2.1 Knowledge and understanding

2.1.1 Core knowledge and understanding

This section is designed to develop learners' knowledge and understanding in design and technology and its impact on daily life. Learners should develop a broad understanding of materials, systems and processes.

Learners need a breadth of technical knowledge and understanding in order to make effective choices in relation to the selection of materials, components and systems. They should consider emerging technologies, environmental issues and impacts on society. They should consider the needs of future generations as well as their own, and take a broad view of the impact of design and technology activities.

The design and manufacture of products depends upon material technology and the development and implementation of materials in products. Learners need to be aware of developments in materials technology and how these impact on the design and use of products.

Content	Amplification

(a) The impact of new and emerging technologies on:
• industry
• enterprise
• sustainability
• people
• culture
• society
• the environment
• production techniques
• systems
	• The impact of new and emerging technologies on industry and enterprise:
	  • market pull;
	  • technology push;
	  • consumer choice.
	• The Product Life Cycle. Introduction – researching, developing and then bringing a product to market; Growth – when sales are increasing; Maturity – sales are near their highest point; Decline – sales begin to fall.
	• Global production and its effects on culture and people.
	• Legislation to which products are subject. BSI (British Standards Institute) and ISO (International Standards Organisation). Their general roles/purpose, ISO numbers, the BSI kite mark and why as consumers these are important when purchasing products.
	• Consumer rights and protection for consumers when purchasing and using products. The basics of consumer rights, return policies, and the Trade Description Act.
	• Moral and ethical factors related to manufacturing products and the sale and use of products. Considering the needs of others in less developed countries and issues related to child labour, fair wage for a fair day's work, companies exploiting underdeveloped countries for profit.
	• Sustainability. Meeting today's needs without compromising the needs of future generations. I. e. sourcing of materials, using sustainable resources, waste materials and CFCs.
	• CAD/CAM the advantages and disadvantages of using computer aided design (CAD) and computer aided manufacture (CAM).

<table>
<tr><th>Content</th><th>Amplification</th></tr>
<tr><td>(b) How the critical evaluation of new and emerging technologies informs design decisions; considering contemporary and potential future scenarios from different perspectives, such as ethics and the environment</td><td>The importance of sustainability issues and environmental issues when designing and making products. e.g. with reference to rapidly updated products such as mobile phones.
Social, cultural, economic and environmental responsibilities in designing and making products.
Life Cycle Analysis to determine the environmental impact of bringing new products to market. i.e. cradle to grave.
Understand design obsolescence. I. e. the advantages and disadvantages to the designer/manufacturer.
The carbon footprint when designing and making.</td></tr>
<tr><td>(c) How energy is generated and stored in order to choose and use appropriate sources to make products</td><td>Types of renewable and non-renewable energy sources including: wind, solar, geothermal, hydroelectric, wood/biomass, wave, coal, gas, nuclear and oil.
Issues surrounding the use of fossil fuels including coal, oil and gas.
The advantages and disadvantages of renewable energy sources.
The use of renewable energy sources in modern manufacturing production systems including the use of solar panels and wind turbines in manufacturing sites.
Renewable energy sources for products including wind-up and photovoltaic cells.
Energy generation and storage in a range of contexts including motor vehicles (e.g. petrol/diesel, electricity) and household products (e.g. battery, solar, mains electricity).</td></tr>
<tr><td>(d) Developments in modern and smart materials</td><td>SMA – shape memory alloys.
Polymorph.
Smart fibres, fabrics and plastics that respond to the environment or stimuli -
photochromic
thermochromic
micro-encapsulation
biometrics.</td></tr>
<tr><td>(e) The ecological and social footprint of materials and components</td><td>Changing society's view on waste and the ecological footprint. The Six Rs of sustainability: rethink, reuse, recycle, repair, reduce and refuse.
Living in a greener world.
Fair-trade policies.</td></tr>
<tr><td>(f) Investigate and analyse the work of past and present professionals and companies in the area of design and technology in order to help inform their own ideas.</td><td>Investigate and analyse the work of past and present designers and companies, including:
<table>
<tr><th></th><th>engineering design</th><th>fashion and textiles</th><th>product design</th></tr>
<tr><td>Company</td><td>Apple</td><td>Laura Ashley</td><td>Airbus</td></tr>
<tr><td>Designers</td><td>James Dyson
Shigeru Miyamoto</td><td>Stella McCartney
Orla Kiely</td><td>James Dyson
Bethan Gray</td></tr>
</table></td></tr>
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Product design	
Content	Amplification
(a) Papers and boards	• The aesthetic and functional properties of common papers, cards and boards including cartridge paper, photocopy paper, bleed proof paper, mounting board, foam board, solid white board, corrugated board and duplex board. • Papers and boards require finishes, these finishes are used to protect and improve aesthetic appeal.
(b) natural and manufactured timber;	• The aesthetic and functional properties of hardwoods and softwoods including beech, oak, balsa, jelutong, scots pine, western red cedar and parana pine. • Natural timber is protected using different finishes and these finishes are sometimes used to improve aesthetic appeal. • Manufactured timbers can be protected using finishes and these finishes are sometimes used to improve the aesthetic appeal.
(c) Ferrous and non-ferrous metals	• The aesthetic and functional properties of ferrous metals including, mild steel, medium carbon steel and high carbon steel. • The aesthetic and functional properties of non-ferrous metals including aluminium, copper and brass. • Ferrous metals may require a protective finish and the finish is sometimes used to improve the aesthetic appeal. • Non-ferrous metals may require a protective finish and the finish is sometimes used to improve the aesthetic appeal.
(d) Thermoforming and thermosetting polymers	• The aesthetic and functional properties of thermoforming and thermosetting polymers including acrylic, polythene, polypropylene, polycarbonate, styrofoam, expanded polystyrene, acrylonitrile butadiene styrene (ABS), polyvinyl chloride (PVC), nylon, urea formaldehyde, melamine, carbon fibre, Kevlar, Styrofoam, modelling foam board and epoxy resins. • Thermoforming plastics have a natural finish. • Thermoforming and thermosetting may require a protective finish and the finish is sometimes used to improve the aesthetic appeal
(e) Modern and smart materials	• Quantum Tunnelling Composite (QTC) - when used in circuits the resistance changes under compression. • Polymorph • Thermochromic polymers or dyes • Photochromic polymers • Nitinol

Content	Amplification
(f) The sources, origins, physical and working properties of materials, components and systems	Metals • Classification as ferrous metals, non-ferrous metals and alloys. • Metals are sourced from ores and are a natural resource. • Alloys of metals are a base metal mixed with other metals or non-metals to change their properties or appearance. • Heat treatment of metals including: annealing, normalising, hardening, tempering and case hardening. Ferrous Metals • Physical properties of metals including: melting point, thermal and electrical conductivity. • Mechanical properties of metals including: tensile strength, toughness, ductility, plasticity, elasticity, malleability and hardness. Non-Ferrous Metals • Physical properties of metals including: melting point, thermal and electrical conductivity. • Mechanical properties of metals including: tensile strength, toughness, plasticity, malleability and hardness. Natural and Manufactured timber • The difference between a hardwood and softwood. • Hardwoods and softwoods are natural resources and are sourced from trees. • The difference between natural wood and man-made boards. • The physical and working properties of hardwoods, softwoods and man-made boards: toughness, flexibility, grain structure, strength, absorbency, surface finish and colour. • Manufactured timbers are made from natural timbers and made from particles/fibres or laminates. • Strengths/weaknesses of the following manufactured boards: plywood, medium density fibreboard (MDF), chipboard and hardboard. • Natural timber is available in the following forms: plank, board, strip, square, and dowel. Thermoforming and Thermosetting Polymers • The differences between a thermoforming (thermoplastic) and thermosetting material. • Oil is the main source for modern polymers, though increasingly some plastics are made from natural sources. • Physical properties of thermoforming (thermoplastic) and thermosetting plastics including: thermal conductivity and electrical conductivity/insulation. • Mechanical properties of thermoforming (thermoplastic) and thermosetting plastics including: tensile strength, elasticity, toughness, plasticity, malleability and hardness.

Content	Amplification
	Papers and boards • The basic sources of paper and boards. • Recycled boards. • The use of microns to measure thickness of paper and boards. • That paper and board is often measured in gsm (grams per square metre). • The physical and working properties of paper and board including: texture, weight, thickness, strength, surface finish, transparency, folding ability and absorbency. • Papers, cards and boards can be laminated to improve strength, finish and appearance.

(g) The way in which the selection of materials or components is influenced by a range of factors such as functional, aesthetic, environmental, availability, cost, social, cultural and ethical	• Aesthetic and functional properties of the following: aluminium, copper, brass, pewter, mild steel, natural and manufactured timbers, common paper, card and cardboards
	• Responsibilities of designers and manufacturers with respect to:
	  • the environment;
	  • working conditions in third world countries, low labour costs and poverty;
	  • exploitation of employees;
	  • recyclability and waste;
	  • biodiversity and deforestation;
	  • new polymers that are being developed often for specific purposes including: biodegradability and compostability;
	  • estimating the true costs of a prototype or product;
	  • aesthetic and functional properties of cards and boards.

(h) Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required	• Natural timber is available in different sectional forms, various standard sizes and can have a different finish (sawn or planed). • Manufactured boards are commonly available in sheet form and in standard sizes and various thicknesses. • Plastic polymers are available in a wide range of forms including: powders, granules, pellets, liquids, films, sheets and extruded shapes. • Standard sizes of papers and boards. I.e. rolls, A5, A4, A3. and measured in grams per square metre. • Cardboard is available in different forms with different cores. • Calculate the costs involved in the design of products including, fixtures, fittings, finishes required and the material cost.

Content	Amplification
(I) Alternative processes that can be used to manufacture products to different scales of production	• Manufacturing systems, including one off, batch and high volume production. • Manufacturing systems, the advantages and disadvantages of producing single, one off products. • The advantages and disadvantages of producing products in limited quantity (batch production). • Jigs and devices to control repeat activities. • The advantages and disadvantages of high volume, continuous production. • The importance of CAM in modern high volume production. • A range of products suitable for high volume, continuous production. • The principles of producing plastic products and components using the following processes: Injection moulding, vacuum forming, press moulding and compression moulding. • On-press and the finishing processes used by commercial printers to produce products in batches or mass/high volume. • Techniques used to produce books, magazines, leaflets, flyers, packages and other printed products.
(J) Specialist techniques and processes that can be used to shape, fabricate, construct and assemble a high quality prototype	**Wastage/Addition** • Cutting materials to the required shape or contour. • Tools and equipment to mark out, hold, cut, shape, drill and form materials. • The pillar drill to drill holes to various diameters. • Jigs and formers to ensure accuracy as part of the process of drilling. • Pilot, clearance, tapping, countersunk and counter bored holes. • Marking out materials using a range of workshop tools. **Deforming/Reforming** • Metal joining can be permanent or temporary, by welding, soldering and the use of nuts, bolts, washers, screws, rivets, hinges, catches. • Lathe to turn materials. • Milling machine to create a slot or face edge. • The main stages in the following joining processes: • Permanent: riveting, brazing and use of epoxy resins. • CAM machines including lasers. • Wood joining can be permanent or temporary. • The principles of producing wood products using the following processes: jointing, veneering, laminating and steam bending. • Frame: mitre, dowel, mortise and tenon, halving and bridle joint. • Box/carcass: butt, lap, housing, dovetail and comb joint.

Content	Amplification
	• Adhesives: Polyvinyl acetate (PVA) (wood to wood), contact adhesive and epoxy resin (wood to other materials). • Temporary: screw (countersunk and round head) and knock down fittings. • Plastics joining can be permanent or temporary, by plastic welding and the use of nuts, bolts, washers, screws, rivets, hinges, catches. • Injection moulding, vacuum forming, press moulding, bending plastics, 3D printing. • Score and fold paper and card. • Embossing, debossing, cropping, folding and binding methods.
(k) Appropriate surface treatments and finishes that can be applied for functional and aesthetic purposes	• Metal surface treatments and finishing processes: plastic coating, enamelling, oil finishing and black steel, paint and primer. • Surface treatments of natural timber and manufactured: sealants and primers. Finishes for aesthetic or functional reasons: varnish, wood stains, oils, polishes and preservative paints. • Self-finishing nature of many thermosetting and thermoforming plastics. Textured finishes of plastics.