When building with wood, consider how each part will bear the load that will be placed upon it. Also consider how the wood joints will transfer the loads from part to part.

GRAIN DIRECTION AND STRENGTH

To take full advantage of a wood's strength, pay attention to the grain direction. Wood is a natural polymer — parallel strands of **cellulose fibers** held together by a **lignin** binder. These long chains of fibers make the wood exceptionally strong — they resist stress and spread the load over the length of the board. Furthermore, cellulose is tougher than lignin. It's easier to split a board with the grain (separating the lignin) than it is to break it across the grain (separating the cellulose fibers).

Remember this when you lay out the parts of a project. Always orient the grain so the fibers support the load. Whenever possible, cut the parts so the grain is continuous, running the length of the board. *This also applies to wood joinery!* When cutting a **tenon**, for example, the wood grain must run the length of the tenon *and* the board so the grain is continuous.

Straight & True

Straight-grained boards are stronger than those with uneven grain, knots, and other defects. Parts such as shelves will support a heavier load if the weight rests on straight grain.

SPECIFIC GRAVITY

When strength is paramount, grain direction may not be your only consideration. Some species of wood are naturally stronger than others. Chairmakers, for example, typically use maple, birch, and hickory for legs, rungs, and spindles. These parts are fairly slender, and weaker woods won't hold up.

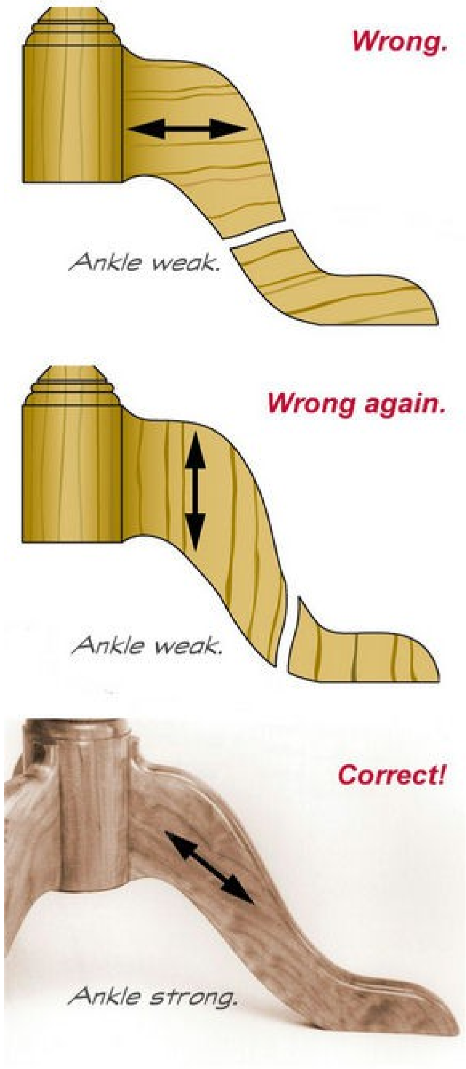
A good indicator of a wood's strength is its density — the weight for a given volume. This is measured by its **specific gravity** — the weight of a volume of wood divided by the weight of the same volume of water. Generally, the higher the ratio, the denser and stronger the wood. This is not always the case, but specific gravity is a useful reference nonetheless.

ADDITIONAL MEASUREMENTS OF STRENGTH

In some woodworking situations, "strength" is an ambiguous term. To say oak is strong doesn't tell you whether an oak shelf will sag when loaded with heavy objects, or whether its surface is hard enough to resist scratches and dents. You may need better information. Engineers have devised ways to measure specific types of strength.

- ***Compressive strength*** tells you how much of a load a wood species can withstand parallel to the grain. How much weight will the legs of a table support before they buckle?
- ***Bending strength*** (also known as the *modulus of rupture)* shows the load the wood can withstand perpendicular to the grain. How much weight can you hang on a peg?
- The ***stiffness*** or *modulus of elasticity* indicates how much the wood will deflect when a load is applied perpendicular to the grain. How far will those shelves sag?
- The ***hardness*** reveals how resistant the surface of the wood is to scratches, dents, and other abuse. How long will that kitchen counter stay looking new and unmarred?

To compare the strengths and specific gravities of common domestic and imported woods, refer to the charts below in "***Relative Wood Strengths***."



The wood grain in the legs of this pedestal table runs parallel to the longest dimension to make the legs as strong as possible. Were the grain to run parallel or perpendicular to the pedestal, the legs would be weak at the ankles.

A "three-point" test to measure bending strength.

Relative Wood Strengths

Wood has several kinds of strength. For a rough, general estimate of strength, refer to the **specific gravity** or density of the wood. When you need more detailed information, there are additional choices.

Engineers measure the **compressive strength** by loading a block of wood parallel to the grain until it breaks, and the **bending strength** by loading a block perpendicular to the grain. Both are measured in pounds per square inch (psi). **Stiffness** is determined by applying a load to a beam until it deflects a certain amount, and it's measured in millions of pounds per square inch (Mpsi). To find **hardness**, engineers drive a metal ball halfway into the wood's surface. The force used is recorded in pounds (lb). In each case, the higher the number, the stronger the wood.

NORTH AMERICAN HARDWOODS

Wood Species	Specific Gravity*	Compressive Strength (psi)	Bending Strength (psi)	Stiffness (Mpsi)	Hardness (lb)
Alder, Red	0.41	5,820	9,800	1.38	590
Ash	0.60	7,410	15,000	1.74	1,320
Aspen	0.38	4,250	8,400	1.18	350

Basswood	0.37	4,730	8,700	1.46	410
Beech	0.64	7,300	14,900	1.72	1,300
Birch, Yellow	0.62	8,170	16,600	2.01	1,260
Butternut	0.38	5,110	8,100	1.18	490
Cherry	0.50	7,110	12,300	1.49	950
Chestnut	0.43	5,320	8,600	1.23	540
Elm	0.50	5,520	11,800	1.34	830
Hickory	0.72	9,210	20,200	2.16	†
Maple, Hard	0.63	7,830	15,800	1.83	1,450
Maple, Soft	0.54	6,540	13,400	1.64	950
Oak, Red	0.63	6,760	14,300	1.82	1,290
Oak, White	0.68	7,440	15,200	1.78	1,360
Poplar	0.42	5,540	10,100	1.58	540
Sassafras	0.46	4,760	9,000	1.12	†
Sweetgum	0.52	6,320	12,500	1.64	850
Sycamore	0.49	5,380	10,000	1.42	770
Walnut	0.55	7,580	14,600	1.68	1,010

NORTH AMERICAN SOFTWOODS

Wood Species	Specific Gravity*	Compressive Strength (psi)	Bending Strength (psi)	Stiffness (Mpsi)	Hardness (lb)
Cedar, Aromatic Red	0.47	6,020	8,800	0.88	900
Cedar, Western	0.32	4,560	7,500	1.11	350

Red					
Cedar, White	0.32	3,960	6,500	0.80	320
Cypress	0.46	6,360	10,600	1.44	510
Fir, Douglas	0.49	7,230	12,400	1.95	710
Hemlock	0.45	7,200	11,300	1.63	540
Pine, Ponderosa	0.40	5,320	9,400	1.29	460
Pine, Sugar	0.36	4,460	8,200	1.19	380
Pine, White	0.35	4,800	8,600	1.24	380
Pine, Yellow	0.59	8,470	14,500	1.98	870
Redwood	0.35	5,220	7,900	1.10	420
Spruce, Sitka	0.40	5,610	10,200	1.57	510

WORLD WOODS (OTHER THAN NORTH AMERICA)

Wood Species	Specific Gravity*	Compressive Strength (psi)	Bending Strength (psi)	Stiffness (Mpsi)	Hardness (lb)
Bubinga	0.71	10,500	22,600	2.48	2,690
Jelutong	0.36	3,920	7,300	1.18	390
Lauan	0.40	7,360	12,700	1.77	780
Mahogany, African	0.42	6,460	10,700	1.40	830
Mahogany, Honduras	0.45	6,780	11,500	1.50	800
Purpleheart	0.67	10,320	19,200	2.27	1,860
Rosewood, Brazilian	0.80	9,600	19,000	1.88	2,720
Rosewood, Indian	0.75	9,220	16,900	1.78	3,170

Teak	0.55	8,410	14,600	1.55	1,000

**After kiln-drying. Specific gravity may be slightly higher in green wood.*
†Rating not available — species has not been tested.