Mēbeļu galdnieku izglītības programma

Profesionālā angļu valoda

Mācību lekciju materiāli – Priede, saplāksnis, masīvkoks, zāģmateriālu izmēri, vainas, agrīnā un vēlīnā koksne

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 PINE

Pines are among the most commercially important of tree species, valued for their [timber](http://en.wikipedia.org/wiki/Timber) and [wood pulp](http://en.wikipedia.org/wiki/Wood_pulp) throughout the world. In temperate and tropical regions, they are fast-growing [softwoods](http://en.wikipedia.org/wiki/Softwood) that will grow in relatively dense stands, their acidic decaying needles inhibiting the sprouting of competing hardwoods. Commercial pines are grown in [plantations](http://en.wikipedia.org/wiki/Plantation) for timber that is denser, more resinous, and therefore more durable than [spruce](http://en.wikipedia.org/wiki/Spruce) (*Picea*). Pine wood is widely used in high-value carpentry items such as furniture, window frames, panelling, floors and roofing, and the [resin](http://en.wikipedia.org/wiki/Resin) of some species is an important source of [turpentine](http://en.wikipedia.org/wiki/Turpentine). **Resin** in the most specific use of the term is a [hydrocarbon](http://en.wikipedia.org/wiki/Hydrocarbon) [secretion](http://en.wikipedia.org/wiki/Secretion) of many plants, particularly [coniferous trees](http://en.wikipedia.org/wiki/Pinophyta). Resins are valued for their chemical properties and associated uses, such as the production of [varnishes](http://en.wikipedia.org/wiki/Varnish), [adhesives](http://en.wikipedia.org/wiki/Adhesive) and food [glazing agents](http://en.wikipedia.org/wiki/Glazing_agent). They are also prized as an important source of raw materials for [organic synthesis](http://en.wikipedia.org/wiki/Organic_synthesis), and as constituents of [incense](http://en.wikipedia.org/wiki/Incense) and [perfume](http://en.wikipedia.org/wiki/Perfume). Plant resins have a very long history that was documented in ancient Greece by [Theophrastus](http://en.wikipedia.org/wiki/Theophrastus), in ancient Rome by [Pliny the Elder](http://en.wikipedia.org/wiki/Pliny_the_Elder), and especially in the resins known as [frankincense](http://en.wikipedia.org/wiki/Frankincense) and [myrrh](http://en.wikipedia.org/wiki/Myrrh), prized in ancient Egypt.[[1]](http://en.wikipedia.org/wiki/Resin#cite_note-ancegy-1) These were highly prized substances, and required as [incense](http://en.wikipedia.org/wiki/Incense) in some religious rites. [Amber](http://en.wikipedia.org/wiki/Amber) is a hard fossilized resin from ancient trees.

Many pine species make attractive ornamental plantings for [parks](http://en.wikipedia.org/wiki/Park) and larger [gardens](http://en.wikipedia.org/wiki/Garden), with a variety of dwarf [cultivars](http://en.wikipedia.org/wiki/Cultivar) being suitable for smaller spaces. Pines are also commercially grown and harvested for [Christmas trees](http://en.wikipedia.org/wiki/Christmas_tree). Pine cones, the largest and most durable of all [conifer cones](http://en.wikipedia.org/wiki/Conifer_cone), are craft favorites. Pine boughs, appreciated especially in wintertime for their pleasant smell and greenery, are popularly cut for decorations. A number of species are attacked by nematodes, causing pine [wilt disease](http://en.wikipedia.org/wiki/Wilt_disease), which can kill some quickly. Pine needles are also used for making decorative articles like baskets, trays, pots, etc. This Native American skill is now being replicated across the world. Pine needle handicrafts are made in the US, Canada, Mexico, Nicaragua and India. Pine needles serve as food for various [Lepidoptera](http://en.wikipedia.org/wiki/Lepidoptera). See [List of Lepidoptera that feed on pines](http://en.wikipedia.org/wiki/List_of_Lepidoptera_that_feed_on_pines).

Because pines have no insect or decay resistant qualities after logging, they are generally recommended for construction purposes as indoor use only (ex. indoor drywall framing). This wood left outside can be expected to last no more than 12–18 months depending on the type of climate it is exposed to. It is commonly referred to by several different names which include North American timber, SPF (spruce, pine, fir) and whitewood.

The [bark](http://en.wikipedia.org/wiki/Bark) of most pines is thick and scaly, but some species have thin, flaking bark. The branches are produced in regular "pseudo whorls", actually a very tight [spiral](http://en.wikipedia.org/wiki/Spiral) but appearing like a ring of branches arising from the same point.

**Lumber** is wood material that has been manufactured into boards. Lumber is predominantly used for structural purposes but has many other uses as well.

## Lumber is supplied either rough or finished. Besides [pulpwood](http://en.wikipedia.org/wiki/Pulpwood), *rough lumber* is the raw material for [furniture](http://en.wikipedia.org/wiki/Furniture)-making and other items requiring additional cutting and shaping. It is available in many species, usually [hardwoods](http://en.wikipedia.org/wiki/Hardwood), but it is also readily available in softwoods such as [white pine](http://en.wikipedia.org/wiki/Pinus_classification) and [red pine](http://en.wikipedia.org/wiki/Red_pine) because of their low cost.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)] *Finished lumber* is supplied in standard sizes, mostly for the construction industry, primarily [softwood](http://en.wikipedia.org/wiki/Softwood) from [coniferous](http://en.wikipedia.org/wiki/Conifer) species including [pine](http://en.wikipedia.org/wiki/Pine), [fir](http://en.wikipedia.org/wiki/Fir) and [spruce](http://en.wikipedia.org/wiki/Spruce) (collectively known as [Spruce-pine-fir](http://en.wikipedia.org/wiki/Spruce-pine-fir)), [cedar](http://en.wikipedia.org/wiki/Cedrus), and [hemlock](http://en.wikipedia.org/wiki/Tsuga), but also some hardwood, **Dimensional lumber**





Example of 2×4.

*Dimensional lumber* is a term used for lumber that is finished/planed and cut to standardized width and depth specified in [inches](http://en.wikipedia.org/wiki/Inch). Examples of common sizes are *2×4* (pictured) (also *two-by-four* and other variants, such as *four-by-two* in the UK, Australia, New Zealand), *2×6*, and *4×4*. The length of a board is usually specified separately from the width and depth. It is thus possible to find 2×4s that are four, eight, or twelve feet in length. In the [United States](http://en.wikipedia.org/wiki/United_States) and [Canada](http://en.wikipedia.org/wiki/Canada) the standard lengths of lumber are 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24 feet. For wall framing, "stud," or "precut" sizes are available, and commonly used. For an eight, nine, or ten foot ceiling height, studs are available in 92 5/8 inches, 104 5/8 inches, and 116 5/8 inches. The term "stud" is used inconsistently to specify length, though, so where the exact length matters, one must specify the length explicitly.

|  |
| --- |
| North American [softwood](http://en.wikipedia.org/wiki/Softwood) dimensional lumber sizes |
| **Nominal** **(inches)** | **Actual** | **Nominal** **(inches)** | **Actual** | **Nominal** **(inches)** | **Actual** |
| 1 × 2 | 3⁄4 in × 1 1⁄2 in (19 mm × 38 mm) | 2 × 2 | 1 1⁄2 in × 1 1⁄2 in (38 mm × 38 mm) | 4 × 4 | 3 1⁄2 in × 3 1⁄2 in (89 mm × 89 mm) |
| 1 × 3 | 3⁄4 in × 2 1⁄2 in (19 mm × 64 mm) | 2 × 3 | 1 1⁄2 in × 2 1⁄2 in (38 mm × 64 mm) | 4 × 6 | 3 1⁄2 in × 5 1⁄2 in (89 mm × 140 mm) |
| 1 × 4 | 3⁄4 in × 3 1⁄2 in (19 mm × 89 mm) | 2 × 4 | 1 1⁄2 in × 3 1⁄2 in (38 mm × 89 mm) | 6 × 6 | 5 1⁄2 in × 5 1⁄2 in (140 mm × 140 mm) |
| 1 × 6 | 3⁄4 in × 5 1⁄2 in (19 mm × 140 mm) | 2 × 6 | 1 1⁄2 in × 5 1⁄2 in (38 mm × 140 mm) | 8 × 8 | 7 1⁄4 in × 7 1⁄4 in (184 mm × 184 mm) |
| 1 × 8 | 3⁄4 in × 7 1⁄4 in (19 mm × 184 mm) | 2 × 8 | 1 1⁄2 in × 7 1⁄4 in (38 mm × 184 mm) |  |  |
| 1 × 10 | 3⁄4 in × 9 1⁄4 in (19 mm × 235 mm) | 2 × 10 | 1 1⁄2 in × 9 1⁄4 in (38 mm × 235 mm) |  |  |
| 1 × 12 | 3⁄4 in × 11 1⁄4 in (19 mm × 286 mm) | 2 × 12 | 1 1⁄2 in × 11 1⁄4 in (38 mm × 286 mm) |  |  |

Solid dimensional lumber typically is only available up to lengths of 24 ft. Engineered wood products, manufactured by binding the strands, particles, fibers, or veneers of wood, together with adhesives, to form composite materials, offer more flexibility and greater structural strength than typical wood building materials.[[6]](http://en.wikipedia.org/wiki/Timber#cite_note-6)

Pre-cut studs save a framer a lot of time as they are pre-cut by the manufacturer to be used in 8 ft, 9 ft & 10 ft ceiling applications, which means they have removed a few inches of the piece to allow for the sill plate and the double top plate with no additional sizing necessary.

In the [Americas](http://en.wikipedia.org/wiki/Americas), *two-bys* (2×4s, 2×6s, 2×8s, 2×10s, and 2×12s), along with the 4×4, are common lumber sizes used in modern construction. They are the basic building block for such common structures as [balloon-frame](http://en.wikipedia.org/wiki/Balloon_framing) or [platform-frame](http://en.wikipedia.org/wiki/Platform_framing) housing. Dimensional lumber made from [softwood](http://en.wikipedia.org/wiki/Softwood) is typically used for construction, while [hardwood](http://en.wikipedia.org/wiki/Hardwood) boards are more commonly used for making cabinets or [furniture](http://en.wikipedia.org/wiki/Furniture).

Lumber's [*nominal* dimensions](http://en.wikipedia.org/wiki/Real_versus_nominal_value#Engineering) are larger than the actual standard dimensions of finished lumber. Historically, the nominal dimensions were the size of the green (not dried), rough (unfinished) boards that eventually became smaller finished lumber through drying and planing (to smooth the wood). Today, the standards specify the final finished dimensions and the mill cuts the logs to whatever size it needs to achieve those final dimensions. Typically, that rough cut is smaller than the nominal dimensions because modern technology makes it possible and it uses the logs more efficiently. For example, a "2x4" board historically started out as a green, rough board actually 2 inches by 4 inches. After drying and planing, it would be smaller, by a nonstandard amount. Today, a "2x4" board starts out as something smaller than 2 inches by 4 inches and not specified by standards, and after drying and planing is reliably 1 1⁄2 inches x 3 1⁄2 inches.

Early standards called for green rough lumber to be of full nominal dimension when dry. However, the dimensions have diminished over time. In 1910, a typical finished 1-inch- (25 mm) board was 13⁄16 in (21 mm). In 1928, that was reduced by 4%, and yet again by 4% in 1956. In 1961, at a meeting in Scottsdale, Arizona, the Committee on Grade Simplification and Standardization agreed to what is now the current U.S. standard: in part, the dressed size of a 1 inch (nominal) board was fixed at 3⁄4 inch; while the dressed size of 2 inch (nominal) lumber was *reduced* from 1 5⁄8 inch to the current 1 1⁄2 inch.[[7]](http://en.wikipedia.org/wiki/Timber#cite_note-7)

Dimensional lumber is available in green, unfinished state, and for that kind of lumber, the nominal dimensions are the actual dimensions.

**Pulp** is a lignocellulosic fibrous material prepared by chemically or mechanically separating [cellulose fibres](http://en.wikipedia.org/wiki/Cellulose_fiber) from [wood](http://en.wikipedia.org/wiki/Wood), [fibre crops](http://en.wikipedia.org/wiki/Fibre_crop) or [waste paper](http://en.wikipedia.org/wiki/Paper_recycling). Wood provides about 90 % of the basis for pulp production, while about 10 % originates from annual plants.[[1]](http://en.wikipedia.org/wiki/Wood_pulp#cite_note-1) Pulp is one of the most abundant raw materials world wide. It is most commonly used as raw material in [papermaking](http://en.wikipedia.org/wiki/Papermaking), but is also used for in [textiles](http://en.wikipedia.org/wiki/Textile_industry), [food](http://en.wikipedia.org/wiki/Food_industry), [pharmaceutical](http://en.wikipedia.org/wiki/Pharmaceutical_industry) and many other industries as well.

The [timber](http://en.wikipedia.org/wiki/Timber) resources used to make wood pulp are referred to as [pulpwood](http://en.wikipedia.org/wiki/Pulpwood). Wood pulp comes from [softwood](http://en.wikipedia.org/wiki/Softwood) trees such as [spruce](http://en.wikipedia.org/wiki/Spruce), [pine](http://en.wikipedia.org/wiki/Pine), [fir](http://en.wikipedia.org/wiki/Fir), [larch](http://en.wikipedia.org/wiki/Larch) and [hemlock](http://en.wikipedia.org/wiki/Tsuga), and [hardwoods](http://en.wikipedia.org/wiki/Hardwood) such as [eucalyptus](http://en.wikipedia.org/wiki/Eucalyptus), [aspen](http://en.wikipedia.org/wiki/Aspen) and [birch](http://en.wikipedia.org/wiki/Birch).[[9]](http://en.wikipedia.org/wiki/Wood_pulp#cite_note-9)

A [pulp mill](http://en.wikipedia.org/wiki/Pulp_mill) is a manufacturing facility that converts wood chips or other plant fiber source into a thick fiber board which can be shipped to a paper mill for further processing. Pulp can be manufactured using mechanical, semi-chemical or fully chemical methods (kraft and sulfite processes). The finished product may be either bleached or non-bleached, depending on the customer requirements.

Wood and other plant materials used to make pulp contain three main components (apart from water): cellulose fibres (desired for papermaking), [lignin](http://en.wikipedia.org/wiki/Lignin) (a three-dimensional polymer that binds the cellulose fibers together) and [hemicelluloses](http://en.wikipedia.org/wiki/Hemicellulose), (shorter branched carbohydrate polymers). The aim of pulping is to break down the bulk structure of the fibre source, be it chips, stems or other plant parts, into the constituent fibers.

Chemical pulping achieves this by degrading the lignin and hemicellulose into small, water-soluble molecules which can be washed away from the cellulose fibers without depolymerizing the cellulose fibres (chemically depolymerizing the cellulose weakens the fibres). The various mechanical pulping methods, such as groundwood (GW) and refiner mechanical (RMP) pulping, physically tear the cellulose fibres one from another. Much of the lignin remains adhering to the fibers. Strength is impaired because the fibres may be cut. There are a number of related hybrid pulping methods that use a combination of chemical and thermal treatment to begin an abbreviated chemical pulping process, followed immediately by a mechanical treatment to separate the fibers. These hybrid methods include thermomechanical pulping, also known as TMP, and chemithermomechanical pulping, also known as CTMP. The chemical and thermal treatments reduce the amount of energy subsequently required by the mechanical treatment, and also reduce the amount of strength loss suffered by the fibers.

**Harvesting trees**

All kinds of paper are made out of 100% wood with nothing else mixed into them (with some exceptions, like fancy resume paper, which may include cotton). This includes newspaper, magazines and even toilet paper. Most pulp mills use good [forest management](http://en.wikipedia.org/wiki/Forest_management) practices in harvesting trees to ensure that they have a sustainable source of raw materials. One of the major complaints about harvesting wood for pulp mills is that it reduces the [biodiversity](http://en.wikipedia.org/wiki/Biodiversity) of the harvested forest. Trees raised specifically for pulp production account for 16 percent of world pulp production, old growth forests account for 9 percent, and second- and third- and more generation forests account for the rest.[[11]](http://en.wikipedia.org/wiki/Wood_pulp#cite_note-chase-11) [Reforestation](http://en.wikipedia.org/wiki/Reforestation) is practiced in most areas, so trees are a renewable resource. The FSC ([Forest Stewardship Council](http://en.wikipedia.org/wiki/Forest_Stewardship_Council)), SFI ([Sustainable Forestry Initiative](http://en.wikipedia.org/wiki/Sustainable_Forestry_Initiative)), PEFC ([Programme for the Endorsement of Forest Certification](http://en.wikipedia.org/wiki/Programme_for_the_Endorsement_of_Forest_Certification)), and other bodies certify paper made from trees harvested according to guidelines meant to ensure good forestry practices.[[12]](http://en.wikipedia.org/wiki/Wood_pulp#cite_note-12)

The number of trees consumed depends on whether mechanical processes or chemical processes are used. It has been estimated that based on a mixture of softwoods and hardwoods 12 metres (40 ft) tall and 15-20 centimetres (6–8 in) in diameter, it would take an average of 24 trees to produce 0.9 tonne (1 ton) of printing and writing paper, using the [kraft process](http://en.wikipedia.org/wiki/Kraft_process) (chemical pulping). Mechanical pulping is about twice as efficient in using trees since almost all of the wood is used to make fibre therefore it takes about 12 trees to make 0.9 tonne (1 ton) of mechanical pulp or [newsprint](http://en.wikipedia.org/wiki/Newsprint).[[13]](http://en.wikipedia.org/wiki/Wood_pulp#cite_note-13)

There are roughly 2 short tons in a cord of wood.[[14]](http://en.wikipedia.org/wiki/Wood_pulp#cite_note-14)

**Preparation for pulping**

Main article: [Woodchips](http://en.wikipedia.org/wiki/Woodchips)

Wood chipping is the act and industry of chipping wood for pulp, but also for other [processed wood](http://en.wikipedia.org/wiki/Wood_processing) products and [mulch](http://en.wikipedia.org/wiki/Mulch). Only the [heartwood](http://en.wikipedia.org/wiki/Heartwood) and [sapwood](http://en.wikipedia.org/wiki/Sapwood_%28wood%29) are useful for making pulp. [Bark](http://en.wikipedia.org/wiki/Bark) contains relatively few useful fibres and is removed and used as fuel to provide steam for use in the pulp mill. Most pulping processes require that the wood be chipped and screened to provide uniform sized chips.

**Pulping**

There are a number of different processes which can be used to separate the wood fibres:

**Mechanical pulp**

Manufactured [grindstones](http://en.wikipedia.org/wiki/Grindstone) with embedded [silicon carbide](http://en.wikipedia.org/wiki/Silicon_carbide) or [aluminum oxide](http://en.wikipedia.org/wiki/Aluminum_oxide) can be used to grind small wood logs called "bolts" to make stone pulp (SGW). If the wood is steamed prior to grinding it is known as pressure ground wood pulp (PGW). Most modern mills use chips rather than logs and ridged metal discs called refiner plates instead of grindstones. If the chips are just ground up with the plates, the pulp is called refiner mechanical pulp (RMP) and if the chips are steamed while being refined the pulp is called thermomechanical pulp (TMP). Steam treatment significantly reduces the total energy needed to make the pulp and decreases the damage (cutting) to fibres. Mechanical pulps are used for products that require less strength, such as [newsprint](http://en.wikipedia.org/wiki/Newsprint) and [paperboards](http://en.wikipedia.org/wiki/Paperboard).

**Thermomechanical pulp**





Mechanical pulping process.[[15]](http://en.wikipedia.org/wiki/Wood_pulp#cite_note-igg-15)

Thermomechanical pulp is pulp produced by processing [wood chips](http://en.wikipedia.org/wiki/Wood_chip) using heat (thus [thermo](http://en.wikipedia.org/wiki/Thermo)) and a mechanical refining movement (thus mechanical). It is a two stage process where the logs are first stripped of their [bark](http://en.wikipedia.org/wiki/Bark) and converted into small chips. These chips have a moisture content of around 25-30% and a mechanical force is applied to the wood chips in a crushing or grinding action which generates heat and water vapour and softens the [lignin](http://en.wikipedia.org/wiki/Lignin) thus separating the individual fibres. The pulp is then screened and cleaned, any clumps of fibre are reprocessed. This process gives a high yield of fibre from the [timber](http://en.wikipedia.org/wiki/Timber) (around 95%) and as the lignin has not been removed, the fibres are hard and rigid.[[15]](http://en.wikipedia.org/wiki/Wood_pulp#cite_note-igg-15)

**Chemithermomechanical pulp**

Wood chips can be pretreated with [sodium carbonate](http://en.wikipedia.org/wiki/Sodium_carbonate), [sodium hydroxide](http://en.wikipedia.org/wiki/Sodium_hydroxide), [sodium sulfite](http://en.wikipedia.org/wiki/Sodium_sulfite) and other chemicals prior to refining with equipment similar to a mechanical mill. The conditions of the chemical treatment are much less vigorous (lower temperature, shorter time, less extreme [pH](http://en.wikipedia.org/wiki/PH)) than in a chemical pulping process since the goal is to make the fibres easier to refine, not to remove lignin as in a fully chemical process. Pulps made using these hybrid processes are known as chemithermomechanical pulps (CTMP).

**Chemical pulp** is produced by combining wood chips and chemicals in large vessels known as [digesters](http://en.wikipedia.org/wiki/Digester) where heat and the chemicals break down the lignin, which binds the [cellulose](http://en.wikipedia.org/wiki/Cellulose) fibres together, without seriously degrading the [cellulose fibres](http://en.wikipedia.org/wiki/Cellulose_fibre). Chemical pulp is used for materials that need to be stronger or combined with mechanical pulps to give a product different characteristics. The [kraft process](http://en.wikipedia.org/wiki/Kraft_process) is the dominant chemical pulping method, with [sulfite process](http://en.wikipedia.org/wiki/Sulfite_process) being second. Historically [soda pulping](http://en.wikipedia.org/wiki/Soda_pulping) was the first successful chemical pulping method.

**Grades and standards**

Individual pieces of lumber exhibit a wide range in quality and appearance with respect to knots, slope of grain, shakes and other natural characteristics. Therefore, they vary considerably in strength, utility and value.

The move to set national standards for lumber in the United States began with publication of the American Lumber Standard in 1924, which set specifications for lumber dimensions, grade, and moisture content; it also developed inspection and accreditation programs. These standards have changed over the years to meet the changing needs of manufacturers and distributors, with the goal of keeping lumber competitive with other construction products. Current standards are set by the American Lumber Standard Committee, appointed by the [Secretary of Commerce](http://en.wikipedia.org/wiki/Secretary_of_Commerce).[[8]](http://en.wikipedia.org/wiki/Timber#cite_note-8)

Design values for most species and grades of visually graded structural products are determined in accordance with [ASTM](http://en.wikipedia.org/wiki/ASTM) standards, which consider the effect of strength reducing characteristics, load duration, safety and other influencing factors. The applicable standards are based on results of tests conducted in cooperation with the [USDA](http://en.wikipedia.org/wiki/USDA) Forest Products Laboratory. Design Values for Wood Construction, which is a supplement to the ANSI/AF&PA National Design Specification® for Wood Construction, provides these lumber design values, which are recognized by the model building codes. A summary of the six published design values—including bending (Fb), shear parallel to grain (Fv), compression perpendicular to grain (Fc-perp), compression parallel to grain (Fc), tension parallel to grain (Ft), and modulus of elasticity (E and Emin) can be found in Structural Properties and Performance[[9]](http://en.wikipedia.org/wiki/Timber#cite_note-9) published by WoodWorks.

Canada has grading rules that maintain a standard among mills manufacturing similar woods to assure customers of uniform quality. Grades standardize the quality of lumber at different levels and are based on moisture content, size and manufacture at the time of grading, shipping and unloading by the buyer. The National Lumber Grades Authority (NLGA)[[10]](http://en.wikipedia.org/wiki/Timber#cite_note-10) is responsible for writing, interpreting and maintaining Canadian lumber grading rules and standards. The Canadian Lumber Standards Accreditation Board (CLSAB)[[11]](http://en.wikipedia.org/wiki/Timber#cite_note-11) monitors the quality of Canada's lumber grading and identification system.

Attempts to maintain lumber quality over time have been challenged by historical changes in the timber resources of the United States—from the slow-growing [virgin forests](http://en.wikipedia.org/wiki/Virgin_forest) common over a century ago to the fast-growing [plantations](http://en.wikipedia.org/wiki/Forest#Forest_plantations) now common in today's commercial forests. Resulting declines in lumber quality have been of concern to both the lumber industry and consumers and have caused increased use of alternative construction products[[12]](http://en.wikipedia.org/wiki/Timber#cite_note-12)[[13]](http://en.wikipedia.org/wiki/Timber#cite_note-13)

Machine stress-rated and machine-evaluated lumber is readily available for end-uses where high strength is critical, such as [truss](http://en.wikipedia.org/wiki/Truss) [rafters](http://en.wikipedia.org/wiki/Rafter), laminating stock, [I-beams](http://en.wikipedia.org/wiki/I-joist) and web joints. Machine grading measures a characteristic such as stiffness or density that correlates with the structural properties of interest, such as [bending strength](http://en.wikipedia.org/wiki/Bending_strength). The result is a more precise understanding of the strength of each piece of lumber than is possible with visually graded lumber, which allows designers to use full-design strength and avoid overbuilding.[[14]](http://en.wikipedia.org/wiki/Timber#cite_note-14)

In Europe, strength grading of sawn softwood is done according to EN-14081-1/2/3/4 and sorted into 9 classes; In increasing strength these are: C14, C16, C18, С22, С24, С27, С30, С35 and С40[[15]](http://en.wikipedia.org/wiki/Timber#cite_note-15)

**Hardwoods**

In North America, sizes for dimensional lumber made from hardwoods varies from the sizes for softwoods. Boards are usually supplied in random widths and lengths of a specified thickness, and sold by the [board-foot](http://en.wikipedia.org/wiki/Board-foot) (144 cubic inches or 2,360 cubic centimetres, 1⁄12th of 1 cubic foot or 0.028 cubic metres). This does not apply in all countries; for example, in Australia many boards are sold to timber yards in packs with a common profile (dimensions) but not necessarily consisting of the same length boards.

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| --- |
| Hardwood dimensional lumber sizes |
| **Nominal** | **Surfaced on one side (S1S)** | **Surfaced on two sides (S2S)** |
| 1⁄2 in | 3⁄8 in (9.5 mm) | 5⁄16 in (7.9 mm) |
| 5⁄8 in | 1⁄2 in (13 mm) | 7⁄16 in (11 mm) |
| 3⁄4 in | 5⁄8 in (16 mm) | 9⁄16 in (14 mm) |
| 1 in or 4⁄4 in | 7⁄8 in (22 mm) | 13⁄16 in (21 mm) |
| 1 1⁄4 in or 5⁄4 in | 11⁄8 in (29 mm) | 11⁄16 in (27 mm) |
| 1 1⁄2 in or 6⁄4 in | 13⁄8 in (35 mm) | 15⁄16 in (33 mm) |
| 2 in or 8⁄4 in | 113⁄16 in (46 mm) | 13⁄4 inches (44 mm) |
| 3 in or 12⁄4 in | 213⁄16 in (71 mm) | 23⁄4 in (70 mm) |
| 4 in or 16⁄4 in | 313⁄16 in (97 mm) | 33⁄4 in (95 mm) |

Also in North America, hardwood lumber is commonly sold in a "quarter" system when referring to thickness. 4/4 (four quarters) refers to a 1-inch-thick (25 mm) board, 8/4 (eight quarters) is a 2-inch-thick (51 mm) board, etc. This system is not usually used for softwood lumber, although softwood decking is sometimes sold as 5/4 (actually one inch thick).

Hardwoods cut for furniture are cut in the fall and winter, after the sap has stopped running in the trees. If hardwoods are cut in the spring or summer the sap ruins the natural color of the timber and decreases the value of the timber for furniture.

**Engineered lumber**

[Engineered lumber](http://en.wikipedia.org/wiki/Engineered_lumber) is lumber created by a manufacturer and designed for a certain structural purpose. The main categories of engineered lumber are:[[16]](http://en.wikipedia.org/wiki/Timber#cite_note-16)

1. [Laminated Veneer Lumber (LVL)](http://en.wikipedia.org/wiki/Laminated_veneer_lumber) – LVL comes in 1 3⁄4 inch thicknesses with depths such as 9 1⁄2, 11 7⁄8, 14, 16, 18, or 24 inches, and are often doubled or tripled up. They function as beams to provide support over large spans, such as removed support walls and garage [door](http://en.wikipedia.org/wiki/Door) openings, places where dimensional lumber isn't sufficient, and also in areas where a heavy load is bearing from a floor, wall or roof above on a somewhat short span where dimensional lumber isn't practical. This type of lumber cannot be altered by holes or notches anywhere within the span or at the ends, as it compromises the integrity of the beam, but nails can be driven into it wherever necessary to anchor the beam or to add hangers for [I-joists](http://en.wikipedia.org/wiki/I-joist) or dimensional lumber joists that terminate at an LVL beam.
2. [Wood I-Joists](http://en.wikipedia.org/wiki/I-joist) – Sometimes called "TJI","Trus Joists" or "BCI", all of which are brands of wood I-joists, they are used for floor joists on upper floors and also in first floor conventional foundation construction on piers as opposed to slab floor construction. They are engineered for long spans and are doubled up in places where a wall will be aligned over them, and sometimes tripled where heavy roof-loaded support walls are placed above them. They consist of a top and bottom chord/flange made from dimensional lumber with a webbing in-between made from oriented strand board (OSB). The webbing can be removed up to certain sizes/shapes according to the manufacturer's or engineer's specifications, but for small holes, wood I-joists come with "knockouts", which are perforated, pre-cut areas where holes can be made easily, typically without engineering approval. When large holes are needed, they can typically be made in the webbing only and only in the center third of the span; the top and bottom chords cannot be cut. Sizes and shapes of the hole, and typically the placing of a hole itself, must be approved by an engineer prior to the cutting of the hole and in many areas, a sheet showing the calculations made by the engineer must be provided to the building inspection authorities before the hole will be approved. Some I-joists are made with W-style webbing like a truss to eliminate cutting and allow ductwork to pass through.





Freshly cut logs showing sap running from beneath bark

1. [Finger-Jointed Lumber](http://en.wikipedia.org/wiki/Finger_joint) – Solid dimensional lumber lengths typically are limited to lengths of 22 to 24 feet, but can be made longer by the technique of "finger-jointing" lumber by using small solid pieces, usually 18 to 24 inches long, and joining them together using finger joints and glue to produce lengths that can be up to 36 feet long in 2×6 size. Finger-jointing also is predominant in precut wall studs. It is also an affordable alternative for non-structural hardwood that will be painted (staining would leave the finger-joints visible). Care must be taken during construction to avoid nailing directly into a glued joint as stud breakage can occur.
2. [Glu-lam Beams](http://en.wikipedia.org/wiki/Glued_laminated_timber) – Created from 2×4 or 2×6 stock by gluing the faces together to create beams such as 4×12 or 6×16. As such, a beam acts as one larger piece of lumber - thus eliminating the need to harvest larger, older trees for the same size beam.
3. [Manufactured Trusses](http://en.wikipedia.org/wiki/Truss) – Trusses are used in home construction as a pre-fabricated replacement for roof rafters and ceiling joists (stick-framing). It is seen as an easier installation and a better solution for supporting roofs as opposed to the use of dimensional lumber's struts and purlins as bracing. In the southern USA and other parts, stick-framing with dimensional lumber roof support is still predominant. The main drawback of trusses are reduced attic space, time required for engineering and ordering, and a cost higher than the dimensional lumber needed if the same project were conventionally framed. The advantages are significantly reduced labor costs (installation is faster than conventional framing), consistency, and overall schedule savings.

A **plank** is a piece of [timber](http://en.wikipedia.org/wiki/Timber) that is flat, elongated and rectangular, with parallel faces, higher or longer than wide, used in [carpentry](http://en.wikipedia.org/wiki/Carpentry) and the construction of [ships](http://en.wikipedia.org/wiki/Ship), [houses](http://en.wikipedia.org/wiki/House), [bridges](http://en.wikipedia.org/wiki/Bridge) and other structures.[[1]](http://en.wikipedia.org/wiki/Plank_%28wood%29#cite_note-Gibson2005-1)

Planks are usually made from sawn timber, more than 38 mm thick, and are generally wider than 63 mm. If the width is less than 63 mm and the thickness less than 38 mm is called [board](http://en.wikipedia.org/wiki/Lumber). Common in the USA planks are usually a minimum of a 2x8, more commonly are 2x10 or 2x12 normally stocked in a lumber retailer. Planks are commonly used as a work surface on elevated scaffolding, therefore need to be wide enough to provide strength without breaking when walking on them

Since ancient times planks sawn from logs were used to build [bridges](http://en.wikipedia.org/wiki/Bridge), [walkways](http://en.wikipedia.org/wiki/Walkway), ships or houses, including [flooring](http://en.wikipedia.org/wiki/Flooring) (where they are known as floorboards), coverings and [furniture](http://en.wikipedia.org/wiki/Furniture). Planks also served as a support to form a shelf or table.

The plank has been the basis of [maritime transport](http://en.wikipedia.org/wiki/Maritime_transport). Wood floats on [water](http://en.wikipedia.org/wiki/Water), and wooden planks are easily produced, making them the primary material in early ship building.

**Wood** is a hard, fibrous structural tissue found in the stems and roots of trees and other [woody plants](http://en.wikipedia.org/wiki/Woody_plant). It has been used for thousands of years for both [fuel](http://en.wikipedia.org/wiki/Fuel) and as a construction material. It is an organic material, a natural [composite](http://en.wikipedia.org/wiki/Composite_material) of [cellulose](http://en.wikipedia.org/wiki/Cellulose) fibers (which are strong in tension) embedded in a [matrix](http://en.wiktionary.org/wiki/matrix) of [lignin](http://en.wikipedia.org/wiki/Lignin) which resists compression. Wood is sometimes defined as only the secondary [xylem](http://en.wikipedia.org/wiki/Xylem) in the stems of trees,[[1]](http://en.wikipedia.org/wiki/Wood#cite_note-1) or it is defined more broadly to include the same type of tissue elsewhere such as in tree roots or in other plants such as shrubs.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)] In a living tree it performs a support function, enabling woody plants to grow large or to stand up by themselves. It also mediates the transfer of water and [nutrients](http://en.wikipedia.org/wiki/Nutrients) to the [leaves](http://en.wikipedia.org/wiki/Leaves) and other growing tissues. Wood may also refer to other plant materials with comparable properties, and to material engineered from wood, or wood chips or fiber.

The earth contains about one trillion tonnes of wood, which grows at a rate of 10 billion tonnes per year. As an abundant, [carbon-neutral](http://en.wikipedia.org/wiki/Carbon-neutral) renewable resource, woody materials have been of intense interest as a source of renewable energy. In 1991, approximately 3.5 billion cubic meters of wood were harvested. Dominant uses were for furniture and building construction.[[](http://en.wikipedia.org/wiki/Wood#cite_note-Ullmann-2)

**Physical properties**

**Growth rings**

Wood, in the strict sense, is yielded by trees, which increase in [diameter](http://en.wikipedia.org/wiki/Diameter) by the formation, between the existing wood and the inner [bark](http://en.wikipedia.org/wiki/Bark), of new woody layers which envelop the entire stem, living branches, and roots. This process is known as secondary growth; it is the result of cell division in the [vascular cambium](http://en.wikipedia.org/wiki/Vascular_cambium), a lateral meristem, and subsequent expansion of the new cells. Where there are clear seasons, growth can occur in a discrete annual or seasonal pattern, leading to [growth rings](http://en.wikipedia.org/wiki/Growth_ring); these can usually be most clearly seen on the end of a log, but are also visible on the other surfaces. If these seasons are annual these growth rings are referred to as annual rings. Where there is no seasonal difference growth rings are likely to be indistinct or absent.

If there are differences within a growth ring, then the part of a growth ring nearest the center of the tree, and formed early in the growing season when growth is rapid, is usually composed of wider elements. It is usually lighter in color than that near the outer portion of the ring, and is known as earlywood or springwood. The outer portion formed later in the season is then known as the latewood or summerwood.[[5]](http://en.wikipedia.org/wiki/Wood#cite_note-5) However, there are major differences, depending on the kind of wood (see below).

**Knots**





A knot on a tree at the [Garden of the Gods](http://en.wikipedia.org/wiki/Garden_of_the_Gods) public park in [Colorado Springs](http://en.wikipedia.org/wiki/Colorado_Springs%2C_Colorado), Colorado (October 2006)

A knot is a particular type of imperfection in a piece of wood; it will affect the technical properties of the wood, usually for the worse, but may be exploited for visual effect. In a longitudinally sawn plank, a knot will appear as a roughly circular "solid" (usually darker) piece of wood around which the [grain](http://en.wikipedia.org/wiki/Wood_grain) of the rest of the wood "flows" (parts and rejoins). Within a knot, the direction of the wood (grain direction) is up to 90 degrees different from the grain direction of the regular wood.

In the tree a knot is either the base of a side [branch](http://en.wikipedia.org/wiki/Branch) or a dormant bud. A knot (when the base of a side branch) is conical in shape (hence the roughly circular cross-section) with the inner tip at the point in stem diameter at which the plant's vascular cambium was located when the branch formed as a bud.

During the development of a tree, the lower limbs often die, but may remain attached for a time, sometimes years. Subsequent layers of growth of the attaching stem are no longer intimately joined with the dead limb, but are grown around it. Hence, dead branches produce knots which are not attached, and likely to drop out after the tree has been sawn into boards.

In grading lumber and structural timber, knots are classified according to their form, size, soundness, and the firmness with which they are held in place. This firmness is affected by, among other factors, the length of time for which the branch was dead while the attaching stem continued to grow.





Wood Knot

Knots materially affect cracking and warping, ease in working, and cleavability of timber. They are defects which weaken timber and lower its value for structural purposes where strength is an important consideration. The weakening effect is much more serious when timber is subjected to forces perpendicular to the grain and/or [tension](http://en.wikipedia.org/wiki/Tension_%28physics%29) than where under load along the grain and/or [compression](http://en.wikipedia.org/wiki/Physical_compression). The extent to which knots affect the strength of a [beam](http://en.wikipedia.org/wiki/Beam_%28structure%29) depends upon their position, size, number, and condition. A knot on the upper side is compressed, while one on the lower side is subjected to tension. If there is a season check in the knot, as is often the case, it will offer little resistance to this tensile stress. Small knots, however, may be located along the neutral plane of a beam and increase the strength by preventing longitudinal [shearing](http://en.wikipedia.org/wiki/Shear_stress). Knots in a board or plank are least injurious when they extend through it at right angles to its broadest surface. Knots which occur near the ends of a beam do not weaken it. Sound knots which occur in the central portion one-fourth the height of the beam from either edge are not serious defects.[[6]](http://en.wikipedia.org/wiki/Wood#cite_note-6)

Knots do not necessarily influence the stiffness of structural timber, this will depend on the size and location. Stiffness and elastic strength are more dependent upon the sound wood than upon localized defects. The breaking strength is very susceptible to defects. Sound knots do not weaken wood when subject to compression parallel to the grain.

In some decorative applications, wood with knots may be desirable to add visual interest. In applications where wood is [painted](http://en.wikipedia.org/wiki/Painted), such as skirting boards, fascia boards, door frames and furniture, resins present in the timber may continue to 'bleed' through to the surface of a knot for months or even years after manufacture and show as a yellow or brownish stain. A knot [primer](http://en.wikipedia.org/wiki/Primer_%28paint%29) paint or solution, correctly applied during preparation, may do much to reduce this problem but it is difficult to control completely, especially when using mass-produced kiln-dried timber stocks.

**Heartwood and sapwood**





A section of a [Yew](http://en.wikipedia.org/wiki/Taxus) branch showing 27 annual growth rings, pale sapwood and dark heartwood, and [pith](http://en.wikipedia.org/wiki/Pith) (center dark spot). The dark radial lines are small knots.

Heartwood (or duramen[[7]](http://en.wikipedia.org/wiki/Wood#cite_note-eb-alburnum-7)) is wood that as a result of a naturally occurring chemical transformation has become more resistant to decay. Heartwood formation occurs spontaneously (it is a genetically programmed process). Once heartwood formation is complete, the heartwood is dead.[[8]](http://en.wikipedia.org/wiki/Wood#cite_note-FOOTNOTECapon200565-8) Some uncertainty still exists as to whether heartwood is truly dead, as it can still chemically react to decay organisms, but only once.[[9]](http://en.wikipedia.org/wiki/Wood#cite_note-9)

Usually heartwood looks different; in that case it can be seen on a cross-section, usually following the growth rings in shape. Heartwood may (or may not) be much darker than living wood. It may (or may not) be sharply distinct from the sapwood. However, other processes, such as decay, can discolor wood, even in woody plants that do not form heartwood, with a similar color difference, which may lead to confusion.

Sapwood (or alburnum[[7]](http://en.wikipedia.org/wiki/Wood#cite_note-eb-alburnum-7)) is the younger, outermost wood; in the growing tree it is living wood,[[8]](http://en.wikipedia.org/wiki/Wood#cite_note-FOOTNOTECapon200565-8) and its principal functions are to conduct water from the [roots](http://en.wikipedia.org/wiki/Root) to the [leaves](http://en.wikipedia.org/wiki/Leaf) and to store up and give back according to the season the reserves prepared in the leaves. However, by the time they become competent to conduct water, all xylem tracheids and vessels have lost their cytoplasm and the cells are therefore functionally dead. All wood in a tree is first formed as sapwood. The more leaves a tree bears and the more vigorous its growth, the larger the volume of sapwood required. Hence trees making rapid growth in the open have thicker sapwood for their size than trees of the same species growing in dense forests. Sometimes trees (of species that do form heartwood) grown in the open may become of considerable size, 30 cm or more in diameter, before any heartwood begins to form, for example, in second-growth [hickory](http://en.wikipedia.org/wiki/Hickory), or open-grown [pines](http://en.wikipedia.org/wiki/Pine).

The term *heartwood* derives solely from its position and not from any vital importance to the tree. This is evidenced by the fact that a tree can thrive with its heart completely decayed. Some species begin to form heartwood very early in life, so having only a thin layer of live sapwood, while in others the change comes slowly. Thin sapwood is characteristic of such species as [chestnut](http://en.wikipedia.org/wiki/Chestnut), [black locust](http://en.wikipedia.org/wiki/Black_locust), [mulberry](http://en.wikipedia.org/wiki/Mulberry), [osage-orange](http://en.wikipedia.org/wiki/Osage-orange), and [sassafras](http://en.wikipedia.org/wiki/Sassafras), while in [maple](http://en.wikipedia.org/wiki/Maple), [ash](http://en.wikipedia.org/wiki/Ash_tree), hickory, [hackberry](http://en.wikipedia.org/wiki/Celtis), [beech](http://en.wikipedia.org/wiki/Beech), and pine, thick sapwood is the rule. Others never form heartwood.

No definite relation exists between the annual rings of growth and the amount of sapwood. Within the same species the cross-sectional area of the sapwood is very roughly proportional to the size of the crown of the tree. If the rings are narrow, more of them are required than where they are wide. As the tree gets larger, the sapwood must necessarily become thinner or increase materially in volume. Sapwood is thicker in the upper portion of the trunk of a tree than near the base, because the age and the diameter of the upper sections are less.

When a tree is very young it is covered with limbs almost, if not entirely, to the ground, but as it grows older some or all of them will eventually die and are either broken off or fall off. Subsequent growth of wood may completely conceal the stubs which will however remain as knots. No matter how smooth and clear a log is on the outside, it is more or less knotty near the middle. Consequently the sapwood of an old tree, and particularly of a forest-grown tree, will be freer from knots than the inner heartwood. Since in most uses of wood, knots are defects that weaken the timber and interfere with its ease of working and other properties, it follows that a given piece of sapwood, because of its position in the tree, may well be stronger than a piece of heartwood from the same tree.

It is remarkable that the inner heartwood of old trees remains as sound as it usually does, since in many cases it is hundreds, and in a few instances thousands, of years old. Every broken limb or root, or deep wound from fire, insects, or falling timber, may afford an entrance for decay, which, once started, may penetrate to all parts of the trunk. The larvae of many insects bore into the trees and their tunnels remain indefinitely as sources of weakness. Whatever advantages, however, that sapwood may have in this connection are due solely to its relative age and position.

If a tree grows all its life in the open and the conditions of [soil](http://en.wikipedia.org/wiki/Soil) and site remain unchanged, it will make its most rapid growth in youth, and gradually decline. The annual rings of growth are for many years quite wide, but later they become narrower and narrower. Since each succeeding ring is laid down on the outside of the wood previously formed, it follows that unless a tree materially increases its production of wood from year to year, the rings must necessarily become thinner as the trunk gets wider. As a tree reaches maturity its crown becomes more open and the annual wood production is lessened, thereby reducing still more the width of the growth rings. In the case of forest-grown trees so much depends upon the competition of the trees in their struggle for light and nourishment that periods of rapid and slow growth may alternate. Some trees, such as southern [oaks](http://en.wikipedia.org/wiki/Oak), maintain the same width of ring for hundreds of years. Upon the whole, however, as a tree gets larger in diameter the width of the growth rings decreases.

Different pieces of wood cut from a large tree may differ decidedly, particularly if the tree is big and mature. In some trees, the wood laid on late in the life of a tree is softer, lighter, weaker, and more even-textured than that produced earlier, but in other trees, the reverse applies. This may or may not correspond to heartwood and sapwood. In a large log the sapwood, because of the time in the life of the tree when it was grown, may be inferior in [hardness](http://en.wikipedia.org/wiki/Hardness), [strength](http://en.wikipedia.org/wiki/Strength_of_materials), and toughness to equally sound heartwood from the same log. In a smaller tree, the reverse may be true.

**Color**

In species which show a distinct difference between heartwood and sapwood the natural color of heartwood is usually darker than that of the sapwood, and very frequently the contrast is conspicuous (see section of yew log above). This is produced by deposits in the heartwood of chemical substances, so that a dramatic color difference does not mean a dramatic difference in the mechanical properties of heartwood and sapwood, although there may be a dramatic chemical difference.

Some experiments on very resinous [Longleaf Pine](http://en.wikipedia.org/wiki/Longleaf_Pine) specimens indicate an increase in strength, due to the [resin](http://en.wikipedia.org/wiki/Resin) which increases the strength when dry. Such resin-saturated heartwood is called "fat lighter". Structures built of fat lighter are almost impervious to rot and [termites](http://en.wikipedia.org/wiki/Termite); however they are very flammable. [Stumps](http://en.wikipedia.org/wiki/Tree_stump) of old longleaf pines are often dug, split into small pieces and sold as kindling for fires. Stumps thus dug may actually remain a century or more since being cut. [Spruce](http://en.wikipedia.org/wiki/Spruce) impregnated with crude resin and dried is also greatly increased in strength thereby.





The wood of [Coast Redwood](http://en.wikipedia.org/wiki/Sequoia_sempervirens) is distinctively red in color

Since the latewood of a growth ring is usually darker in color than the earlywood, this fact may be used in judging the density, and therefore the hardness and strength of the material. This is particularly the case with coniferous woods. In ring-porous woods the vessels of the early wood not infrequently appear on a finished surface as darker than the denser latewood, though on cross sections of heartwood the reverse is commonly true. Except in the manner just stated the color of wood is no indication of strength.

Abnormal discoloration of wood often denotes a diseased condition, indicating unsoundness. The black check in western [hemlock](http://en.wikipedia.org/wiki/Tsuga) is the result of insect attacks. The reddish-brown streaks so common in hickory and certain other woods are mostly the result of injury by birds. The discoloration is merely an indication of an injury, and in all probability does not of itself affect the properties of the wood. Certain [rot-producing fungi](http://en.wikipedia.org/wiki/Wood-decay_fungus) impart to wood characteristic colors which thus become symptomatic of weakness; however an attractive effect known as [spalting](http://en.wikipedia.org/wiki/Spalting) produced by this process is often considered a desirable characteristic. Ordinary sap-staining is due to fungal growth, but does not necessarily produce a weakening effect.

**Water content**

Water occurs in living wood in three conditions, namely: (1) in the [cell walls](http://en.wikipedia.org/wiki/Cell_wall), (2) in the [protoplasmic](http://en.wikipedia.org/wiki/Protoplasm) contents of the [cells](http://en.wikipedia.org/wiki/Cell_%28biology%29), and (3) as free water in the cell cavities and spaces. In heartwood it occurs only in the first and last forms. Wood that is thoroughly air-dried retains 8–16% of the water in the cell walls, and none, or practically none, in the other forms. Even oven-dried wood retains a small percentage of moisture, but for all except chemical purposes, may be considered absolutely dry.

The general effect of the water content upon the wood substance is to render it softer and more pliable. A similar effect of common observation is in the softening action of water on paper or [cloth](http://en.wikipedia.org/wiki/Textile). Within certain limits, the greater the water content, the greater its softening effect.

Drying produces a decided increase in the strength of wood, particularly in small specimens. An extreme example is the case of a completely dry [spruce](http://en.wikipedia.org/wiki/Spruce) block 5 cm in section, which will sustain a permanent load four times as great as a green (undried) block of the same size will.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]

The greatest strength increase due to drying is in the ultimate crushing strength, and strength at [elastic limit](http://en.wikipedia.org/wiki/Yield_%28engineering%29) in endwise compression; these are followed by the modulus of rupture, and stress at elastic limit in cross-bending, while the [modulus of elasticity](http://en.wikipedia.org/wiki/Elastic_modulus) is least affected.

**Structure**

Wood is a [heterogeneous](http://en.wikipedia.org/wiki/Heterogeneous), [hygroscopic](http://en.wikipedia.org/wiki/Hygroscopic), [cellular](http://en.wikipedia.org/wiki/Cell_%28biology%29) and [anisotropic](http://en.wikipedia.org/wiki/Anisotropy) material. It is composed of cells, and the cell walls are composed of micro-fibrils of [cellulose](http://en.wikipedia.org/wiki/Cellulose) (40% – 50%) and [hemicellulose](http://en.wikipedia.org/wiki/Hemicellulose) (15% – 25%) impregnated with [lignin](http://en.wikipedia.org/wiki/Lignin) (15% – 30%).[[10]](http://en.wikipedia.org/wiki/Wood#cite_note-10)





Sections of [tree trunk](http://en.wikipedia.org/wiki/Tree_trunk)





A tree trunk as found at the [Veluwe](http://en.wikipedia.org/wiki/Veluwe), Netherlands

In coniferous or softwood species the wood cells are mostly of one kind, [tracheids](http://en.wikipedia.org/wiki/Tracheid), and as a result the material is much more uniform in structure than that of most hardwoods. There are no vessels ("pores") in coniferous wood such as one sees so prominently in oak and ash, for example.

The structure of hardwoods is more complex.[[11]](http://en.wikipedia.org/wiki/Wood#cite_note-11) The water conducting capability is mostly taken care of by vessels: in some cases (oak, chestnut, ash) these are quite large and distinct, in others ([buckeye](http://en.wikipedia.org/wiki/Aesculus), [poplar](http://en.wikipedia.org/wiki/Populus), [willow](http://en.wikipedia.org/wiki/Willow)) too small to be seen without a hand lens. In discussing such woods it is customary to divide them into two large classes, *ring-porous* and *diffuse-porous*.[[12]](http://en.wikipedia.org/wiki/Wood#cite_note-sperry1994-12) In ring-porous species, such as ash, black locust, [catalpa](http://en.wikipedia.org/wiki/Catalpa), chestnut, [elm](http://en.wikipedia.org/wiki/Elm), hickory, mulberry,[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)] and oak,[[12]](http://en.wikipedia.org/wiki/Wood#cite_note-sperry1994-12) the larger vessels or pores (as cross sections of vessels are called) are localised in the part of the growth ring formed in spring, thus forming a region of more or less open and porous tissue. The rest of the ring, produced in summer, is made up of smaller vessels and a much greater proportion of wood fibers. These fiber are the elements which give strength and toughness to wood, while the vessels are a source of weakness.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]





Magnified cross-section of [Black Walnut](http://en.wikipedia.org/wiki/Juglans_nigra), showing the vessels, rays (white lines) and annual rings: this is intermediate between diffuse-porous and ring-porous, with vessel size declining gradually

In diffuse-porous woods the pores are evenly sized so that the water conducting capability is scattered throughout the growth ring instead of being collected in a band or row. Examples of this kind of wood are [alder](http://en.wikipedia.org/wiki/Alnus),[[12]](http://en.wikipedia.org/wiki/Wood#cite_note-sperry1994-12) [basswood](http://en.wikipedia.org/wiki/Tilia),[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)] [birch](http://en.wikipedia.org/wiki/Birch),[[12]](http://en.wikipedia.org/wiki/Wood#cite_note-sperry1994-12) buckeye, maple, willow,[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)] and the [Populus](http://en.wikipedia.org/wiki/Populus) species such as aspen, cottonwood and poplar.[[12]](http://en.wikipedia.org/wiki/Wood#cite_note-sperry1994-12) Some species, such as [walnut](http://en.wikipedia.org/wiki/Walnut) and [cherry](http://en.wikipedia.org/wiki/Cherry), are on the border between the two classes, forming an intermediate group.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]

**Earlywood and latewood in softwood**





Earlywood and latewood in a softwood; radial view, growth rings closely spaced in a [Pseudotsuga taxifolia](http://en.wikipedia.org/wiki/List_of_trees_and_shrubs_by_taxonomic_family)

In temperate softwoods there often is a marked difference between latewood and earlywood. The latewood will be denser than that formed early in the season. When examined under a microscope the cells of dense latewood are seen to be very thick-walled and with very small cell cavities, while those formed first in the season have thin walls and large cell cavities. The strength is in the walls, not the cavities. Hence the greater the proportion of latewood the greater the density and strength. In choosing a piece of pine where strength or stiffness is the important consideration, the principal thing to observe is the comparative amounts of earlywood and latewood. The width of ring is not nearly so important as the proportion and nature of the latewood in the ring.

If a heavy piece of pine is compared with a lightweight piece it will be seen at once that the heavier one contains a larger proportion of latewood than the other, and is therefore showing more clearly demarcated growth rings. In [white pines](http://en.wikipedia.org/wiki/Pinus_classification) there is not much contrast between the different parts of the ring, and as a result the wood is very uniform in texture and is easy to work. In [hard pines](http://en.wikipedia.org/wiki/Pinus_classification), on the other hand, the latewood is very dense and is deep-colored, presenting a very decided contrast to the soft, straw-colored earlywood.

It is not only the proportion of latewood, but also its quality, that counts. In specimens that show a very large proportion of latewood it may be noticeably more porous and weigh considerably less than the latewood in pieces that contain but little. One can judge comparative density, and therefore to some extent strength, by visual inspection.

No satisfactory explanation can as yet be given for the exact mechanisms determining the formation of earlywood and latewood. Several factors may be involved. In conifers, at least, rate of growth alone does not determine the proportion of the two portions of the ring, for in some cases the wood of slow growth is very hard and heavy, while in others the opposite is true. The quality of the site where the tree grows undoubtedly affects the character of the wood formed, though it is not possible to formulate a rule governing it. In general, however, it may be said that where strength or ease of working is essential, woods of moderate to slow growth should be chosen.

**Earlywood and latewood in ring-porous woods**





Earlywood and latewood in a ring-porous wood (ash) in a [Fraxinus excelsior](http://en.wikipedia.org/wiki/Fraxinus_excelsior) ; tangential view, wide growth rings

In ring-porous woods each season's growth is always well defined, because the large pores formed early in the season abut on the denser tissue of the year before.

In the case of the ring-porous hardwoods there seems to exist a pretty definite relation between the rate of growth of timber and its properties. This may be briefly summed up in the general statement that the more rapid the growth or the wider the rings of growth, the heavier, harder, stronger, and stiffer the wood. This, it must be remembered, applies only to ring-porous woods such as oak, ash, hickory, and others of the same group, and is, of course, subject to some exceptions and limitations.

In ring-porous woods of good growth it is usually the latewood in which the thick-walled, strength-giving fibers are most abundant. As the breadth of ring diminishes, this latewood is reduced so that very slow growth produces comparatively light, porous wood composed of thin-walled vessels and wood parenchyma. In good oak these large vessels of the earlywood occupy from 6 to 10 percent of the volume of the log, while in inferior material they may make up 25% or more. The latewood of good oak is dark colored and firm, and consists mostly of thick-walled fibers which form one-half or more of the wood. In inferior oak, this latewood is much reduced both in quantity and quality. Such variation is very largely the result of rate of growth.

Wide-ringed wood is often called "second-growth", because the growth of the young timber in open stands after the old trees have been removed is more rapid than in trees in a closed forest, and in the manufacture of articles where strength is an important consideration such "second-growth" hardwood material is preferred. This is particularly the case in the choice of hickory for handles and [spokes](http://en.wikipedia.org/wiki/Spoke). Here not only strength, but toughness and resilience are important. The results of a series of tests on hickory by the U.S. Forest Service show that:

"The work or shock-resisting ability is greatest in wide-ringed wood that has from 5 to 14 rings per inch (rings 1.8-5 mm thick), is fairly constant from 14 to 38 rings per inch (rings 0.7–1.8 mm thick), and decreases rapidly from 38 to 47 rings per inch (rings 0.5–0.7 mm thick). The strength at maximum load is not so great with the most rapid-growing wood; it is maximum with from 14 to 20 rings per inch (rings 1.3–1.8 mm thick), and again becomes less as the wood becomes more closely ringed. The natural deduction is that wood of first-class mechanical value shows from 5 to 20 rings per inch (rings 1.3–5 mm thick) and that slower growth yields poorer stock. Thus the inspector or buyer of hickory should discriminate against timber that has more than 20 rings per inch (rings less than 1.3 mm thick). Exceptions exist, however, in the case of normal growth upon dry situations, in which the slow-growing material may be strong and tough."[[13]](http://en.wikipedia.org/wiki/Wood#cite_note-USforest-13)

The effect of rate of growth on the qualities of chestnut wood is summarised by the same authority as follows:

"When the rings are wide, the transition from spring wood to summer wood is gradual, while in the narrow rings the spring wood passes into summer wood abruptly. The width of the spring wood changes but little with the width of the annual ring, so that the narrowing or broadening of the annual ring is always at the expense of the summer wood. The narrow vessels of the summer wood make it richer in wood substance than the spring wood composed of wide vessels. Therefore, rapid-growing specimens with wide rings have more wood substance than slow-growing trees with narrow rings. Since the more the wood substance the greater the weight, and the greater the weight the stronger the wood, chestnuts with wide rings must have stronger wood than chestnuts with narrow rings. This agrees with the accepted view that sprouts (which always have wide rings) yield better and stronger wood than seedling chestnuts, which grow more slowly in diameter."[[13]](http://en.wikipedia.org/wiki/Wood#cite_note-USforest-13)

**Earlywood and latewood in diffuse-porous woods**

In the diffuse-porous woods, the demarcation between rings is not always so clear and in some cases is almost (if not entirely) invisible to the unaided eye. Conversely, when there is a clear demarcation there may not be a noticeable difference in structure within the growth ring.

In diffuse-porous woods, as has been stated, the vessels or pores are even-sized, so that the water conducting capability is scattered throughout the ring instead of collected in the earlywood. The effect of rate of growth is, therefore, not the same as in the ring-porous woods, approaching more nearly the conditions in the conifers. In general it may be stated that such woods of medium growth afford stronger material than when very rapidly or very slowly grown. In many uses of wood, total strength is not the main consideration. If ease of working is prized, wood should be chosen with regard to its uniformity of texture and straightness of grain, which will in most cases occur when there is little contrast between the latewood of one season's growth and the earlywood of the next.

**Construction**

Wood has been an important construction material since humans began building shelters, houses and boats. Nearly all boats were made out of wood until the late 19th century, and wood remains in common use today in boat construction. [Elm](http://en.wikipedia.org/wiki/Elm) in particular was used for this purpose as it resisted decay as long as it was kept wet (it also served for water pipe before the advent of more modern plumbing).

Wood to be used for construction work is commonly known as [*lumber*](http://en.wikipedia.org/wiki/Lumber) in North America. Elsewhere, *lumber* usually refers to felled trees, and the word for sawn planks ready for use is *timber*. In Medieval Europe [oak](http://en.wikipedia.org/wiki/Oak) was the wood of choice for all wood construction, including beams, walls, doors, and floors. Today a wider variety of woods is used: solid wood doors are often made from [poplar](http://en.wikipedia.org/wiki/Poplar), small-knotted [pine](http://en.wikipedia.org/wiki/Pine), and [Douglas fir](http://en.wikipedia.org/wiki/Douglas_fir).

New domestic housing in many parts of the world today is commonly made from timber-framed construction. [Engineered wood](http://en.wikipedia.org/wiki/Engineered_wood) products are becoming a bigger part of the construction industry. They may be used in both residential and commercial buildings as structural and aesthetic materials.

In buildings made of other materials, wood will still be found as a supporting material, especially in roof construction, in interior doors and their frames, and as exterior cladding.

Wood is also commonly used as shuttering material to form the mould into which concrete is poured during [reinforced concrete](http://en.wikipedia.org/wiki/Reinforced_concrete) construction.

**Furniture and utensils**

Wood has always been used extensively for furniture, such as chairs and beds. Also for tool handles and cutlery, such as [chopsticks](http://en.wikipedia.org/wiki/Chopsticks), [toothpicks](http://en.wikipedia.org/wiki/Toothpick), and other utensils, like the [wooden spoon](http://en.wikipedia.org/wiki/Wooden_spoon).

**Engineered wood**

Main article: [Engineered wood](http://en.wikipedia.org/wiki/Engineered_wood)





Wood can be cut into straight planks and made into a [wood flooring](http://en.wikipedia.org/wiki/Wood_flooring).

Engineered wood products, glued building products "engineered" for application-specific performance requirements, are often used in construction and industrial applications. Glued engineered wood products are manufactured by bonding together wood strands, veneers, lumber or other forms of wood fiber with glue to form a larger, more efficient composite structural unit.[[19]](http://en.wikipedia.org/wiki/Wood#cite_note-apawood-19)

These products include [glued laminated timber](http://en.wikipedia.org/wiki/Glued_laminated_timber) (glulam), wood structural panels (including [plywood](http://en.wikipedia.org/wiki/Plywood), [oriented strand board](http://en.wikipedia.org/wiki/Oriented_strand_board) and composite panels), [laminated veneer lumber](http://en.wikipedia.org/wiki/Laminated_veneer_lumber) (LVL) and other structural composite lumber (SCL) products, [parallel strand lumber](http://en.wikipedia.org/wiki/Parallel_strand_lumber), and I-joists.[[19]](http://en.wikipedia.org/wiki/Wood#cite_note-apawood-19) Approximately 100 million cubic meters of wood was consumed for this purpose in 1991.[[2]](http://en.wikipedia.org/wiki/Wood#cite_note-Ullmann-2) The trends suggest that particle board and fiber board will overtake plywood.

Wood unsuitable for construction in its native form may be broken down mechanically (into fibers or chips) or chemically (into cellulose) and used as a raw material for other building materials, such as engineered wood, as well as [chipboard](http://en.wikipedia.org/wiki/Particle_board), [hardboard](http://en.wikipedia.org/wiki/Hardboard), and [medium-density fiberboard](http://en.wikipedia.org/wiki/Medium-density_fiberboard) (MDF). Such wood derivatives are widely used: wood fibers are an important component of most paper, and cellulose is used as a component of some [synthetic materials](http://en.wikipedia.org/wiki/Synthetic_material). Wood derivatives can also be used for kinds of flooring, for example [laminate flooring](http://en.wikipedia.org/wiki/Laminate_flooring).

**Next generation wood products**

Further developments include new [lignin](http://en.wikipedia.org/wiki/Lignin) glue applications, recyclable food packaging, rubber tire replacement applications, anti-bacterial medical agents, and high strength fabrics or composites.[[20]](http://en.wikipedia.org/wiki/Wood#cite_note-20) As scientists and engineers further learn and develop new techniques to extract various components from wood, or alternatively to modify wood, for example by adding components to wood, new more advanced products will appear on the marketplace.





Trunks of the [Coconut](http://en.wikipedia.org/wiki/Coconut) palm, a monocot, in Java. From this perspective these look not much different from trunks of a [dicot](http://en.wikipedia.org/wiki/Dicot) or [conifer](http://en.wikipedia.org/wiki/Conifer)

Structural material that roughly (in its gross handling characteristics) resembles ordinary, "dicot" or conifer wood is produced by a number of [monocot](http://en.wikipedia.org/wiki/Monocotyledon) plants, and these also are colloquially called wood. Of these, [bamboo](http://en.wikipedia.org/wiki/Bamboo), botanically a member of the grass family, has considerable economic importance, larger culms being widely used as a building and construction material in their own right and, these days, in the manufacture of engineered flooring, panels and [veneer](http://en.wikipedia.org/wiki/Wood_veneer). Another major plant group that produce material that often is called wood are the [palms](http://en.wikipedia.org/wiki/Arecaceae). Of much less importance are plants such as [*Pandanus*](http://en.wikipedia.org/wiki/Pandanus)*,* [*Dracaena*](http://en.wikipedia.org/wiki/Dracaena_%28plant%29) and [*Cordyline*](http://en.wikipedia.org/wiki/Cordyline)*.* With all this material, the structure and composition of the structural material is quite different from ordinary wood.

**Hard and soft woods**

There is a strong relationship between the properties of wood and the properties of the particular tree that yielded it. The density of wood varies with species. The density of a wood correlates with its strength (mechanical properties). For example, [mahogany](http://en.wikipedia.org/wiki/Mahogany) is a medium-dense hardwood that is excellent for fine furniture crafting, whereas [balsa](http://en.wikipedia.org/wiki/Ochroma_pyramidale) is light, making it useful for [model](http://en.wikipedia.org/wiki/Physical_model) building. One of the densest woods is [black ironwood](http://en.wikipedia.org/wiki/Olea_laurifolia).

It is common to classify wood as either [softwood](http://en.wikipedia.org/wiki/Softwood) or [hardwood](http://en.wikipedia.org/wiki/Hardwood). The wood from [conifers](http://en.wikipedia.org/wiki/Pinophyta) (e.g. pine) is called softwood, and the wood from [dicotyledons](http://en.wikipedia.org/wiki/Dicotyledons) (usually broad-leaved trees, e.g. oak) is called hardwood. These names are a bit misleading, as hardwoods are not necessarily hard, and softwoods are not necessarily soft. The well-known balsa (a hardwood) is actually softer than any commercial softwood. Conversely, some softwoods (e.g. [yew](http://en.wikipedia.org/wiki/Taxus_baccata)) are harder than many hardwoods.

**Chemistry of wood**

Aside from water, wood has three main components. [Cellulose](http://en.wikipedia.org/wiki/Cellulose), a crystalline polymer derived from glucose, constitutes about 41–43%. Next in abundance is hemicellulose, which is around 20% in deciduous trees but near 30% in conifers. It is mainly [five-carbon sugars](http://en.wikipedia.org/wiki/Pentose) that are linked in an irregular manner, in contrast to the cellulose. Lignin is the third component at around 27% in coniferous wood vs 23% in deciduous trees. Lignin confers the hydrophobic properties reflecting the fact that it is based on [aromatic rings](http://en.wikipedia.org/wiki/Aromatic_ring). These three components are interwoven, and direct covalent linkages exist between the lignin and the hemicellulose. A major focus of the paper industry is the separation of the lignin from the cellulose, from which paper is made.

**Strength**

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| [icon] | This section requires [expansion](http://en.wikipedia.org/w/index.php?title=Woodworking_joints&action=edit). *(May 2008)* |

Wood is stronger when stressed along the [grain](http://en.wikipedia.org/wiki/Wood_grain) (longitudinally) than it is when stressed across the grain (radially and tangentially). Wood is a natural composite material; parallel strands of [cellulose](http://en.wikipedia.org/wiki/Cellulose) fibers are held together by a [lignin](http://en.wikipedia.org/wiki/Lignin) binder. These long chains of fibers make the wood exceptionally strong by resisting stress and spreading the load over the length of the board. Furthermore, cellulose is tougher than lignin, a fact demonstrated by the relatively ease with which wood can be split along the grain than across it.

Different species of wood have different strength levels, and the exact strength may vary from sample to sample.

**Dimensional stability**

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| [icon] | This section requires [expansion](http://en.wikipedia.org/w/index.php?title=Woodworking_joints&action=edit). *(May 2008)* |

Timber expands and contracts in response to [humidity](http://en.wikipedia.org/wiki/Moisture_content), usually much less so longitudinally than in the radial and tangential directions. As [tracheophytes](http://en.wikipedia.org/wiki/Vascular_plant), trees have [lignified](http://en.wikipedia.org/wiki/Lignin) [tissues](http://en.wikipedia.org/wiki/Tissue_%28biology%29) which transport resources such as water, minerals and photosynthetic products up and down the plant. While lumber from a harvested tree is no longer alive, these tissues still absorb and expel water causing swelling and shrinkage of the wood in kind with change in humidity.[[3]](http://en.wikipedia.org/wiki/Woodworking_joints#cite_note-3) When the dimensional stability of the wood is paramount, [quarter-sawn lumber](http://en.wikipedia.org/wiki/Quarter_sawing) is preferred because its grain pattern is consistent and thus reacts less to humidity.

**Timber**





*P. abies* wood

The [bark](http://en.wikipedia.org/wiki/Bark) of most pines is thick and scaly, but some species have thin, flaking bark. The branches are produced in regular "pseudo whorls", actually a very tight [spiral](http://en.wikipedia.org/wiki/Spiral) but appearing like a ring of branches arising from the same point.

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**Pulpwood**

Spruce is one of the most important [woods](http://en.wikipedia.org/wiki/Pulpwood) for paper uses, as it has long wood fibres which bind together to make strong paper. The fibres are thin walled and collapse to thin bands upon drying. Spruces are commonly used in mechanical pulping as they are easily [bleached](http://en.wikipedia.org/wiki/Bleaching_of_wood_pulp). Together with northern [pines](http://en.wikipedia.org/wiki/Pine), northern spruces are commonly used to make [NBSK](http://en.wikipedia.org/wiki/NBSK). Spruces are [cultivated](http://en.wikipedia.org/wiki/Plantation) over vast areas as pulpwood.

**Plywood** is a manufactured wood panel made from thin sheets of [wood veneer](http://en.wikipedia.org/wiki/Wood_veneer). It is one of the most widely used wood products. It is flexible, inexpensive, workable, and re-usable, and usually can be manufactured locally. Plywood is used instead of plain wood because of plywood's resistance to cracking, shrinkage, splitting, and twisting/warping, and because of its generally high strength.

Plywood layers (called veneers) are glued together, with adjacent plies having their [wood grain](http://en.wikipedia.org/wiki/Wood_grain) at right angles to each other, to form a [composite material](http://en.wikipedia.org/wiki/Composite_material). This alternation of the grain is called *cross-graining* and has several important benefits: it reduces the tendency of wood to split when nailed at the edges; it reduces expansion and shrinkage, providing improved dimensional stability; and it makes the strength of the panel consistent across both directions. There is usually an odd number of plies, so that the sheet is balanced—this reduces warping. Because plywood is bonded with grains running against one another and with an odd number of composite parts, it is very hard to bend it perpendicular to the grain directio

Plywood was invented about 3400 B.C. by the [Ancient Mesopotamians](http://en.wikipedia.org/wiki/Ancient_Mesopotamians), who attached several thinner layers of wood together to make one thick layer. They originally did this during a shortage of quality wood, gluing very thin layers of quality wood over lesser-quality wood.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]

Modern plywood was invented, in the 19th century, by [Immanuel Nobel](http://en.wikipedia.org/wiki/Immanuel_Nobel), father of [Alfred Nobel](http://en.wikipedia.org/wiki/Alfred_Nobel). Nobel realized that several thinner layers of wood bonded together would be stronger than one single thick layer of wood, and invented the rotary lathe used in plywood manufacturing.

**Structural characteristics**

A typical plywood panel has face veneers of a higher grade than the core veneers. The principal function of the core layers is to increase the separation between the outer layers where the bending stresses are highest, thus increasing the panel's resistance to [bending](http://en.wikipedia.org/wiki/Bending). As a result, thicker panels can span greater distances under the same loads. In bending, the maximum stress occurs in the outermost layers, one in [tension](http://en.wikipedia.org/wiki/Tension_%28physics%29), the other in [compression](http://en.wikipedia.org/wiki/Compression_%28physical%29). Bending stress decreases from the maximum at the face layers to nearly zero at the central layer. [Shear stress](http://en.wikipedia.org/wiki/Shear_stress), by contrast, is higher in the center of the panel, and zero at the outer fibers.

**Softwood plywood**

[Softwood](http://en.wikipedia.org/wiki/Softwood) panel is usually made either of [cedar](http://en.wikipedia.org/wiki/Cedrus), [Douglas fir](http://en.wikipedia.org/wiki/Douglas_fir) or [spruce](http://en.wikipedia.org/wiki/Spruce), [pine](http://en.wikipedia.org/wiki/Pine), and [fir](http://en.wikipedia.org/wiki/Fir) (collectively known as [spruce-pine-fir](http://en.wikipedia.org/wiki/Spruce-pine-fir) or SPF) or [redwood](http://en.wikipedia.org/wiki/Redwood) and is typically used for construction and industrial purposes.[[1]](http://en.wikipedia.org/wiki/Plywood#cite_note-1)

The most common dimension is 1.2m × 2.4m or the slightly larger imperial dimension of 4 feet × 8 feet. Plies vary in thickness from 1.4 mm to 4.3 mm. The amount of plies depends on the thickness and grade of the sheet but at least 3. [Roofing](http://en.wikipedia.org/wiki/Roofing) can use the thinner 5/8" (15 mm) plywood. Subfloors are at least 3/4" (18 mm) thick, the thickness depending on the distance between floor [joists](http://en.wikipedia.org/wiki/Joist). Plywood for flooring applications is often [tongue and groove](http://en.wikipedia.org/wiki/Tongue_and_groove); This prevents one board from moving up or down relative to its neighbor, so providing a solid feeling floor when the joints do not lie over joists. T&G plywood is usually found in the 1/2" to 1" (12–25 mm) range

**Hardwood plywood**

Used for demanding end uses. [Birch](http://en.wikipedia.org/wiki/Birch) plywood is characterized by its excellent strength, stiffness and resistance to creep. It has a high planar shear strength and impact resistance, which make it especially suitable for heavy-duty floor and wall structures. Oriented plywood construction has a high wheel-carrying capacity. Birch plywood has excellent surface hardness, and damage- and wear-resistance.[[2]](http://en.wikipedia.org/wiki/Plywood#cite_note-Handbook-2)

**Tropical plywood**

[Tropical](http://en.wikipedia.org/wiki/Tropical) plywood is made of mixed species of tropical wood. Originally from the Asian region, it is now also manufactured in African and South American countries. Tropical plywood is superior to softwood plywood due to its density, strength, evenness of layers, and high quality. It is usually sold at a premium in many markets if manufactured with high standards. Tropical plywood is widely used in the UK, Japan, United States, Taiwan, Korea, Dubai, and other countries worldwide. It is the preferred choice for construction purposes in many regions due to its low cost. However, many countries’ forests have been over-harvested, including the Philippines, Malaysia and Indonesia, largely due to the demand for plywood production and export.

**Special-purpose plywood**

Certain plywoods do not have alternating plies. These are designed for specific purposes.

**Aircraft plywood**

High-strength plywood also known as aircraft plywood, is made from mahogany and/or birch, and uses adhesives with increased resistance to heat and humidity. It was used for several [World War II](http://en.wikipedia.org/wiki/World_War_II) [fighter aircraft](http://en.wikipedia.org/wiki/Fighter_aircraft). Although the British-built [Mosquito](http://en.wikipedia.org/wiki/De_Havilland_Mosquito) bomber, nicknamed "The Wooden Wonder", was constructed of a plywood [monocoque](http://en.wikipedia.org/wiki/Monocoque), this was formed in moulds from individual veneers of birch, balsa and birch[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)], rather than machined from pre-laminated plywood sheets.

Structural aircraft-grade plywood is more commonly manufactured from African mahogany or American birch veneers that are bonded together in a hot press over hardwood cores of basswood or poplar. Basswood is another type of aviation-grade plywood that is lighter and more flexible than mahogany and birch plywood but has slightly less[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)] structural strength. All[[*where?*](http://en.wikipedia.org/wiki/Wikipedia%3AWikiProject_Countering_systemic_bias)] aviation-grade plywood is manufactured to specifications outlined in MIL-P-607, which calls for shear testing after immersion in boiling water for three hours to verify the adhesive qualities between the plies and meets specifications.

**Decorative plywood (overlaid plywood)**

Usually faced with [hardwood](http://en.wikipedia.org/wiki/Hardwood), including [ash](http://en.wikipedia.org/wiki/Ash_%28tree%29), [oak](http://en.wikipedia.org/wiki/Oak), [red oak](http://en.wikipedia.org/wiki/Erythrobalanus), [birch](http://en.wikipedia.org/wiki/Birch), [maple](http://en.wikipedia.org/wiki/Maple), [mahogany](http://en.wikipedia.org/wiki/Mahogany), [Philippine mahogany](http://en.wikipedia.org/wiki/Shorea) (often called lauan, luan or meranti and having no relation to true mahogany), [rose wood](http://en.wikipedia.org/wiki/Rose_wood), [teak](http://en.wikipedia.org/wiki/Teak) and a large number of other hardwoods. However, [Formica](http://en.wikipedia.org/wiki/Formica_%28plastic%29), metal and resin-impregnated paper or fabric bonded are also added on top of plywood at both side as a kind of ready for use in the decoration field. This plywood is a lot easier to dye and draw on than any other plywoods.

**Flexible plywood**

Flexible plywood is very flexible and is designed for making curved parts. In the UK this is sometimes known as "Hatters Ply" as it was used to make [stovepipe hats](http://en.wikipedia.org/wiki/Top_hat) in Victorian times[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]. It is also often referred to as "Bendy Ply" due to its flexibility. However these may not be termed plywood in some countries because the basic description of plywood is layers of veneered wood laid on top of each other with the grain of each layer perpendicular to the grain of the next. In the U.S., the terms "Bender Board" and "Wiggle Board" are commonly used.

**Marine plywood**

Marine plywood is manufactured from durable face and core veneers, with few defects so it performs longer in humid and wet conditions and resists delaminating and fungal attack. Its construction is such that it can be used in environments where it is exposed to moisture for long periods. More recently, tropical producers have become dominant in the marine plywood market. Okoumé from Gabon is now the accepted standard for marine plywood, even though the wood is not very resistant to rot and decay. Each wood veneer will be from tropical hardwoods, have negligible core gap, limiting the chance of trapping water in the plywood and hence providing a solid and stable glue bond. It uses an exterior Water and Boil Proof (WBP) glue similar to most exterior plywoods.

Marine plywood can be graded as being compliant with [BS 1088](http://en.wikipedia.org/wiki/BS_1088), which is a [British](http://en.wikipedia.org/wiki/United_Kingdom) Standard for marine plywood. There are few international standards for grading marine plywood and most of the standards are voluntary. Some marine plywood has a [Lloyd's of London](http://en.wikipedia.org/wiki/Lloyd%27s_of_London) stamp that certifies it to be BS 1088 compliant. Some plywood is also labeled based on the wood used to manufacture it. Examples of this are [Okoume](http://en.wikipedia.org/wiki/Aucoumea_klaineana) or [Meranti](http://en.wikipedia.org/wiki/Meranti).

Marine plywood is frequently used in the construction of [docks](http://en.wikipedia.org/wiki/Dock_%28maritime%29) and [boats](http://en.wikipedia.org/wiki/Boat). It is much more expensive than standard plywood: the cost for a typical 4-foot by 8-foot 1/2-inch thick board is roughly $75 to $100 U.S. or around $2.5 per square foot, which is about three times as expensive as standard plywood.

**Other plywoods**

Other types of plywoods include fire-retardant, moisture-resistant, sign-grade and pressure-treated. However, the plywood may be treated with various chemicals to improve the plywood's fireproofing. Each of these products is designed to fill a need in industry.

**Production**

Plywood production requires a good log, called a peeler, which is generally straighter and larger in diameter than one required for processing into dimensioned lumber by a [sawmill](http://en.wikipedia.org/wiki/Sawmill). The log is laid horizontally and rotated about its long axis while a long blade is pressed into it, causing a thin layer of wood to peel off (much as a continuous sheet of paper from a roll). An adjustable nosebar, which may be solid or a roller, is pressed against the log during rotation, to create a "gap" for veneer to pass through between the knife and the nosebar. The nosebar partly compresses the wood as it is peeled; it controls vibration of the peeling knife; and assists in keeping the veneer being peeled to an accurate thickness. In this way the log is peeled into sheets of veneer, which are then cut to the desired oversize dimensions, to allow it to shrink (depending on wood species) when dried. The sheets are then patched, graded, glued together and then baked in a press at a temperature of at least 140 °C (284 °F), and at a pressure of up to 1.9 MPa (280 psi) (but more commonly 200 psi) to form the plywood panel. The panel can then be patched, have minor surface defects such as splits or small knot holes filled, re-sized, sanded or otherwise refinished, depending on the market for which it is intended.

Plywood for indoor use generally uses the less expensive [urea-formaldehyde](http://en.wikipedia.org/wiki/Urea-formaldehyde) glue, which has limited water resistance, while outdoor and marine-grade plywood are designed to withstand rot, and use a water resistant [phenol](http://en.wikipedia.org/wiki/Phenol)-[formaldehyde](http://en.wikipedia.org/wiki/Formaldehyde) glue to prevent [delamination](http://en.wikipedia.org/wiki/Delamination) and to retain strength in high [humidity](http://en.wikipedia.org/wiki/Humidity).

The adhesives used in plywood have become a point of concern. Both urea formaldehyde and phenol formaldehyde are carcinogenic in very high concentrations. As a result, many manufacturers are turning to low formaldehyde-emitting glue systems, denoted by an "E" rating ("E0" possessing the lowest formaldehyde emissions). Plywood produced to "E0" has effectively zero formaldehyde emissions.[[3]](http://en.wikipedia.org/wiki/Plywood#cite_note-3)

In addition to the glues being brought to the forefront, the wood resources themselves are becoming the focus of manufacturers, due in part to energy conservation, as well as concern for natural resources. There are several certifications available to manufacturers who participate in these programs. [Forest Stewardship Council](http://en.wikipedia.org/wiki/Forest_Stewardship_Council) (FSC), [Leadership in Energy and Environmental Design](http://en.wikipedia.org/wiki/Leadership_in_Energy_and_Environmental_Design) (LEED), [Sustainable Forestry Initiative](http://en.wikipedia.org/wiki/Sustainable_Forestry_Initiative) (SFI), and Greenguard are all certification programs that ensure that production and construction practices are sustainable. Many of these programs offer tax benefits to both the manufacturer and the end user.[[4]](http://en.wikipedia.org/wiki/Plywood#cite_note-4)

**Sizes**

The most commonly used thickness range is from 0.14 to 3.0 in (0.36 to 7.6 cm). The sizes of the most commonly used plywood sheets are 4 by 8 ft (1.2 by 2.4 m). Width and length may vary in 1 ft (30 cm) increments.

In the United States, the most commonly used size is 4 ft by 8 ft or 5 ft by 5 ft.[[5]](http://en.wikipedia.org/wiki/Plywood#cite_note-5)

Sizes on specialised plywood for concrete forming range from 6 to 21 mm, and a multitude of formats exist, though 15x750x1500mm is very commonly use.

**Grades**

Grading rules differ according to the country of origin. Most popular standard is the British Standard (BS) and American Standard (ASTM). Joyce (1970), however, list some general indication of grading rules:[[6]](http://en.wikipedia.org/wiki/Plywood#cite_note-6)

|  |  |
| --- | --- |
| **Grade** | **Description** |
| A | Face and back veneers practically free from all defects. |
| A/B | Face veneers practically free from all defects. Reverse veneers with only a few small knots or discolorations. |
| A/BB | Face as A but reverse side permitting jointed veneers, large knots, plugs, etc. |
| B | Both side veneers with only a few small knots or discolorations. |
| B/BB | Face veneers with only a few small knots or discolorations. Reverse side permitting jointed veneers, large knots, plugs, etc. |
| BB | Both sides permitting jointed veneers, large knots, plugs, etc. |
| WG | Guaranteed well glued only. All broken knots plugged. |
| X | Knots, knotholes, cracks, and all other defects permitted. |

JPIC Standards

|  |  |
| --- | --- |
| **Grade** | **Description** |
| BB/CC | Face as BB, back as CC. BB as very little knots of less than 1/4 inches, slight discoloration, no decay, split and wormholes mended skillfully, matched colors, no blister, no wrinkle. Most popular choice for most applications. |

**Applications**

Plywood is used in many applications that need high-quality, high-strength sheet material. Quality in this context means resistance to cracking, breaking, shrinkage, twisting and warping.

Exterior glued plywood is suitable for outdoor use, but because moisture affects the strength of wood, optimal performance is achieved in end uses where the wood's moisture content remains relatively low. On the other hand, subzero conditions don't affect plywood's dimensional or strength properties, which makes some special applications possible.

Plywood is also used as an engineering material for stressed-skin applications. It has been used for marine and aviation applications since WWII. Most notable is the British [de Havilland Mosquito](http://en.wikipedia.org/wiki/De_Havilland_Mosquito) bomber, which was primarily made using a moulded sandwich of two layers of birch plywood around a [balsa](http://en.wikipedia.org/wiki/Ochroma_pyramidale) core. Plywood is currently successfully used in [stressed-skin](http://en.wikipedia.org/wiki/Stressed_skin) applications.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]. The American designers [Charles](http://en.wikipedia.org/wiki/Charles_Eames) and [Ray Eames](http://en.wikipedia.org/wiki/Ray_Eames) are famous for their plywood-based furniture, while [Phil Bolger](http://en.wikipedia.org/wiki/Phil_Bolger) is famous for designing a wide range of boats built primarily of plywood.

Plywood is often used to create curved surfaces because it can easily bend with the grain. Skateboard ramps often utilize plywood as the top smooth surface over bent curves to create transition that can simulate the shapes of ocean waves.

In [woodworking](http://en.wikipedia.org/wiki/Woodworking), **veneer** refers to thin slices of wood, usually thinner than 3 mm (1/8 inch), that typically are [glued](http://en.wikipedia.org/wiki/Glue) onto core panels (typically, [wood](http://en.wikipedia.org/wiki/Wood), [particle board](http://en.wikipedia.org/wiki/Particle_board) or [medium-density fiberboard](http://en.wikipedia.org/wiki/Medium-density_fiberboard)) to produce flat panels such as doors, tops and panels for [cabinets](http://en.wikipedia.org/wiki/Cabinet_%28furniture%29), [parquet](http://en.wikipedia.org/wiki/Parquetry) [floors](http://en.wikipedia.org/wiki/Flooring) and parts of [furniture](http://en.wikipedia.org/wiki/Furniture). They are also used in [marquetry](http://en.wikipedia.org/wiki/Marquetry). [Plywood](http://en.wikipedia.org/wiki/Plywood) consists of three or more layers of veneer, each glued with its [grain](http://en.wikipedia.org/wiki/Wood_grain) at right angles to adjacent layers for strength. Veneer [beading](http://en.wikipedia.org/wiki/Bead_%28woodworking%29) is a thin layer of decorative edging placed around objects, such as jewelry boxes. Veneer is also used to replace decorative papers in Wood Veneer HPL. Veneer is also a type of manufactured board.

Veneer is obtained either by "peeling" the trunk of a tree or by slicing large rectangular blocks of wood known as flitches. The appearance of the [grain](http://en.wikipedia.org/wiki/Grain_%28wood%29) and [figure](http://en.wikipedia.org/wiki/Figure_%28wood%29) in wood comes from slicing through the [growth rings](http://en.wikipedia.org/wiki/Growth_rings) of a tree and depends upon the angle at which the wood is sliced. There are three main types of veneer-making equipment used commercially:

* A rotary [lathe](http://en.wikipedia.org/wiki/Lathe_%28tool%29) in which the wood is turned against a very sharp blade and peeled off in one continuous or semi-continuous roll. Rotary-cut veneer is mainly used for plywood, as the appearance is not desirable because the veneer is cut concentric to the growth rings.
* A slicing machine in which the flitch or piece of log is raised and lowered against the blade and slices of the log are made. This yields veneer that looks like sawn pieces of wood, cut across the growth rings; such veneer is referred to as "crown cut".
* A half-round lathe in which the log or piece of log can be turned and moved in such a way as to expose the most interesting parts of the grain.

Each slicing processes gives a very distinctive type of grain, depending upon the tree species. In any of the veneer-slicing methods, when the veneer is sliced, a distortion of the grain occurs. As it hits the wood, the knife blade creates a "loose" side where the cells have been opened up by the blade, and a "tight" side.

Historically veneers were also [sawn](http://en.wikipedia.org/wiki/Saw), but this is more wasteful of wood. Veneering is an ancient art, dating back to the [ancient Egyptians](http://en.wikipedia.org/wiki/Ancient_Egyptians) who used veneers on their [furniture](http://en.wikipedia.org/wiki/Furniture) and [sarcophagi](http://en.wikipedia.org/wiki/Sarcophagus).

**Producing wood veneers**

The finest and rarest logs are sent to companies that produce veneer. The advantage to this practice is twofold. First, it provides the most financial gain to the owner of the log. Secondly, and of more importance to the woodworker, it greatly expands the amount of usable wood. While a log used for solid lumber is cut into thick pieces, usually no thinner than 1 1/8 inches (3 cm), veneers are cut as thin as 1/40 of an inch (0.6mm). Depending on the cutting process used by the veneer manufacturer, very little wood is wasted by the saw blade thickness, known as the saw kerf. Accordingly the yield of a rare grain pattern or wood type is greatly increased, in turn placing less stress on the resource. Some manufacturers even use a very wide knife to "slice off" the thin veneer pieces. In this way, none of the wood is wasted. The slices of veneer are always kept in the order in which they are cut from the log and are often sold this way.

**Types of veneers**

There are a few types of veneers available, each serving a particular purpose.

* **Raw** veneer has no backing on it and can be used with either side facing up. It is important to note that the two sides will appear different when a finish has been applied, due to the cell structure of the wood.
* **Paper backed** veneer is as the name suggests, veneers that are backed with paper. The advantage to this is it is available in large sizes, or sheets, as smaller pieces are joined together prior to adding the backing. This is helpful for users that do not wish to join smaller pieces of raw veneers together. This is also helpful when veneering curves and columns as the veneer is less likely to crack.
* **Phenolic backed** veneer is less common and is used for composite, or manmade wood veneers. Due to concern for the natural resource, this is becoming more popular. It too has the advantage of being available in sheets, and is also less likely to crack when being used on curves.
* **Laid up** veneer is raw veneer that has been joined together to make larger pieces. The process is time-consuming and requires great care, but is not difficult and requires no expensive tools or machinery. Veneers can be ordered through some companies already laid up to any size, shape or design.
* **Reconstituted veneer** is made from fast-growing tropical species. Raw veneer is cut from a log, and dyed if necessary. Once dyed, the sheets are laminated together to form a block. The block is then sliced so that the edges of the laminated veneer become the “grain” of the reconstituted veneer.
* **Wood on Wood** Also called 2-ply is a decorative wood veneer face with a utility grade wood backer applied at an opposing direction to the face veneer. [[1]](http://en.wikipedia.org/wiki/Wood_veneer#cite_note-1)

Birch species are generally small to medium-sized [trees](http://en.wikipedia.org/wiki/Tree) or [shrubs](http://en.wikipedia.org/wiki/Shrub), mostly of [temperate](http://en.wikipedia.org/wiki/Temperate) climates. The simple [leaves](http://en.wikipedia.org/wiki/Leaf) are alternate, singly or doubly serrate, feather-veined, petiolate and stipulate. They often appear in pairs, but these pairs are really borne on spur-like, two-leaved, lateral branchlets.[[2]](http://en.wikipedia.org/wiki/Birch#cite_note-Keeler-2) The fruit is a small [samara](http://en.wikipedia.org/wiki/Samara_%28fruit%29), although the wings may be obscure in some species. They differ from the [alders](http://en.wikipedia.org/wiki/Alder) (*Alnus*, other genus in the family) in that the female [catkins](http://en.wikipedia.org/wiki/Catkin) are not woody and disintegrate at maturity, falling apart to release the seeds, unlike the woody, cone-like female alder catkins.

The bark of all birches is characteristically marked with long, horizontal [lenticels](http://en.wikipedia.org/wiki/Lenticel), and often separates into thin, papery plates, especially upon the [paper birch](http://en.wikipedia.org/wiki/Paper_Birch). It is resistant to decay, due to the resinous oil it contains. Its decided color gives the common names [gray](http://en.wikipedia.org/wiki/Gray_birch), [white](http://en.wikipedia.org/wiki/Paper_birch), [black](http://en.wikipedia.org/wiki/Black_birch), [silver](http://en.wikipedia.org/wiki/Silver_birch) and [yellow](http://en.wikipedia.org/wiki/Yellow_birch) birch to different species.

The buds form early and are full grown by midsummer, all are lateral, no terminal bud is formed; the branch is prolonged by the upper lateral bud. The wood of all the species is close-grained with satiny texture, and capable of taking a fine polish; its fuel value is fair.