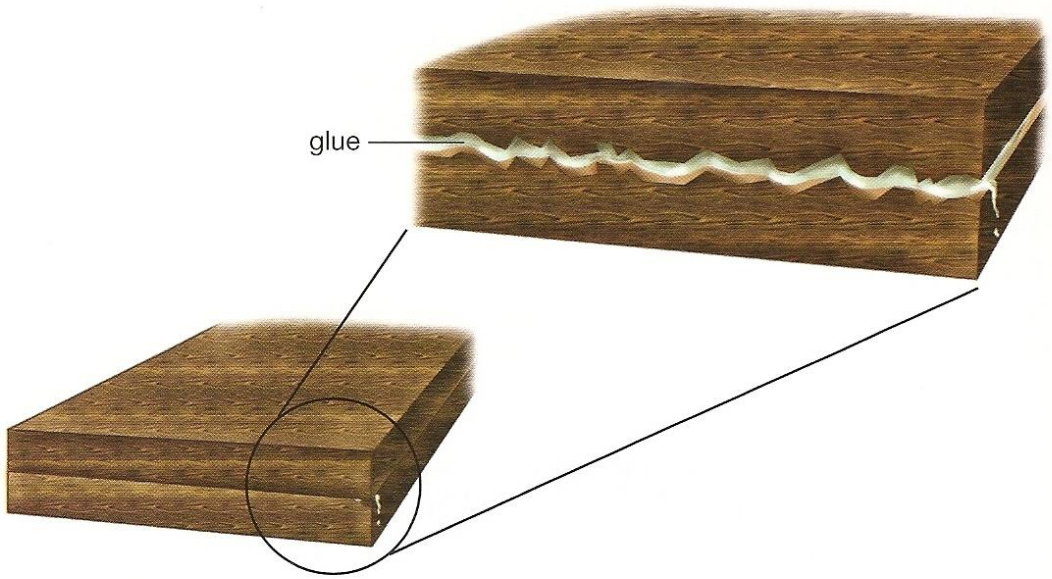


Figure 13.22 Glue creates a bridge between two surfaces and locks them together.

Melting

Pieces of metal or pieces of plastic can be melted together. **Welding** melts the pieces themselves. **Brazing** and **soldering** surround pieces with a different melted material, which locks the pieces together as it cools and hardens. To increase strength, the pieces to be joined may be twisted or folded together. No matter which process is used, the pieces must be carefully cleaned before joining, and the melted material must be cooled slowly and carefully or the joint will be brittle and weak.

There are many ways of melting materials to make welded joints. Torches use a hot flame. Arc welders and spot welders use heat from an electric spark. Plastics can be melted and welded together with strong chemicals and even with sound waves.

Figure 13.23 Welders use a dark mask to protect their eyes and to see white-hot joints clearly.

Interlocking Shapes

Carefully shaped parts can hold themselves together. Lego™ bricks and some paving stones fit together and stay together because of their shape. The fronts of wooden drawers are often locked to the sides with dovetail joints. Dentists shape the holes they drill in teeth to keep the filling material in place.

The joints in flexible materials are also carefully shaped. The sheet metal in the furnace and heating ducts of your home is overlapped or folded to strengthen the places where it is joined. Folded seams protect the cut edges of pieces of cloth and give a neat, finished appearance to the joints in clothing. Figure 13.24 shows some of the different kinds of interlocking joints.

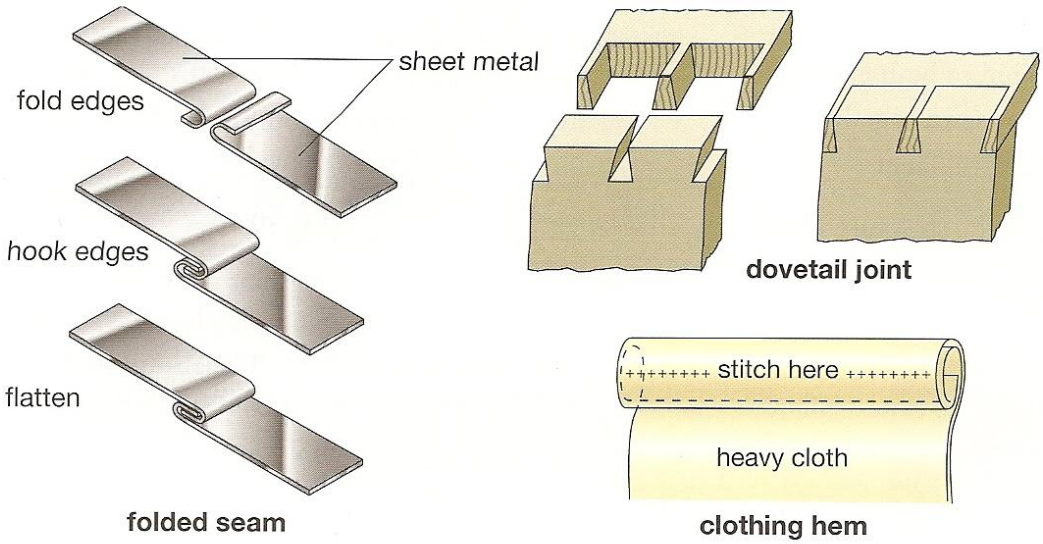
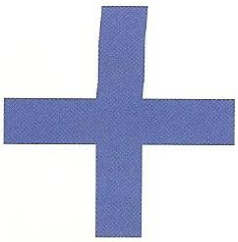


Figure 13.24 Various kinds of interlocking joints can be used to strengthen different types of structures.

STRETCH Your Mind

Builders need to avoid waste when cutting large pieces of building materials. How can you make one straight vertical cut and one straight horizontal cut to divide the cross shape below into four pieces that can be reassembled into a square?



Skill POWER

For tips on library and Internet research, turn to page 497.

Find Out ACTIVITY

A Better Mousetrap?

What to Do

1. Use library or Internet resources to find out how a common product or invention was developed. Choose your own product, or investigate a product in the list at the right.

Velcro ™
Super Glue™
soft drinks
zippers
ball-point pens
bubble gum
nylon stockings
automotive air bags
telephones

2. Prepare a short paragraph, poster, or oral presentation to tell the story of the product.