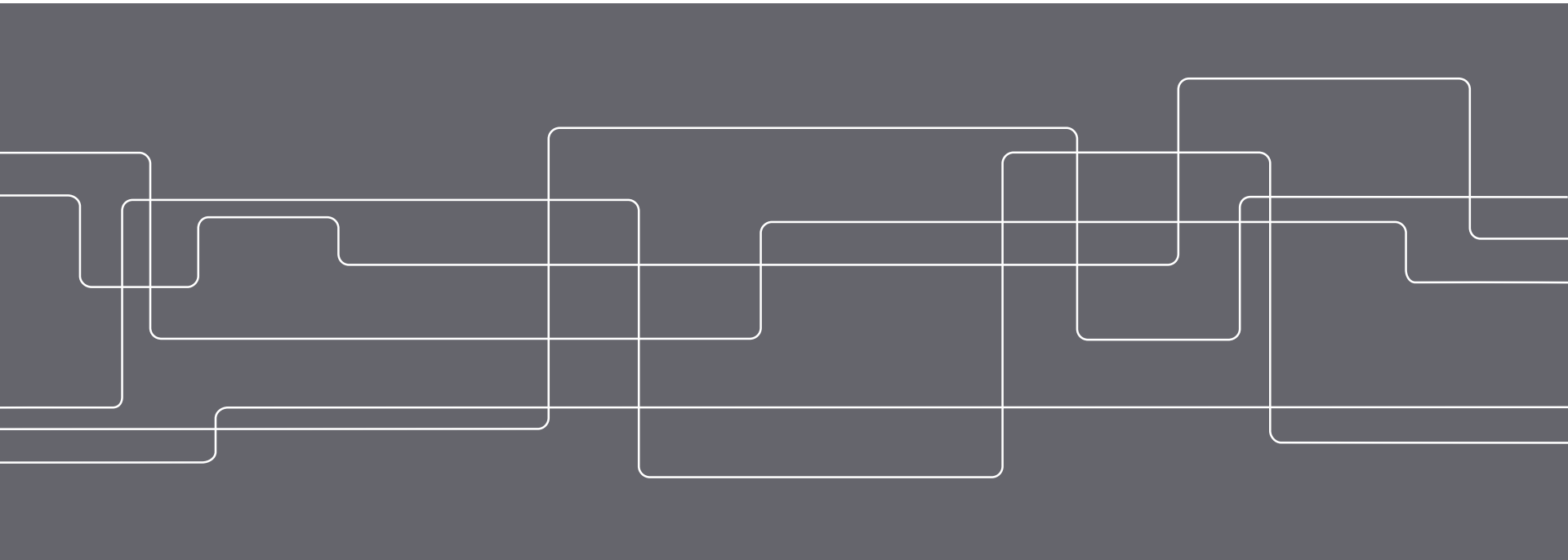
Assembly Technology

Lecture: wood assembly



Outline

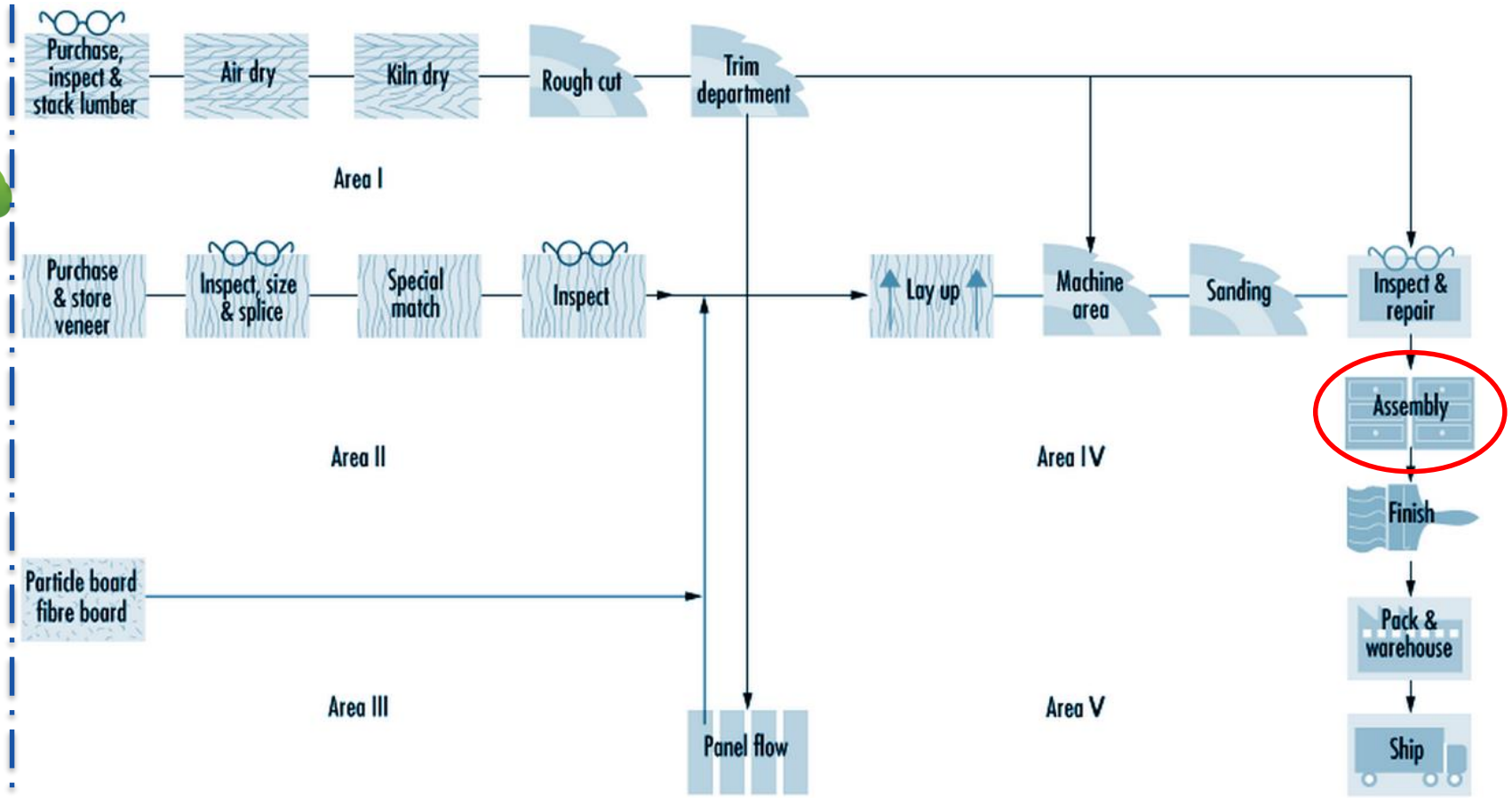
- The assembly process in Wood industry
- Fastening methods
- Adhesive processes

Intended Learning Outcomes

- Contestualize the assembly process withing the wood industry related processes
- Describe the main and supporting processes for joing wood components:
  - Main:
    - Fastening with emphasis on nails and screws
    - Adhesives including properties and kinds of glue and strategies for coping with wood deformation
  - Support
    - Clamping

Wood industry flow diagram: furniture manufacturing

Forest Industry



Raw material: timber

Timber (British English) or Lumber (American English), is wood that has been processed into beams and planks, a stage in the process of wood production

Manufactured material: veneer

In woodworking, **veneer** refers to thin slices of wood, usually thinner than 3 mm (1/8 inch), that typically are glued onto core panels (typically, wood, particle board or medium-density fiberboard) to produce flat panels such as doors, tops and panels for cabinets, parquet floors and parts of furniture

Manufactured material: High Pressure Laminated (HPL)

Laminated wood is usually built by the parallel gluing of lumber boards in a variety of sizes and shapes according to intended use. The main products are load-carrying members, such as beams and arches. Parallel-glued veneers are sometimes used to produce specialized items (for example, furniture, sporting goods, and novelties). These materials are often referred to as engineered wood.

Wood assembly process

The process of connecting of joining two pieces of wood together can be done through use of:

- Fasteners
- Adhesives

The process can be supported by:

- Preparation of the material in form of wood joint
- Use of clamping

Wood fasteners

- Fasteners include a huge variety of objects: nail, screws, bolts, staples, metal plates, joist hanger etc.
- They provide a mechanical joint using friction between the fastener and two pieces of wood

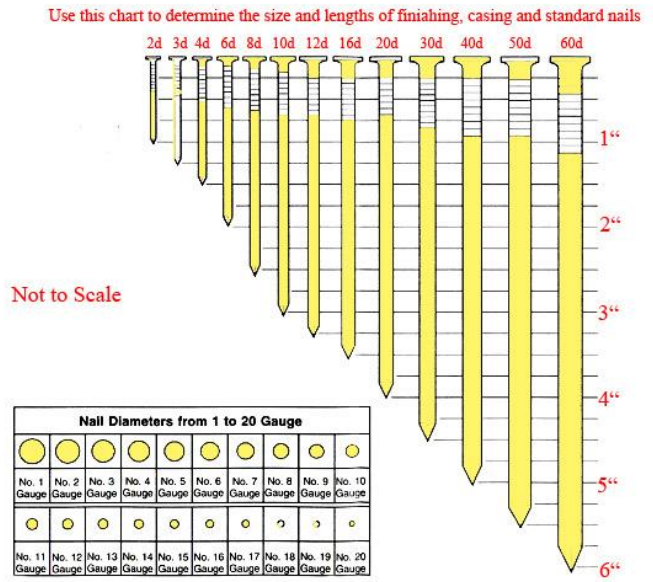
- What fastener is best to use?
- There are a few questions you need ask to determine which type of fastener you need to use.
  - What materials need to be joined? *Wood, metal and masonry all require different fasteners.*
  - What is the thickness of the material to be joined? *For a secure connection, the fastener must be the correct length.*
  - What weight or strength requirements are there? *From framing a house to hanging a picture, there's a fastener for the job.*
  - How permanent will the connection be? *If the work will be disassembled at some point, use a screw.*
  - Will the work be indoors or outdoors? *There are specific fasteners for both types of applications.*

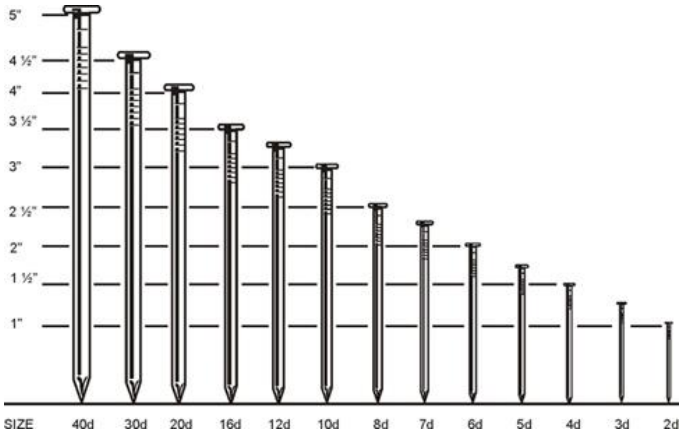
Nails

- The nail has been around for thousands of years.
- The first versions were heat-forged. When machinery entered the picture, they were cut from sheets of metal.
- Today, most nails are drawn and cut from rolls of wire.

Nail Size

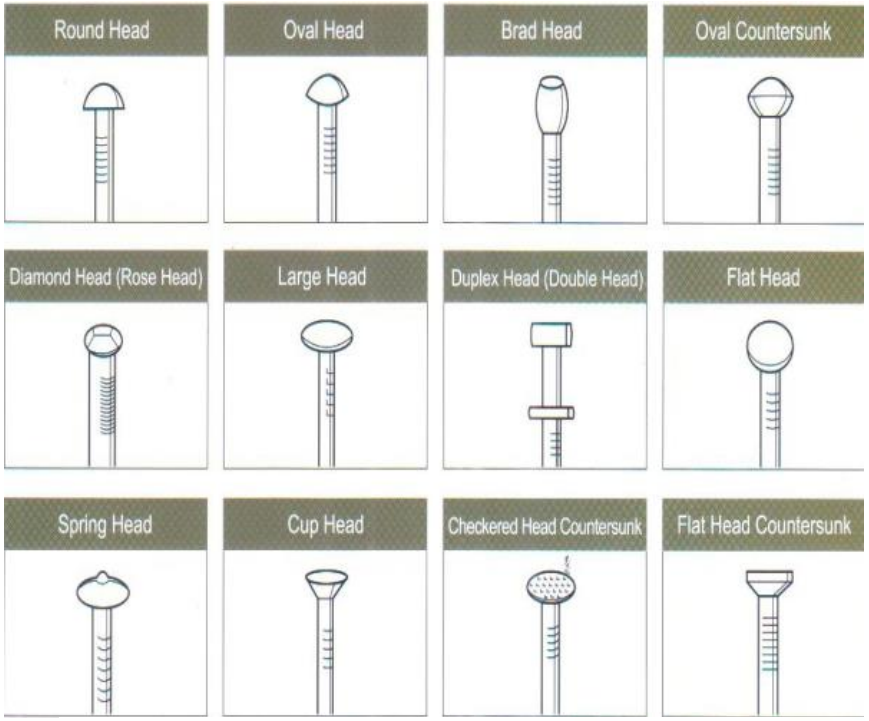
- Nails are sold by weight or length.
- Wood nails are measured, or sized, according to length.
  - This is expressed by the letter "d" (called penny). The symbol is English, signifying a pound in weight, related to the weight in pounds of 1000 nails.
  - Sizes run from 2d (2-penny/1" long) to 60d.
- Nails generally are 1" to 6" in length, usually getting thicker as they get longer.
- Nails larger than 6" are sometimes called spikes.

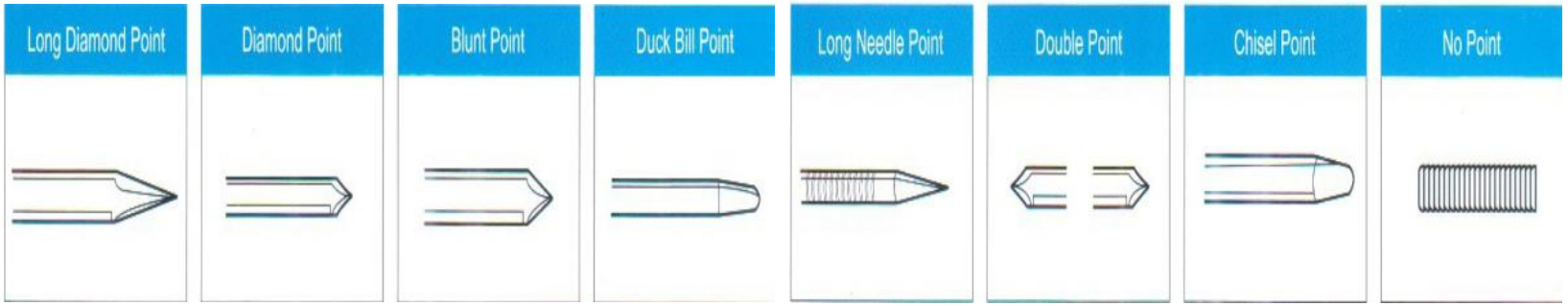




Nail styles

- Nail points vary, but the four-sided diamond point is the standard point found on most nails.
- Nail heads also vary.
  - Smaller heads can be driven in and painted over.
  - Large framing nails have corrugated heads to reduce the danger of a hammer slipping and causing injury or damage.
- Regular wood nails are often referred to as wire nails.





Kind of nails (1)

Kind	Description use	Pic
Common Nail	Thick, heavy-duty, general-purpose nail. Large, flat head for performing rough work such as construction framing.	
Box Nail	Short, thin shaped nail with a blunt tip. Used to fasten smaller stock when common nails are too large.	
Finishing Nail	Small nail with cupped head for fastening trim when nail heads should not show. Can be countersunk with a nailset, then filled over.	
Brad	Smaller version of the finishing nail up to about 1" long. Used for detail work such as attaching molding or trim.	

Kind of nails (2)

Kind	Description use	Pic
Casing Nail	Similar to finishing nail, but thicker and heavier. Used to attach case molding or rough trim where strength and concealment are required.	
Tack	Very short nail with relatively large head and very sharp point. Used to fasten upholstery or carpet or to perform other light fastening jobs.	
Upholstery Tacks	Short nails with ornamental or colored heads. Used for attaching upholstery where fasteners will show.	

Screws

- For fastening, screws are stronger than nails.
- They can be removed with less damage to the material (especially wood) than nails.
- When using with wood, best practice is to pre-drill a “pilot” hole to guide the screw into position.

Screw Slot Types

- Slotted
  - Conventional single-groove screwhead.
  - Applied with a flathead screwdriver.

- Phillips
  - Cross-slotted screwheads with U or V-Shaped slots of uniform width.
  - Driven with a Phillips screwdriver.

- Torx™
  - Require special drivers with six point heads.
  - Commonly used in electronics, metal or automotive applications.

Wood Screw Head & Thread Types

- Head Types
  - Oval
    - Lower portion is countersunk and top is rounded.
    - Easier to remove & better looking than flathead screws.
  - Round
    - Used where the fastened piece is too thin to permit countersinking.
    - Also used on parts that may require a washer.
  - Flat
    - Used in applications where the head needs to be flush with the surface.
    - Slotted and Phillips type are available.
- Thread Styles
  - Fine-thread
    - Work best for hardwoods.
  - Coarse-thread
    - Intended for soft woods.

Glue

- By definition, *glue* is made from animal byproducts such as skins and bones.
- An *adhesive* is any product that joins materials together.
- Today, the words "glue" and "adhesive" have become interchangeable.
    - *Natural Glues* are made from animal byproducts (hide glue and casein) or plant sources (paste, cellulose and rubber). [L SEP]
    - *Synthetic Adhesives* include polyvinyl acetate (PVA), aliphatic resin, contact cement, hot melt, and polyurethane.
- Adhesives are often used in conjunction with fasteners to strengthen wood joints.

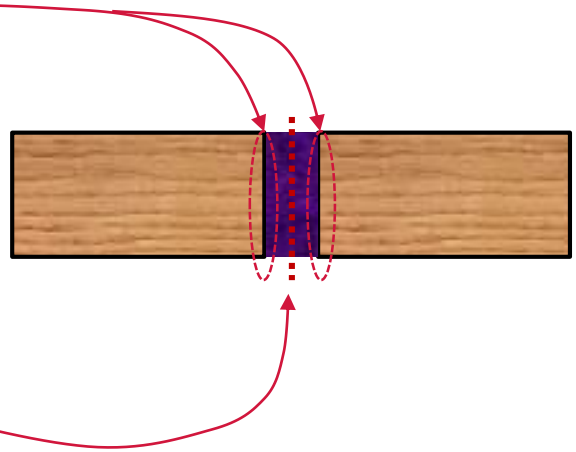
Glue

Two main ingredients:

- Resin – glue solid
- Solvent – keeps liquified until applied

How does glue work? there are two mechanisms:

- Specific adhesion - results from strong molecular attraction between the wood and the glue and for this to occur, the adhesive must penetrate the wood cells and "wet" the fibers.
- Cohesion - the force which makes the glue stick to itself. This is the solid glue "line" in a joint. It is the strongest when the two pieces to be joined are machined so they mate as closely as possible



Animal glues

- Used mostly for furniture making and woodworking.

- They are easy to work with, but less resistant to heat or cold.
  - Hide glue
    - » Made from bones, hoofs and skin from animals and fish.
    - » Dry form is mixed and heated (in a glue pot) into a gelatinous mixture that is applied with brush.
  - Casein
    - » Made from milk, powdered and reformulated with water.
    - » Creates a waterproof bond.

White Glue (polyvinyl acetate)

- For wood, engineered wood, paper, crafts and simple projects.
- Most commonly available in plastic squeeze bottles.
- Begins to set within one hour, dries clear.
- Has easy clean up, doesn't stain, nontoxic, nonflammable.
- Is not waterproof.
- Requires work to be clamped for best results.

Yellow or Carpenter’s Glue (aliphatic resin)

- For woodworking.
- "Refined" version of PVA.
- Packaged in squeeze bottles.
- Varieties typically come in yellow or brown.
- Begins to set within 15 minutes.
- Water-resistant nontoxic, nonflammable.
- More resistant to temperature and water than white glue.
- Work needs to be clamped for best results.
- Used for indoor and outdoor applications.

Contact Cement

- For bonding wood veneer and plastic laminates to countertops.
- Water-resistant.
- Applied to both surfaces needing to be bonded.
- After a designated curing time, the two work pieces are put together.
- Forms an instant bond, leaving no margin for error.
- Water-based versions are nonflammable.

Hot melt

- For crafts, general projects and repair.
- Requires an electric glue gun.
- Adhesive is a 2-4" glue stick that is inserted into the gun. Heat converts solid to liquid for application.
- Begins to set in about a minute as it cools and solidifies.
- Fills gaps for good adhesion.

Polyurethane

- For woodworking.
- Synthetic plastic-based material.
- Requires moistening of one or both sides of the materials to be joined.
- Creates a strong bond.
- Can be difficult to clean up.

Adhesive

How do adhesives cure?

- Some harden (solvent evaporates)
- Some change chemically
- Some harden as they cool

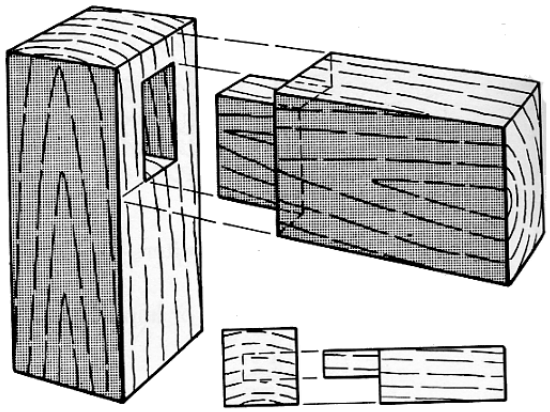
Adhesive

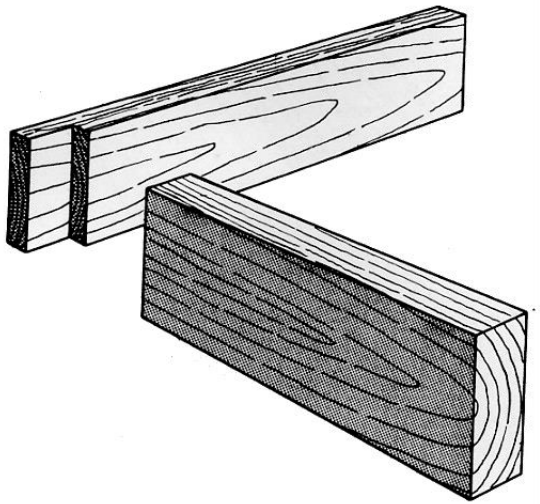
Glue property:

- Workability and durability
- Parameters:
  - Shelf or pot life
  - Open assembly time
  - Closed assembly time (in clamp)
  - Cure time (full strength)
  - Sandability
  - Working temperature range
  - Strength

Joinery

- The process of *connecting or joining two pieces of wood together* through the use of various forms of wood joints.
- In basic materials processing, common forms of joinery include dovetail joints, mortise-and-tenon joints, biscuit joints, lap joints, and spline joints

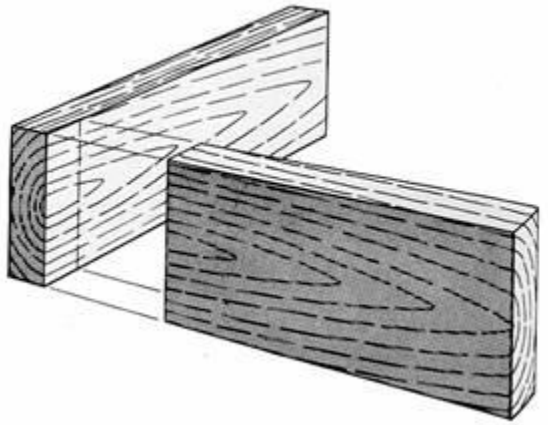




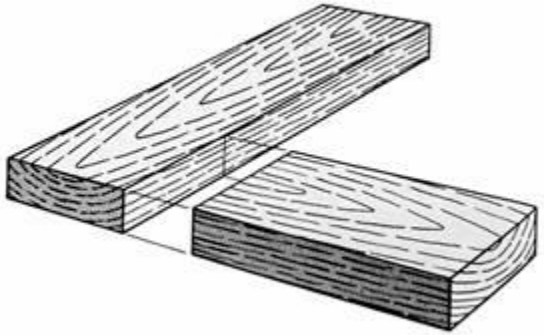
Butt Joint

- An easy but often weak technique for joining two boards together simply by gluing and pressing two flat surfaces together.

- Typically made by gluing an end to an adjoining flat surface.



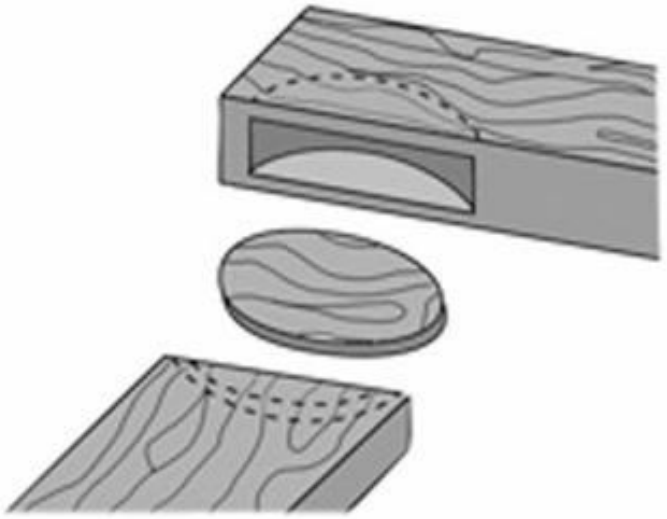
34–20a. Butt joint on edge.



34–20b. Butt joint flat.

Biscuit Joint

- A butt joint that is reinforced with football- or lozenge-shaped wooden "biscuits."
- Biscuits are usually made from compressed wood, frequently birch wood.
- When the biscuit comes into contact with glue in the biscuit slot, it swells thus creating a tighter joint.
- Sometimes called a plate joint.



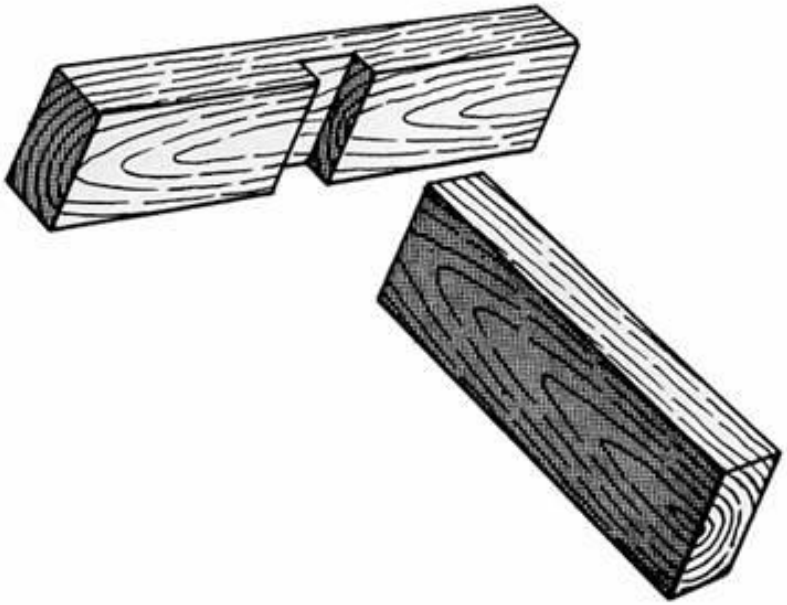
Dado Joint

A joint where one piece is grooved to receive the piece which forms the other part of the joint.

Dado (definition)

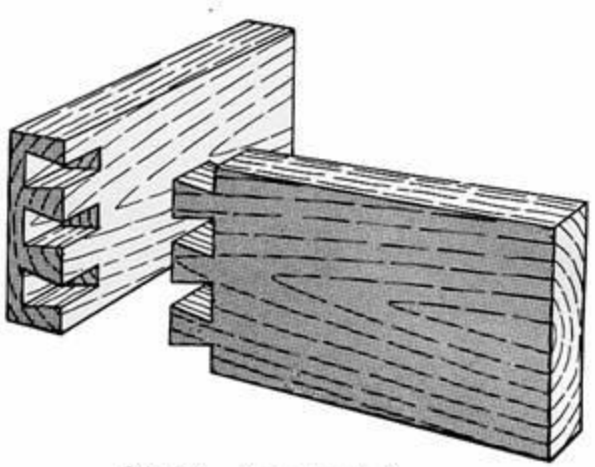
- *A groove which is cut across the grain to receive the butt end or edge of a second piece.*

34–43. A simple dado joint. The groove is cut to a width equal to the thickness of the second piece and to a depth of about one half the thickness of the first piece.

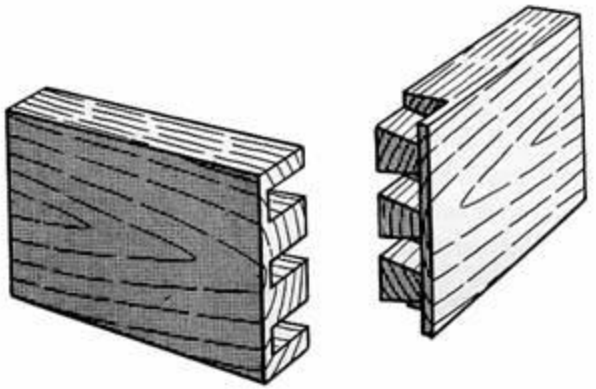


Dovetail Joint

- Joining two boards in which alternating slots (or tails) and protrusions (or pins), each resembling in shape the v-shaped outline of a bird's tail, are snugly fitted together, thus increasing the gluing area.
- Produces a joint that, even without glue, can be difficult to pull apart.
- Regarded as one of the strongest and most reliable forms of wood joinery.



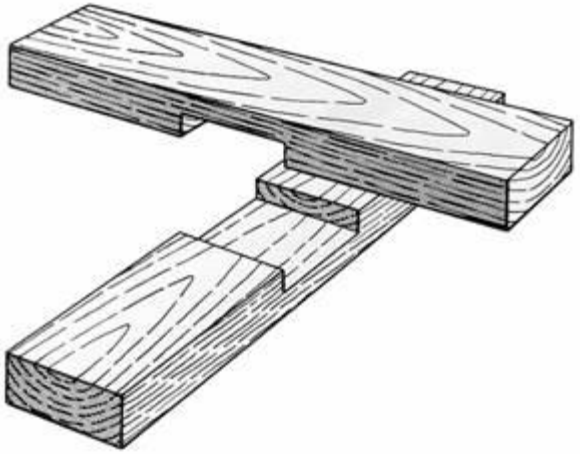
34–76a. Lap dovetail.



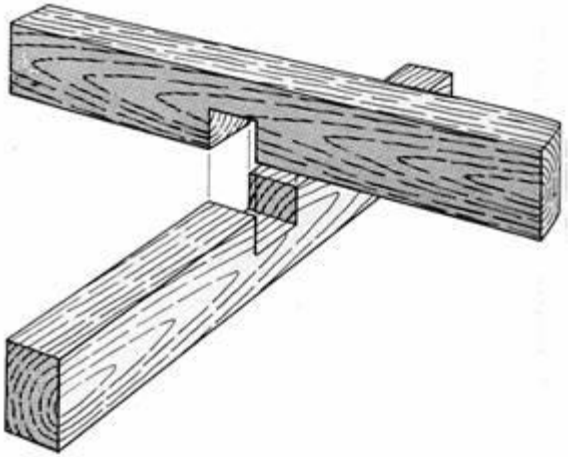
34–76b. Stopped-lap dovetail.

Lap Joint

A joint where one piece of wood is crossed over another.



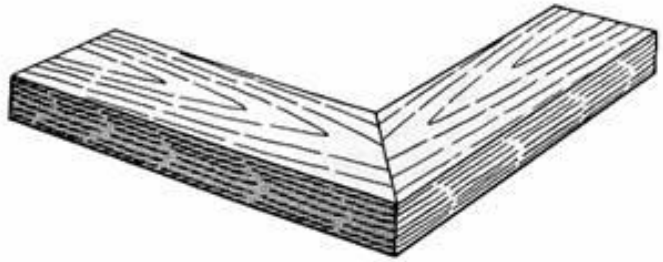
34–51. Cross lap or middle half lap.



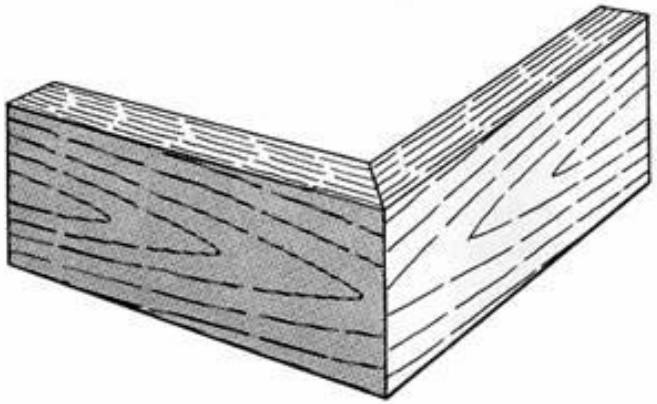
34–53. Edge lap.

Miter Joint

- The woodworking joint created when two boards are cut at an angle to one another.
- The most common miter joint is the 45-degree miter such as the cuts used to build square or rectangular picture frames.



34–59. Flat miter. This may be held together by nails, screws, or other metal fastener.



34–60. Edge miter.

Mortise-and-Tenon Joint

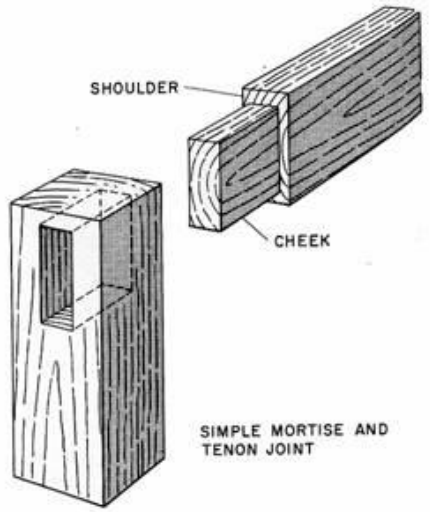
A joinery technique where the cut end (tenon) from one board fits into the matching opening (mortise) of another.

Mortise (definition)

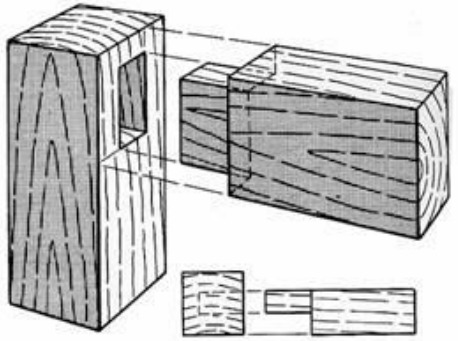
- *An opening chiseled, drilled or routed into a board to receive the end of an intersecting board.*
- *The opening or socket that receives the tenon in the classic woodworker's mortise-and-tenon joint.*
- *The female part of a mortise-and-tenon joint.*

Tenon (definition)

- *The end of a board, cut to a specific size and shape, that is inserted into the mortise, or opening, in a second board.*
- *The male part of a mortise-and-tenon joint.*



34–73. The blind or simple mortise-and-tenon.



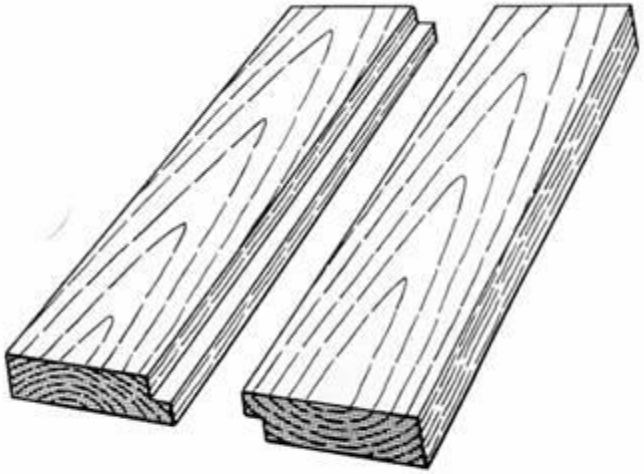
34–74. Bare-faced mortise-and-tenon.

Rabbet Joint

A joinery technique where an “L” groove across the end of the edge of one piece of wood fits into a edge or end of another board with an “L” groove.

Rabbet (definition)

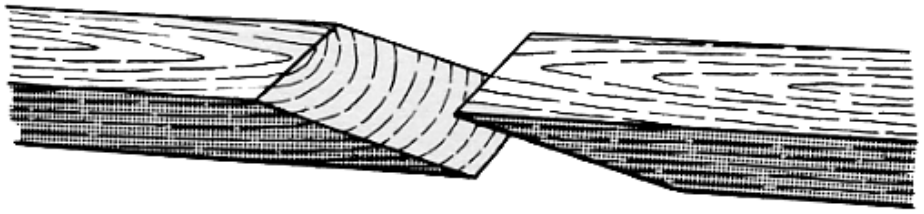
- *A rectangular, stepped recess cut along the edge of a section of wood. (May be used as a verb or noun.)*



34–34. Rabbet edge. This is also called ship lap when used in siding.

Scarf Joint

A joinery technique where two wedge-shaped pieces have been cut to correspond to one another.



34–15. Scarf joint. This is sometimes strengthened with dowels or by nailing a strip on either side.

Finger Joint

- A joinery technique used mostly in industry where small “fingers” are cut into corresponding pieces that will be joined together.

- Finger joints are used to making wide boards, in extending the length of dimensional lumber, an in laminated construction.

34–16. The finger joint is considered the most important industrial joint.

Joinery Reinforcements

Key (or Biscuit)

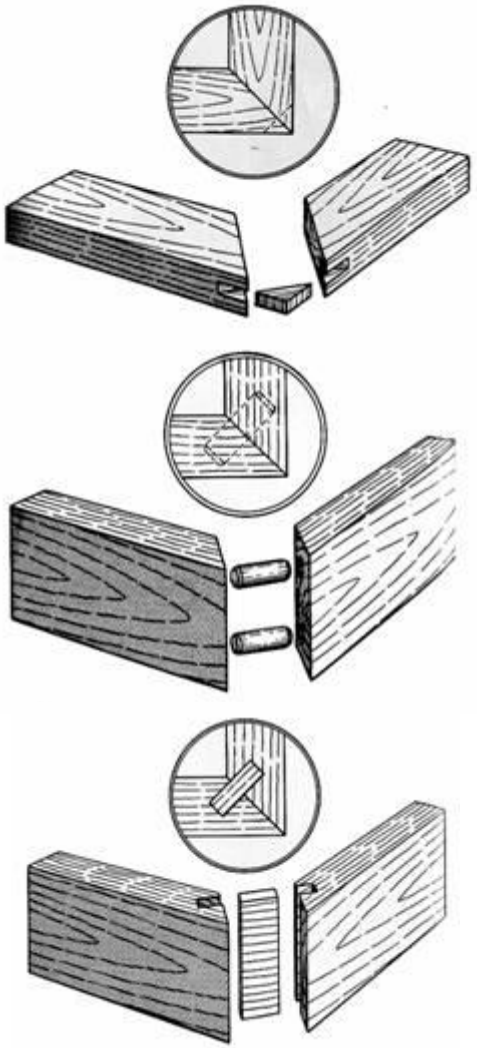
- A small, flat lozenge-shaped dowel for edge or corner-jointing. Wood biscuits are fitted into slots that are created with a biscuit jointer.

Dowel pin

- Pegs of wood that fit into two matching holes to strengthen a joint.

Spline

- A thin piece of wood that fits in the mating grooves cut into two pieces of wood.



Clamping

Three reasons to use clamps:

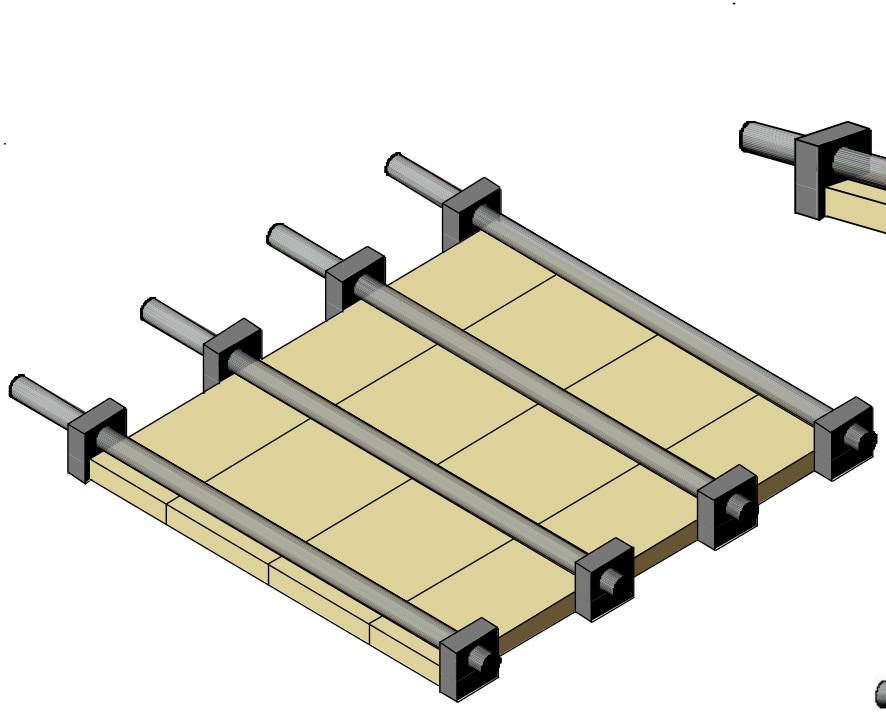
1. Dry fit

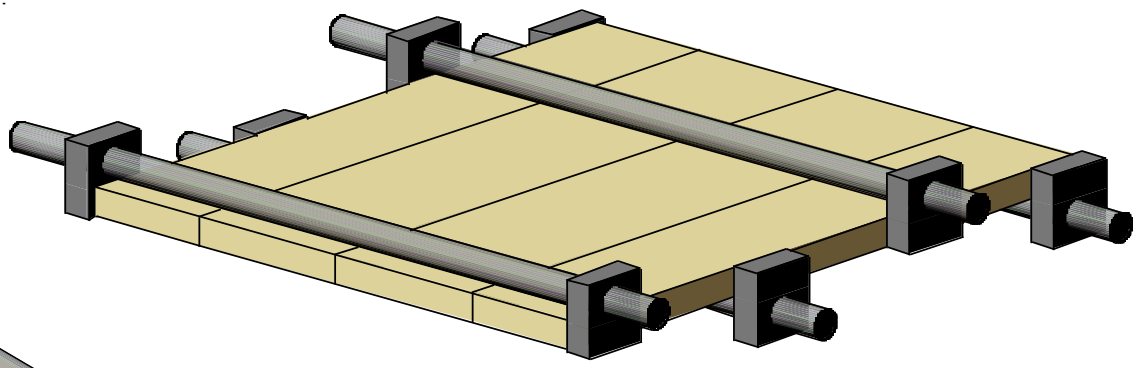
Check before you glue!

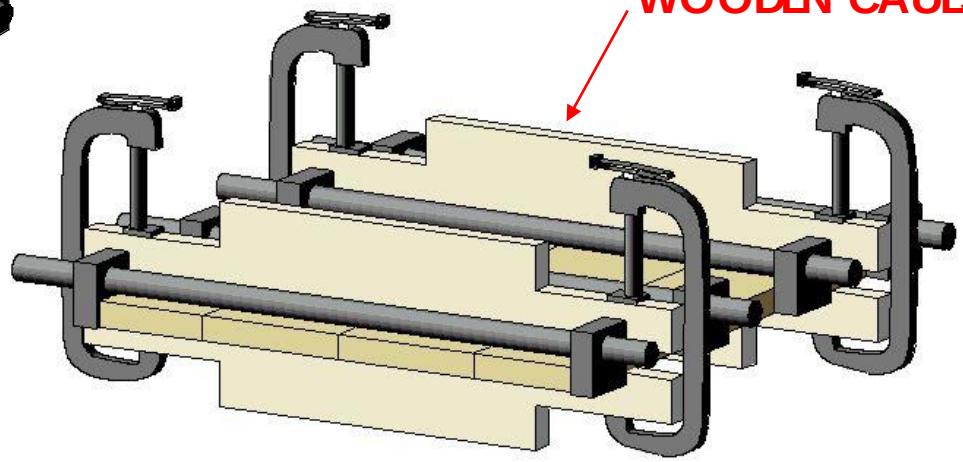
2. Keep parts aligned while glue cures

3. Most glues require pressure:
   - brings members into contact
   - squeeze out air
   - thin out glue –no thicker than a piece of paper

Clamp layouts







Clamping

How much pressure is required?

- Low Density Woods – 100 to 150 psi*
  - PINE
- Medium Density Woods – 150 to 250 psi
  - ALDER
- High Density Hardwoods – UP to 300 psi
  - RED OAK
- High Pressure Laminates (HPL) – 30 to 80 psi
- Veneer – 100 to 125 psi

* The pound per square inch or, more accurately, pound-force per square inch (abbreviations: psi, lbf/in^2, lbf/in^2, lbf/sq in, lbf/sq in) is a unit of pressure. 1psi is the pressure resulting from a force of one pound-force applied to an area of one square inch

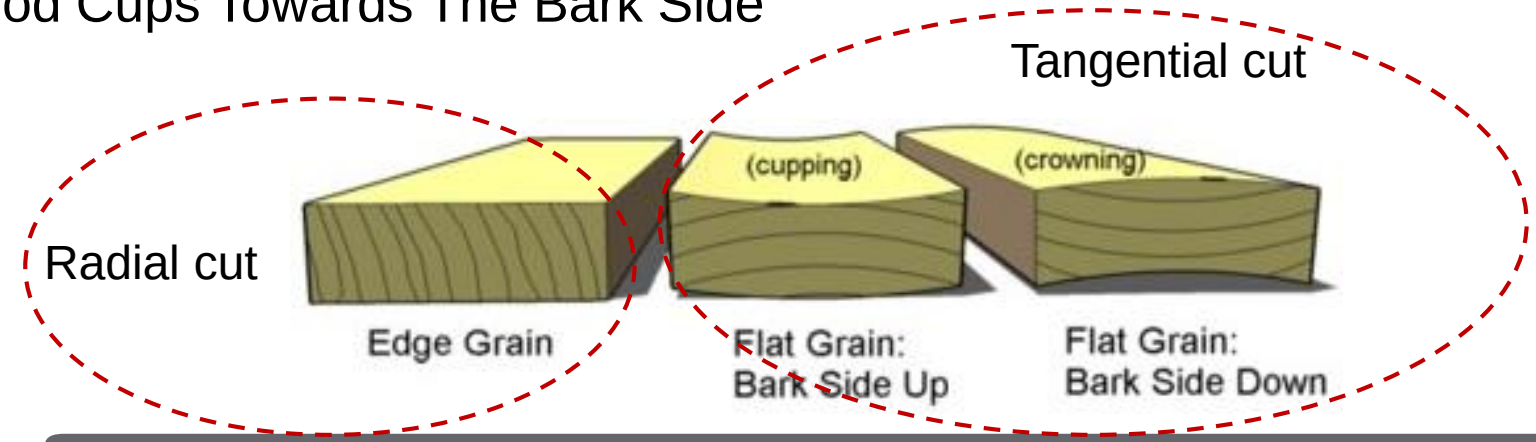
Clamping

How Much Pressure Can Be Exerted By A Clamp?

- Wood Screw Clamp – 800 to 1000 #
- Bar Clamp – Up to 2000#
- C-clamp – 1000#
- Spring Clamp – 25#

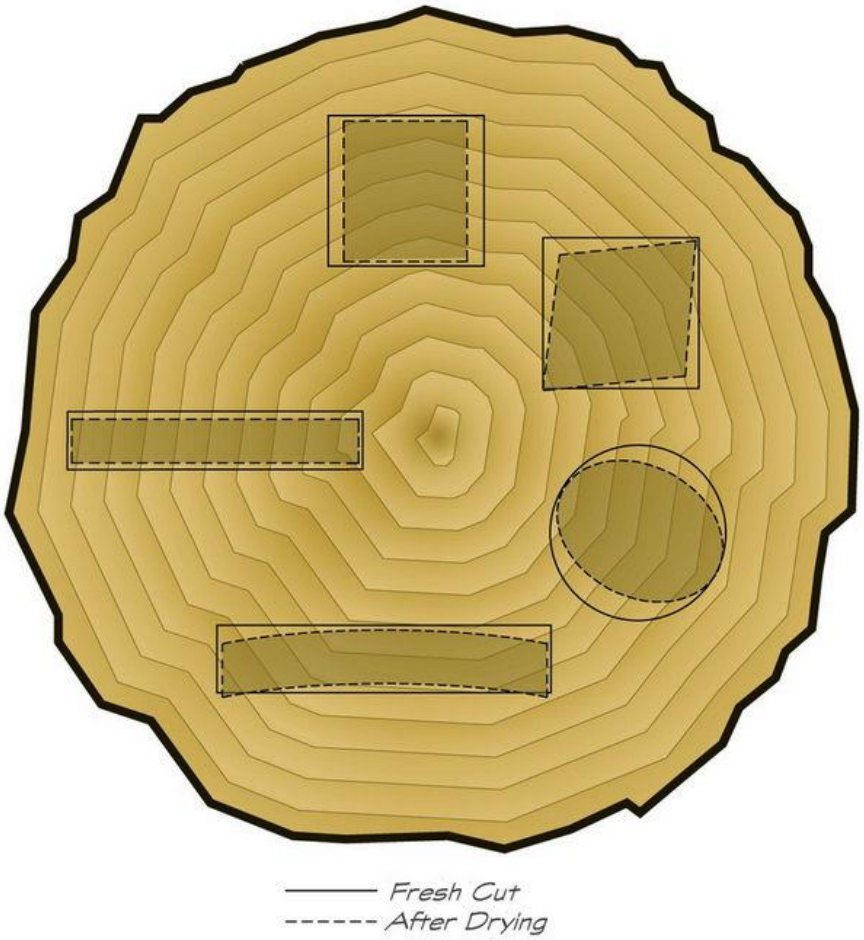
Gluing and wood movement

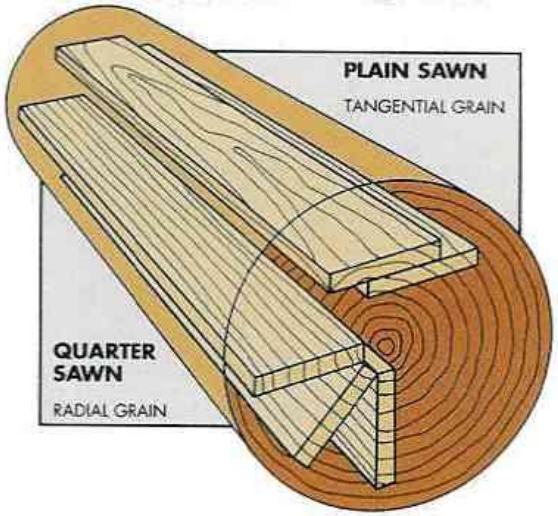
- Wood Is Hygroscopic which means it naturally takes on and give off water to balance out with its surrounding environment. Wood can safely absorb large quantities of water before reaching moisture content levels that will be inviting for decay fungi
- Wood shrinks/swells when it loses/gains moisture below its fiber saturation point. Most movement occurs tangentially. Where in the log a piece was cut will be a factor in how it changes shape as it shrinks*
- Radial cuts are better than tangential cut in this respect
- Wood Cups Towards The Bark Side

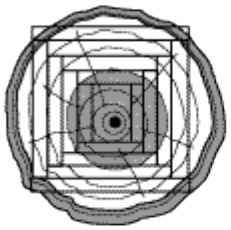


*One advantage of using dry lumber is that most of the shrinkage has been achieved prior to purchase. Dry lumber is lumber with a moisture content no greater than 19%; wood does most of its shrinking as it drops from 28-19%.

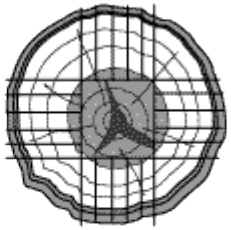
Glue cuts



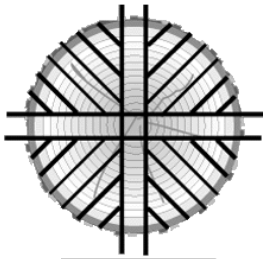


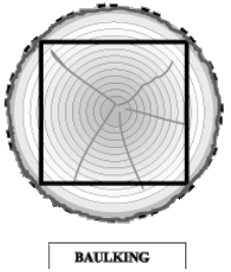


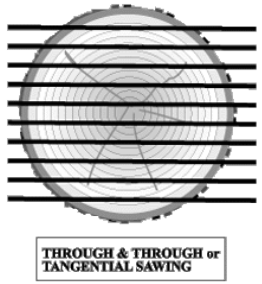
tangential cuts
(heart is boxed)



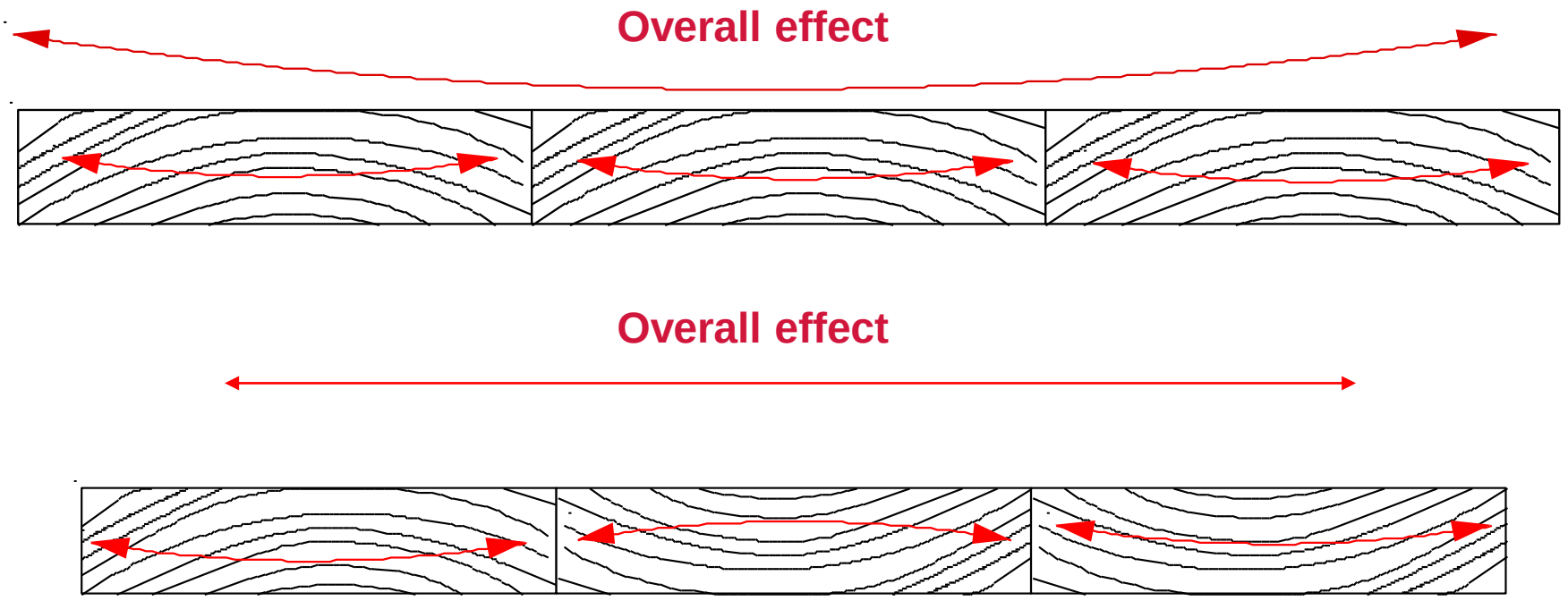
boxed heart





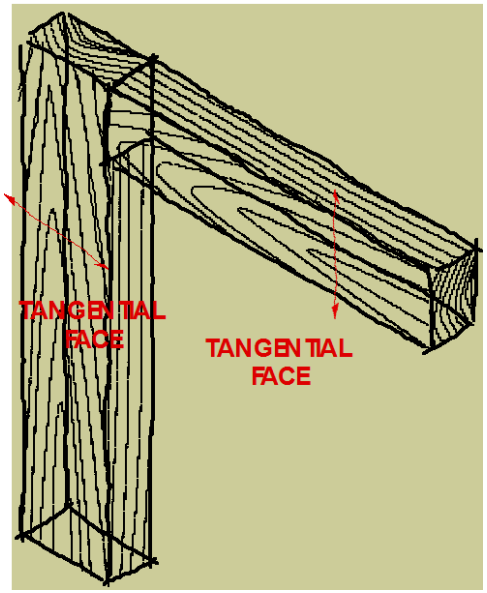


Gluing and wood movement

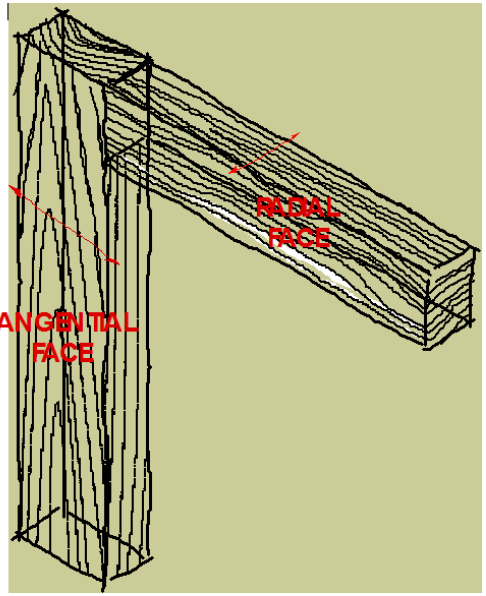


Gluing and wood movement

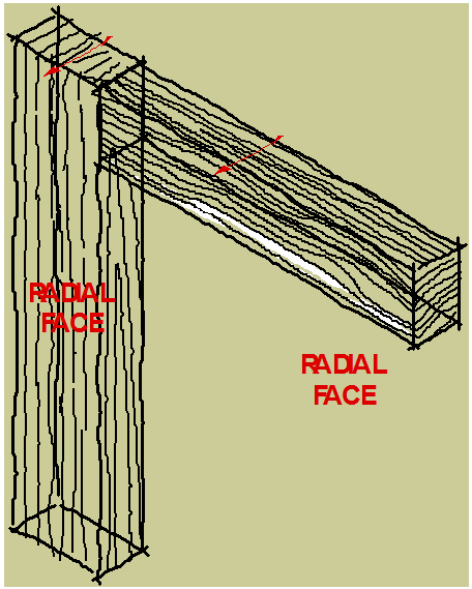
NOT Good



Acceptable



Good



Assembly hazards

As seen above a wide range of adhesives is used in the bonding of veneers to manufactured panels, depending on the characteristics required of the final product. Apart from casein glue, natural adhesives are less widely employed and the greatest use is made of synthetic adhesives such as urea-formaldehyde. Synthetic adhesives may pose a hazard of skin disease or systemic intoxication, especially those which release free formaldehyde or organic solvents into the atmosphere. Adhesives should be handled in well ventilated premises and sources of vapour emission should be equipped with exhaust ventilation. Employees should be provided with gloves, protective creams, respirators and eye protection when necessary.

From Sweden

- The customer perform the assembly process!
- It must be easy and safe!
  - Smart solutions with ad-hoc «can't get it wrong» fasteners → no unstable process such as gluing!
  - Requires reliable manufacturing processes for the wood component→ no adjustment during assembly

Video

- ABB Robot Producing wooden pallet (2:28)
- Workstation for wooden frames assembly (2:19)
- Automatic door assembly (4:50)
- Semi-automatic frame assembly (03:21)
- Gluing a tabletop (4:39)
- Strenght of glue (2:18)
- How to drill pilot holes (01:23)

Other video:

- An introduction to wood screws (≈13:00)
- Realizing common Woodworking Joinery (≈20:00)

Question for the formative assessment

1. List and describe the two common means of joining wood and related mechanisms of forming an assembly
2. Discuss the use of screws in woodwork in comparison with the use of nails. List and describe the most common kind of screws used in wood industry in terms of slot type, head and thread.
3. Sketch a butt joint with a biscuit (AKA Biscuit joint)
4. Mark the best solution in relation with the movement to form a butt joint among the three proposed. Explain your choice referring to the hygroscopic properties of wood.