UNIT 3: MATERIALS

PAPERS AND BOARDS

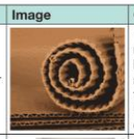
What is paper?

Papers and boards are made from natural fibres (cellulose), usually sourced from wood
Other sources of fibre include bamboo, flax, hemp, kenaf, straw and sugarcane

Paper weight

Paper is characterised by weight
The weight is measured in grams per square metre (GSM)

Name	Appearance	Image	Characteristics	Uses
Bleed proof paper	Coated white cartridge-like paper that can be slightly textured		70gsm sheet, coated to stop solvent-based markers staining through the page. Deeper colours are achieved as ink stays on the surface	Used with marker pens for design ideas and final designs
Cartridge paper	Thick white paper with a slightly rough surface texture		120-150gsm, completely opaque and more expensive than photocopier paper	Pencil and ink drawings, sketching and watercolour
Grid paper	White paper with a printed grid of squares, isometric lines or other patterns		Usually printed onto 80gsm paper with faint lines often in a light blue ink. Lines can be printed darker for use under plain paper as a drawing guide	Used for graphical, scientific and mathematical diagrams, particularly in conjunction with a lightbox as a drawing guide
Layout paper	Off white, medium opacity sheet with a smooth finish. Translucency decreases as gsm increases		40-60gsm, semi-translucent, takes pencil and most media well. Some inks can smear on heavily coated papers	Creating sketches and working ideas; copying and tracing images with a variety of media
Tracing paper	Off white, low opacity sheet. Translucency decreases as gsm increases		40-120gsm, translucent, takes pencil and most colours well	Copying and tracing images. Used with a light box, overlays for design adaptations and working drawings

Name	Appearance	Image	Characteristics	Uses
Corrugated cardboard (fibreboard)	Natural brown board finished on one or both sides with bonded paper		1000-5000 microns, strong, lightweight and rigid perpendicular to corrugations. Insulative and easily printed on	Packaging, boxes and impact protection
Duplex board	Two layers of card bonded together, often with a white external layer		200-500gsm, stiff, lightweight coatings to improve functionality	Cheaper version of white card used for packaging boxes. Often given a waxy coating and used for food and drinks containers
Foil lined board	White card, usually coated or laminated with aluminium foil bonded on one side		200-400gsm, stiff, foil reflects heat and a water and oil resistant coating enables food and liquid based products to be contained	Takeaway containers and lids, used to retain heat for longer

Name	Appearance	Image	Characteristics	Uses
Foam core board	Smooth board surface front and back, foam inner core, limited variety of colours and thicknesses		3-10mm thick, lightweight and rigid in all directions. Can crease and crack under pressure, expanded polystyrene centre	Architectural models, model making, prototyping, mounting and framing of photographs and art work
Ink jet card	Brilliant white card treated for a smooth finish		120-350gsm, medium to thick card treated to hold a high quality photo image. Ink dries on the surface to create deeper colours	High quality photographic images
Solid white board	High quality card, brilliant white smooth finish on both sides		200-500gsm, stiff board, holds colour well, easily cut or creased	Many uses including greeting cards, packaging and advertising, hot foil stamping and embossing

TIMBERS

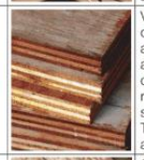
SOFT WOOD

Name	Appearance	Image	Characteristics	Example uses
Larch	Pale to reddish brown with a contrasting grain		Durable, tough, good water resistance, good surface finish and machines well. Issues with loose knots	Exterior cladding, flooring, machined mouldings, furniture and joinery
Pine	Pale yellow to pale brown, attractive grain that darkens with age		Lightweight, easy to work, can split and be resinous near knots	Interior construction (and exterior if treated), cheaper furniture, decking
Spruce	White/cream with a fine even grain		Easy to work, high stiffness to weight ratio. Variable results when staining	Construction, furniture and musical instruments

HARD WOOD

Name	Appearance	Image	Characteristics	Example uses
Ash	Pale brown/cream		Flexible, tough and shock resistant, laminates well	Sports equipment and tool handles
Beech	Dense/close grain with an attractive pink hue		Fine finish, tough and durable	Children's toys and models, furniture and veneers
Mahogany	Rich reddish brown		Easily worked, durable and finishes well	High end furniture and joinery, veneers
Oak	Light brown with an interesting and variable grain		Tough, hard and durable, high quality finish possible	Flooring, furniture, railway sleepers and veneers
Balsa	Pale cream/white. An open grained, large and unusually fast growing hardwood tree		Very soft and spongy, very lightweight but can snap in thin sections	Prototyping and modelling - especially model aircraft

MANUFACTURED BOARD

Name	Appearance	Image	Characteristics	Example uses
Medium density fibreboard (MDF)	Smooth, dull, light brown finish available in many veneered options. Edges can be hard to finish well		Rigid and stable, good value with a smooth, easy to finish surface. Very absorbent so not good in high humidity or damp areas	Flat pack furniture, toys, kitchen units and internal construction
Plywood	Alternating layers of natural grain veneers with the outer material usually of a higher quality for aesthetics		Very stable in all directions due to alternate layering at 90°, with outside layers running in the same direction. Thin flexible versions available (flexiply)	Furniture, shelving, toys and construction. Interior, exterior and marine grades available for greater water resistance
Chipboard	Pale grey/brown with no natural grain. Frequently covered with a laminate such as melamine formaldehyde (Formica®)		Good compressive strength, not water resistant unless treated, good value but prone to chipping on edges and corners	Flooring, low-end furniture, kitchen units and worktops

POLYMERS

THERMOFORMING/THERMOPLASTICS

Name	Appearance	Image	Characteristics	Example uses
Polyethylene terephthalate (1 PETE)	Clear, easily coloured with a smooth finish		Dimensionally stable, easily blow moulded, chemically resistant and fully recyclable	Bottles, food packaging, sheeting and some food wraps
High density Polyethylene (2 HDPE)	Opaque, takes colour well and can be textured		Lightweight, rip and chemical resistant, premium price paid when recycled	Milk bottles, pipes, storage crates, hard hats and wheelie bins
Polyvinyl chloride (3 PVC)	Good range of colours with a high gloss finish. Available in sheets or shaped as rigid PVC		Flexible, high plasticity, chemically resistant, tough and easily extruded	Raincoats, pipes, electrical tape, air mattresses and self-adhesive vinyl
Low density Polyethylene (4 LDPE)	Clear, thin to medium thick film with a smooth finish that takes colour well		Very flexible and tough with a high strength to weight ratio. It is blow-mouldable and easily extruded into rolls of film	Plastic carrier bags, refuse sacks, piping, bottles and some plastic food wraps
Polypropylene (5 PP)	Available in sheets or shaped that are easily coloured		Flexible, tough, lightweight, chemically resistant, easily cleaned and safe with food	Kitchen, medical and stationery products, rope
High Impact Polystyrene HIPS (6 PS)	Flat, clear or coloured sheets for vacuum forming		Flexible, impact resistant, lightweight, can be food safe, sheet used for vacuum forming. Very toxic when burnt	Vacuum-formed products such as food containers or yoghurt pots.
Acrylic (Poly-methyl Meth Acrylate – PMMA) (7 OTHER)	Thick to thin sheets, bars and tubes in huge colour ranges with a smooth finish. Can be spun into thread and woven. Very versatile		Tough but brittle when thin. Easily scratched, formed and bonded. Common in school workshops with laser cutting and line bending	Car lights, display stands, trophies, table tops, modern baths, jumpers, hats and gloves

THERMOSETTING PLASTICS

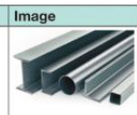
Name	Appearance	Image	Characteristics	Example uses
Epoxy resin (ER) Araldite™	Supplied as two liquids: a resin and a hardener (catalyst), which when mixed, sets clear with a very smooth finish. Can be coloured		Stronger than other resins, better strength to weight ratio, expensive, heat resistant, and a good electrical insulator. High **VOCs** when curing	Bonding different materials together, electronic circuit boards, waterproof coatings, used in fibreglass and carbon fibre lamination
Melamine formaldehyde (MF)	Formed and moulded into a variety of shapes, smooth, available in many colours and can be printed		Food safe and hygienic, lightweight, hard, brittle but not microwave safe	Kitchenware and heat resistant surfaces bonded to worktops and flat packed furniture
Urea formaldehyde (UF)	Very smooth finish, mainly white, limited colours available. Very versatile		Heat resistant, very good electrical insulator, hard, brittle, easily injection moulded	Electrical fittings, casings, buttons and handles. Also used as an adhesive or to treat fabrics to enhance easy-care properties
Polyester resin (PR)	Similar to epoxy resin, it is supplied as two liquids, a resin and a hardener (catalyst). Sets very clear, very smooth and can be coloured		Reasonably strong, heat resistant and a good electrical insulator. High VOCs when curing	Encapsulation of artefacts, waterproof coatings, flooring, used in the lamination of fibreglass
Phenol formaldehyde (PF)	Frequently injection moulded, it has a limited colour palette with high gloss finish achievable		Formerly known as an early plastic called **Bakelite**, very rigid, hard and brittle. An excellent electrical insulator with good chemical resistance	Electrical components, mechanical parts, casting resin, old Bakelite style household artefacts such as clocks, telephones and radios

METALS AND ALLOYS

NON-FERROUS METALS

Name	Appearance	Image	Characteristics	Example uses
Aluminium	Light grey, can be polished to a mirror finish but often has brushed matt finish		Lightweight, high strength to weight ratio, ductile but can be difficult to weld	Pots and pans, sports car body panels, bike frames, drinks cans, foil or take-away trays
Copper	Light reddish brown, polishes well, oxidises to an attractive green-grey shade		Ductile, malleable and a good electrical conductor that is easily joined by soldering	Plumbing supplies, electrical cables, bespoke roofing and guttering
Tin	Silvery white, often plated onto steel with a shiny finish achievable		Soft, malleable and ductile; a good electrical conductor	Can production - used for plating surfaces to preserve contents, soft solder, alloyed with copper to form bronze
Zinc	Silvery grey with bluish-white hue, matt finish		Fair electrical conductivity, malleability and ductility; however, all are improved when alloyed	Mainly used to **galvanise** steel to prevent rusting, easily die cast or used in alloys

FERROUS METALS

Name	Appearance	Image	Characteristics	Example uses
Low carbon steel (Mild steel) Carbon content 0.05 – 0.3%	Bright grey with a smooth texture that quickly oxidises if not protected		Tough and ductile, easily machined, formed, brazed or welded	Construction girders, screws, nails, nuts and bolts. Many car bodies and bike frames
High carbon steel (Tool steel) Carbon content 0.6 – 1.5%	Very similar to mild steel but does not rust as readily, very smooth texture		Less ductile and harder than mild steel due to higher carbon content. Very hard wearing and keeps an edge well	Garden or workshop tools, blades, scissors, wood and metal cutting tools
Cast iron Carbon content 2.4 – 4%	Dull, varying shades of grey depending on type, rough texture unless machined, less prone to rust		Hard but brittle in thin sections. Easily cast into complex shapes, but some types are hard to machine	Kitchen pots and pans, machine bases and bodies, vices, manhole covers, post boxes

ALLOY METALS

Name	Appearance	Image	Characteristics	Example uses
Brass Copper 65% Zinc 35%	Yellowish gold, polishes well and oxidises to a dark antique brown		A heavy alloy of copper and zinc that is malleable, easy to cast and machine, and has naturally low friction	Musical instruments, bushes, plumbing fitments, ornate artefacts and hardware
Stainless steel Low carbon 0.03 – 0.08% Chromium 10.5 – 26%	Silver hue that can be polished to mirror finish. Resists rust well		A ferrous alloy with chromium, nickel and manganese. Hard, very smooth but difficult to weld	Cutlery, kitchen and medical equipment
High speed steel Alloys can include: Chromium Molybdenum Tungsten Vanadium Cobalt Carbon	Varies depending on the combination of metals alloyed with steel		Able to withstand the high temperatures created when machining at high speed, keeps its cutting edge well	Cutting tools such as drill bits, mill cutters, taps and dies

TEXTILES

Name	Appearance	Image	Characteristics	Example uses
Polyester	Can be made into different fabrics including satin, rip-stop, tent and sail material, and brushed Polartec® fleece		Tough, strong, hard wearing, very versatile, holds colour well, non-absorbent so quick drying, machine washes well. Often blended with other fibres. Easily coloured	Clothing, fleece garments bedsheets, carpets, wadding, rope, threads, backpacks, umbrellas and sportswear
Polyamide (Nylon)	A very versatile fibre, woven into many different forms including rip-stop. Easily coloured		Good strength, hard wearing, non-absorbent, machine washes well, easily and frequently blended	Clothing, ropes and webbings, parachutes and sports material. Used as a tough thread on garments
Elastane (LYCRA®)	Smooth to touch with a sheen and easily takes colour		Added to fabric to enhance working properties, particularly to add stretch. Allows freedom of movement, quick drying, holds colour well, machine washable	Sportswear, exercise clothing, swimsuits, hosiery, general clothing, surgical and muscular supports

Name	Appearance	Image	Characteristics	Example uses
Wool	Animal fleece, most commonly from sheep, is spun into yarn. It is easy to dye and available in many colours and textures		From fine and soft to thick and coarse, it is warm and naturally crease resistant. Can shrink. Often blended to add functionality	Jumpers, coats, suits and accessories worn for warmth. Specialist wools are very soft and expensive. Felt products and carpets
Silk	Very fine natural protein fibre from the cocoon of the silkworm. The thread has a natural shine due to its triangular structure and readily takes dye. A watered effect, called moiré, is often seen on silk		Very soft and fine finish, gentle on skin, can feel cool in summer yet warm in winter, drapes well, absorbent, strong when dry (weaker when wet), tricky to wash, can crease easily and is usually expensive	Luxury clothing including nightwear and underwear, soft furnishings, bed sheets, silk paintings and wall hangings

Name	Appearance	Image	Characteristics	Example uses
Cotton	White fluffy 'boll' taken from the cotton plant; contains fibres that are combed and spun into yarn. Takes dye readily		Soft and strong, absorbent, cool to wear and easily washable. Cotton fabrics can be given a brushed finish to increase their thermal properties	Most clothing, especially shirts, underwear and denim can be made from cotton. Also used for towels and bedsheets