

Material Properties		Calculations		Metals and Alloys (cont)	
Strength	The ability of a material to resist an applied force	Stress	The force per unit area of a material- N/mm^2	Cast Iron	3-3.5% Carbon Cheap, rusts easily, hard, good compressive strength Anvils, vices
Tensile Strength	The maximum pulling force a material can withstand before failure	Stress Equation	$\text{Stress} = \text{force} / \text{cross sectional area}$	Low Carbon Steel	Less than 0.3% Carbon Lower strength, tough, cheap Nails, Car bodies
Yield Strength	The amount of stress at which the material will reach plasticity	Stress Symbol Equation	$\sigma = F/A$	High Carbon Steel	0.8-1.4% Carbon Strong and tough Difficult to form Saw blades, hammers
Ultimate Tensile Strength (UTS)	The amount of stress at which a material breaks	Strain	The ratio of an amount a material is extended to its original length	Stainless Steel	At least 11.5% Chromium Strong, hard, expensive Difficult to machine Good corrosion resistance Cutlery
Compressive Strength	The resistance of a material under a pushing force	Strain Equation	$\epsilon = \Delta l / l$	Non-Ferrous Metals	
Ductility	The amount that a material can be stretched while being deformed	Young's Modulus	The measure of how much force is needed to stretch or compress a substance- N/mm^2	Aluminium and its alloys	Light, soft, ductile, malleable Good conductor of heat and electricity Corrosion-resistant Aircraft bodies, foil, saucepans
Malleability	The ability of a material to be deformed without breaking	Young's Equation	$\text{Young's Modulus} = \text{Stress} / \text{Strain}$	Copper	Tough, malleable Good conductor of heat and electricity Easily Joined Wires, printed circuits
Hardness	The ability of a material to resist wear and abrasion	Young's Symbol Equation	$E = \sigma / \epsilon$	Brass	65% Copper and 35% Zinc Casts well, easily joined Castings, boat fittings
Toughness	The ability of a material to withstand an impact without breaking	Factor of Safety	How much stronger the product is than it needs to be for expected loading	Bronze	90% Copper and 10% Tin Tough and hardwearing Bearings, coins, water and steam valves
Brittleness	The potential for a material to shatter when experiences an impact	FoS Equation	$\text{FoS} = \text{Yield Stress} / \text{Load Stress}$		
Stiffness	The ability of a material to resist bending	FoS Symbol Equation	$\text{FoS} = \sigma_y / \sigma_L$		
Elasticity	The ability of a material to return to its original shape when the load upon its removed	Metals and Alloys			
Plasticity	When you stretch a material and it doesn't return to its original shape once the force is removed	Ferrous Metals	Contains iron Generally tougher and stronger They are magnetic		
		Non-Ferrous Metals	Doesn't contain iron Malleable and ductile They are not magnetic		
		Alloys	Made from two or more base metals to improve properties		

Ferrous Metals

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Page 1 of 2.

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Metals and Alloys (cont)

Lead Very soft, low m.p, heavy common metal
Roof coverings

Zinc Poor strength-weight ratio, low m.p
Coating steel

Polymers

Polymers A plastic

Thermo-plastic Polymer Can be reshaped when heated

Thermo-setting Polymer Cannot be reshaped when heated

Thermoplastic

ABS Strong and rigid Toys
Keyboard

Acrylic Transparent, hard wearing Plastic
Windows
Bath tubs

Nylon Ductile, durable Gear wheels

Polycarbonate High Strength Heat resistant Safety glasses
DVDs

Polystyrene Tough, Good impact strength Packaging, Foam cups

Thermosetting

Epoxy Stiff and brittle Temperature, Chemical and Electrical resistance Circuit boards, Electrical insulator

Polyester Resin Cheap, good strength and stiffness Suitcases

Melamine Resin Resistant to some chemicals and stains Laminate coverings for kitchen worktops

Polymers (cont)

Polyurethane Hard with high strength Flexible and tough Low thermal conductivity Hoses, surface coatings and sealants

Vulcanised Rubber Elastic, High tensile strength, resistant to abrasion Tyres, shoe sales, bouncing balls

Composites, Ceramics & Timber

Composites A type of material made by combining two or more different types of materials

Reinforcement The particles of fibres within a composite matrix that increases its strength

CRP: Carbon fibres in an epoxy resin matrix Extremely high strength, Low density, Expensive Racing bicycles Helmets

GRP: Glass fibres in a polyester resin matrix High strength, Good chemical resistance, Lower cost than CRP Canoes Water tanks

Plywood: Layers of wood bonded at 90° to each other, using adhesive matrix Smooth surface and good strength, May be covered in veneer Furniture Boat building