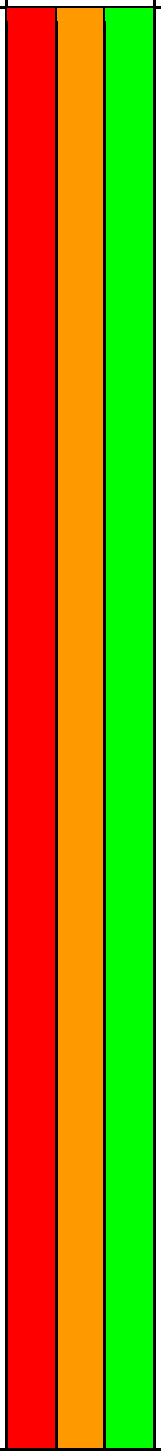
Personal Learning and Revision Checklist

Use this checklist to make sure that all topics are covered in your revision and to ensure you know what your focus areas are.

Subject: Design Technology TIER: N/A

Topic	RAG Rate	Further support required?
Core Technical Principles **New and emerging technologies** **Impact on industry** Technology continues to be developed for manufacturing processes in order to improve quality and speed of making while maintaining customer satisfaction. **Automation** Automation has been developing in factories since the Industrial Revolution, machinery being used to complete tasks previously done by humans. Quicker, more efficient. **Impact on enterprise** New ideas are continually emerging, but it is difficult to ensure these ideas are developed successfully. **Crowdfunding** Uses websites to advertise products as investment opportunities, where people can choose to back a project with a financial donation if they think it will be viable. **Virtual marketing and retail** Promotion of products online and sharing experiences, reviews and recommendations has rapidly become part of the retail experience. Blogs, vlogs and social media all provide advertising platforms. **Cooperatives** Cooperatives are organisations with lots of people working together towards common goals. The cooperative is run and owned by members who share decision-making, profits and risk. **Fair trade** Fair trade is a trading partnership that ensures workers in developing countries are given suitable working conditions and are paid a fair wage.		

Impact on sustainability

Greater consideration is now given to ensuring that the materials and energy we use are sustainable. This includes where the resources come from and how they are disposed of at the end of their life.

Finite resources

Finite resources are non-renewable and will eventually run out. Metals, plastics and fossil fuels (coal, natural gas and oil) are all examples of finite resources.

Impact on the environment
Modern companies are encouraged to be less wasteful and more considerate of how they affect the natural environment.

Continuous improvement

The practice of continually making small adjustments to production techniques to improve speed and quality and save resources. This process is known in industry by the Japanese name ‘Kaizen’.

Efficient working

It is important to ensure that companies work in an efficient manner. This includes increasing the speed of production, reducing errors and reducing waste, which can be done by utilising automation or computer aided manufacture (CAM).

Pollution
Pollution is caused when harmful substances are released into the natural environment. Pollution can occur in the air, water or natural land. Legislation has been brought in to help with this issue.

Climate change

Manufacturing processes in factories or the use of day-to-day products like cars can cause harmful chemicals, such as carbon monoxide and nitrogen oxides, to be released. These chemicals pollute the air and natural land. Worldwide environmental awareness has led to limitations on the levels of pollution and emissions of greenhouse gases, as well as targets on renewable energy generation, to try to stop climate change.

Product life cycle

- Introduction
- Growth
- Maturity
- Decline

There is a link between the development of technology and people. On the one hand, people influence how technology is developed in order to suit their own wants and needs. On the other hand, technological developments change people's lifestyle and behaviours.

Technology push

Research and development in science and industry can lead to new discoveries, which can be used to improve existing products or develop new ones.

Market pull

Market pull is when product ideas are produced in response to market forces or customer needs.

Change in job roles
The rapid changes in technology and automation in recent years have meant a decline in the need for traditional skills.

Impact on culture
In a consumer-driven society, the desire to own the latest product, such as a smartphone or fashionable trainers, has become part of our culture.

Changes in fashion trends
Fashion trends continue to be influenced by changing technology. Wearable items embrace new technology, such as high-tech watches, while textile technology utilises electrically-conductive material or 3D printing technology.

Respecting faiths and beliefs
Many countries now have a diverse range of cultures, so it has become important for designers to consider a range of cultural beliefs when designing for the mass market.

Impact on society
Not all products are designed for the mass market - there are some groups of people who have specific needs that must be met. This can be achieved either through inclusive design or through specific products.

Physical disabilities

Products aimed at users with physical disabilities will ensure they can use the product with ease. User needs are met by understanding the nature of the physical disability, eg visual impairments, mobility restrictions or motor control. The range of everyday products that help to increase independence continues to grow.

Elderly

When designing products aimed at elderly users, it is important to understand the difficulties this user group may experience, such as mobility issues, visual impairment and hearing loss. An example of a product aimed at this group is a long shoehorn, which will allow an elderly person to put a shoe on without having to bend down.

Religious groups

Religious groups have a variety of preferences that can be addressed through design. The use of certain symbols, dietary restrictions and clothing requirements all need to be considered so that beliefs are upheld.

Automation

The automation of workplaces has led to an increase in skilled workers but a decrease in job opportunities, as machines have taken over the jobs previously done by humans.

Computer aided design (CAD) now has the capability to design new products in 3D, visualise them in a variety of materials and send images around the world for collaboration and consultation.

CAM equipment

- CNC routing
- CNC embroidery
- vinyl cutting
- laser cutting
- 3D printing

Flexible manufacturing systems (FMS)
A series of different machines producing different parts for a product. The system is flexible because, at any time, machines in the process can be reprogrammed to change their task and production.

Just in time (JIT) - Manufacturing triggered by a customer order. The correct amounts of materials are ordered in to cover the order, and these arrive just as they are needed by production.

Lean manufacturing - Japanese concept, based on minimising costs and maximising efficiency by cutting down on waste and the amount of materials and energy used in production.

Informing design decisions

It is important for designers to consider a wide range of perspectives when designing a product and to consider the many scenarios that affect the product's life.

Planned obsolescence - Practice of designing products that will have a limited life cycle and that will become obsolete and require to be replaced.

Design for maintenance - Designing products that are more durable and have spare parts available to mend and maintain them.

Design for disassembly - A concept that when a product has reached the end of its life it can be taken apart and parts reused or recycled.

Environmental design - something designers are increasingly considering by:

- making products from renewable materials.
- transporting materials in a more efficient way.
- cutting down the use of finite resources.
- using products made from biodegradable materials.

Designers who are conscious of the product life cycle will consider all aspects of their design, from the very start and manufacturing stage, to consumer use and where it will go at the end of its life.

Energy generation and storage

Energy generation and storage have a huge global impact on our lives - from decisions about the use of fossil fuels and their effect on our environment, to the development of cleaner, more modern ways to create and store energy.

Fossil fuels - finite resource, meaning that they cannot be replaced once extracted from the ground. Examples include:

- coal
- natural gas
- oil

Coal - energy is created through the burning of coa. Hot coal heats water, turning it into steam. The steam builds up to a very high pressure - spins a turbine. The turbine is connected to an electrical generator.

Natural gas - commonly produced off-shore and transported through pipelines to a gas-powered electricity power station. Shale gas is obtained using a process known as fracking.

Oil - Very little of the UK's electricity comes from oil as it is mainly used for fuel or is turned into plastics.

Nuclear power - A huge amount of energy can be produced through the nuclear process using a relatively small amount of uranium. The energy is produced as heat through the fission process.

Renewable energy

In 2018 around a third of the UK's electricity was generated by renewable energy sources. They are a non-finite resource as they harness the Earth's natural resources. Examples include:

- wind
- solar
- tidal
- hydroelectric
- biomass

Wind - harnessed through the use of wind turbines.The blades turn with the wind, driving a generator, which produces the electricity.

Tidal - relies on the gravitational pull of the Moon, which causes the change in water levels known as tides. A tidal barrage is built across the mouth of a river where it meets the ocean.

Hydroelectricity - uses a dam to block a valley or a major river, often creating a reservoir behind the dam.
Once the water has built up behind the dam, it is directed and released by valves through turbines.

Biomass - Animal waste or plants such as rapeseed or willow are specifically grown as biomass crops so that they can be burned in a furnace.

Energy use in context

Batteries - two main types of batteries that are commonly used are ‘single-use’ and ‘rechargeable’. All batteries are available in a range of sizes and shapes. Once a battery runs out it has to be replaced unless it is rechargeable.

Batteries contain harmful chemicals and metals that are bad for the environment if disposed of incorrectly; these elements can contaminate the ground or poison the wildlife that may eat them.

Wind-up energy - A wind-up mechanism allows the user to generate energy by using muscle power to turn a hand crank.

Modern manufacturing

Many global companies are increasing the use of renewable energy sources within their offices, retail spaces and manufacturing sites.

Electric vehicles - powered by an electric motor, rather than a traditional combustion engine. Electric vehicles create fewer exhaust emissions.

Developments in new materials

What is a modern material?

Many modern materials are developed for specialist applications; however, some have become available for general use.

Concrete, aluminium and steel are all commonly used modern materials.

Graphene is a single carbon layer material which is hypothetically 100 times stronger than steel.

Liquid crystal displays (LCDs) use the light-modulating properties of liquid crystals to display an image. LCDs require a backlight to work and many modern devices now use organic light-emitting diodes (OLEDs) instead, which allows devices to be thinner and lighter.

Nanomaterials are tiny particles of 1 to 100 nanometres (nm) that can be used in thin films or coatings. smartphone screens that repel greasy fingerprints, or hydrophobic materials that repel water

Breathable fabrics are designed to allow body moisture to evaporate away from the body, through the use of a breathable membrane

laminated between layers of fabric, whilst still remaining waterproof. Gore-Tex, Permatex and SympaTex.

Smart materials

While smart materials are modern materials, modern materials are not necessarily smart.

Shape-memory alloys (SMA) Nickel titanium (nitinol) is a type of SMA, and it contracts when heated, whereas most metals expand.

Thermochromic pigments change colour when their temperature changes. The term 'thermo' relates to heat, and chroma means colour

Photochromic pigments work in a similar way but 'photo' refers to light - so these pigments change their properties when exposed to ultraviolet (UV) light. A well-known example would be photochromic lenses in glasses,

Quantum-tunnelling composite (QTC) is an insulating rubber containing tiny particles of metal. When squashed, the metal particles meet and allow the flow of electrical current. As a result, QTC is an insulator when resting and a conductor when pressure is applied.

Self-healing materials have the ability to repair themselves, which can extend the lifespan of the products that use them. These include polymers that can heal knife cuts in themselves, metals that resist corrosion and concrete that can heal when cracked. Polymorph is a polymer that becomes malleable when heated to about 62°C.

Composite materials
Composite materials are made up of different materials which are combined to improve their properties. They can be a combination of natural and synthetic materials but fall into three main categories:

- fibre-based composites
- particle-based composites
- sheet-based composites

Fibre-based composites

Fibre-based composites are reinforced with fibres. By mixing resin or concrete with fibres of glass or carbon we get the ability to mould complex shapes, but reinforcing them with the fibres makes them very strong.

Particle-based composites

Particle-based composites are made with small particles of material. By mixing smaller particles of sand with larger particles of cement and aggregate, such as stones, we get a very strong and dense material suitable for building large structures.

Sheet-based composites

Sheet-based composites are often available in large sheets. By mixing wood fibres or thin slices of wood veneers with resin it is possible to form large and stable sheets for furniture panels and interior construction.
Like all modern materials, composites are engineered to improve their properties.
Geotextiles are materials used in contact with or within soil to improve construction and long-term performance. Geotextiles can make poor soil more manageable so that it is possible to build in places which would otherwise prove difficult.

Technical textiles

A major advance in textiles technology was the invention of polyamide, more commonly known as nylon.

Conductive fabrics allow a small electrical current to safely pass through them. This technology is used to dissipate static charge or for touch-screen gloves,

Fire-retardant fabrics are textiles that are more resistant to fire than others, through chemical treatment or manufactured fireproof fibres. Nomex is a flame-resistant material. As it withstands the intense heat of flames, it is worn by firefighters and Formula 1 racing car drivers for protection.

Kevlar is a tightly woven fabric that has great impact resistance. It is used in racing tyres, racing sails, gardening gloves and bulletproof vests.

Microfibres are much thinner than human hairs and can be coiled to provide a very warm, soft or absorbent material that can be used in winter clothes or products such as cleaning cloths.

Microencapsulation involves encapsulating liquid or solid substances in tiny thin-walled bubbles.

- fragrances added to socks to disguise smelly feet
- anti-allergen chemicals added to bedding to prevent irritation

Rhovyl is an antibacterial material that has antibacterial agents integrated into the fibre itself. This prevents the formation of bacteria and does not wash out. It is used in bedding, children's clothes, sportswear and underwear, and has many properties:

- thermal insulation and natural fire retardancy
- wicks away moisture
- resistant to mildew, fungi and chemicals

Electronic systems

The systems approach

- input - starts the process
- process - the thought process in the middle
- output - the response or outcome

Communicating systems

There are several ways to communicate systems effectively.

Block diagrams - are clear, simple diagrams showing all of the input, process and output elements

Flowcharts - are clear diagrams showing the individual steps that will take place in the process.

Inputs - Input devices allow systems to understand changes in the environment around them. Examples include a sensor such as a light-dependent resistor (LDR)

Switches - allow current to flow through them when the contacts inside are joined together.

Sensors - can be used to detect changes in light level, temperature and pressure.

Types of sensors

A light-dependent resistor (LDR)
A thermistor works in a similar way except it responds to changing temperature levels. Pressure sensors produce a signal that varies depending on the amount of pressure placed on them.

Process devices take the signal from the input stage of a system and act on it by changing it in some way - for example, introducing a time delay, counting the number of times something happens or making decisions. Programmable components, such as microcontrollers, are often used for this purpose.

Semi-conductors contain a material, such as silicon, that controls whether it is going to conduct the electrical current or prevent it - depending on how it is connected to power. A diode is a semi-conductor

Microprocessors are the main processor inside a computer and are designed to be programmed to perform different functions. They contain small transistors, resistors, diodes and capacitors to make up the circuit inside, meaning all the controls are in one place.

Microcontrollers as process devices
Microcontrollers provide functionality and give intelligence to products and systems.

A microcontroller is an example of a single board computer (SBC) and is manufactured as an integrated circuit (IC). It can be programmed to perform different processing functions.

Advantages and disadvantages of using microcontrollers

Advantages

- The size of a circuit can be significantly reduced. This is because programming replaces physical components.
- They can be reprogrammed many times. This allows changes to be made without replacing actual components.
- They have pins for connecting several input and output devices, adding to flexibility.

Disadvantages

- They often cost more than traditional integrated circuits. They are therefore not always the best option for simple systems.
- Programming software and hardware is required. This can be expensive to buy.
- The language of the system must be learned and this adds to training costs.

Programming microcontrollers

Microcontrollers can be programmed using a range of different methods. These include:

- text-based programming languages, such as BASIC, C++ and Python
- block-based programming editors
- flowchart software

Each have their own advantages and disadvantages:

Example of a flowchart program

PICAXE Editor, **GENIE** and **Yenka** can be used for writing flowchart programs.

Downloading a program

Once written and tested, the program must be downloaded onto the microcontroller. A serial or USB cable is commonly used to download the program.

Outputs

Output devices allow a system to present information back into the 'real' world. Examples can be seen everywhere, from car indicators to doorbell buzzers or information displays.

Light outputs, Sound outputs (Buzzers, Speakers etc.)

Feedback

Open loop systems - Open loop systems are the simplest type of system. The input sends an electronic signal to the process, and the process signals the output to respond.

Closed loop systems - have an added dimension of feedback, where a signal from the output is sent back to the input. The feedback information controls the input and provides an automated system.

Mechanical devices

Closed loop systems

Changing speed

Motion - There are four types of motion:

Rotary motion moves in a complete circle, eg a wheel turning.

Linear motion moves in a straight line, eg a train moving down a track

Oscillating motion moves backwards and forwards in part of a circle, eg a pendulum of a mechanical clock.

Reciprocating motion moves backwards and forwards in a straight line, eg a piston or pump.

Pulleys use mechanical advantage, similar to levers, to lift up loads. Pulleys are wheel shaped with a groove that allows a cord to sit inside the groove. They can be used by hand or attached to a motorised winch to increase the amount of weight that can be lifted.

Belts transfer movement from one rotating pulley to another, each held on a shaft.

Gears are wheels with teeth around the outside, the simplest form of which is a spur gear. When several wheels are interlocked, they can transfer motion from one place to another, eg in some hand whisks or on bikes.

Gear trains are when two or more gears are joined together. In a simple gear train, the drive gear causes the driven gear to turn in the opposite direction.

Rack and pinion is a gear system that changes rotary motion to linear. The pinion is fixed onto a shaft and when it rotates the rack moves in a straight line.

Levers use mechanical advantage to make lifting or applying pressure easier. All levers are

made of a bar and a pivot, called a fulcrum. Levers have three main parts:

- effort - the amount of force applied by the user, also referred to as the input
- fulcrum - where the lever pivots
- load - the weight that needs to be moved, also referred to as the output

Classes of lever

First order levers (Class 1) place the fulcrum between the effort and the load. An example would be a seesaw, which places the fulcrum in the centre and allows equally weighted children to lift each other up.

Second order levers (Class 2) place the fulcrum at one end of the lever and the effort at the other, with the load in the centre. The closer together the fulcrum and load are, the easier it is to lift the load. Examples include wheelbarrows, nutcrackers and some bottle openers.

Third order levers (Class 3) place the effort between the fulcrum and the load. If the effort and the fulcrum are further apart, it becomes easier to lift. A third order lever does not have the mechanical advantage of first order levers or second order levers so are less common. They are generally used for moving small or delicate items. Examples include tweezers or fishing rods.

Linkages

Levers can be joined together to form linkages. Simple linkages change the direction of motion and the amount of force.

- **Reverse motion**
- **Parallel or push/pull**
- **Bell crank**
- **Crank and slider**
- **Treadle**
- **Angles in linkages**

Cams

A cam mechanism has two main parts:

- a cam - attached to a crankshaft, which rotates
- a follower - touches the cam and follows the shape, moving up and down

- **Circular**
- **Pear**
- **Snail or drop**
- **Roller**

Material categories and properties

Papers and boards

What is paper and how is it made

Common types of paper -properties and uses
International paper sizes
Paper grades and weights

Ferrous and non-ferrous metals

What are ferrous metals - commonly used types, properties and uses
Types of ferrous metals - what are they, common types, properties and common uses

Non-ferrous metals - what are they, common types, properties and common uses

Alloys - what are they, common types, properties and common uses

Thermoforming and thermosetting polymers

Thermoforming plastics - properties, common types and uses

Thermosetting plastics - properties, common types and uses

Textiles - natural and synthetic fibres

Types of natural fibres - plant based, animal, types, properties and common uses

Synthetic fibres - origins, types, common types properties and uses

In Depth Technical Principles Timbers

Sources and origins

Hardwoods
Types of tree, general properties
Common commercial species, their physical properties and common uses.

Softwoods
Types of tree, general properties
Common commercial species, their physical properties and common uses.

Manufactured Boards
Origins, types, methods of manufacture, main commercial forms, their physical properties and common uses.

Finishes in wood - types, function and types of wood finishes e.g. stain, oil, varnish, paint, preservatives, laminating etc.

Defects in wood - types, causes, identifying defects in wood e.g. shrinkage, splits, shakes, knots, fungal and insect attack.

Social and Economical Issues

Deforestation
Sustainably sourced materials - MDF, Plywood etc.

FSC - who they are, what do they do

Life Cycle analysis of timber products

Linear and circular economy - what are they, how do these approaches affect the design, manufacture and disposal of products made from woods.

Selecting materials

Materials can be selected based upon their working properties. It is important to know and understand which materials can be used for a specific purpose:

- How do they look?
- What are they commonly used for?
- How can they be manufactured?
- How do they perform in use?
- What makes them unique - are they the most durable, the lightest etc?

Environmental factors - environmental cost to cutting down trees for materials (CO_2). Loss of wildlife habitat. Unsustainable forestry practices etc. Availability of materials, rare woods, hardwoods slower growing, softwoods faster.

Responsibilities of designers and manufacturers - Choosing more ethically sourced woods, more sustainable, design products that meet 6 R's

Material costs - timbers sold by m3,

Stock forms - rough sawn, planed, PSE, PAR, planks, boards, mouldings, standardised sizes and thicknesses.

Reinforcing and stiffening
Forces act on materials all the time - even if a material appears stationary it still has a force acting on it. There are five terms used to describe what type of force can act on a material:

- tension - a pulling force
- compression - a pushing force
- bending - forces at an angle to the material
- torsion - a twisting force
- shear - forces acting across the material

Timber has good tensile strength and compressive strength because of its fibrous structure.

Scales of production
There are four terms used to describe the scale of production in relation to manufacturing a product:

- prototypes or one-off production
- batch production
- mass production
- continuous production

marking out timber:

- pencil - the most popular, can go blunt with use and needs to be kept sharp
- marking knife - produces a fine crisp line that can be cut to, will produce many lines on timber before it needs to be sharpened again
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The measuring tools associated with timber are used to measure lengths and angles. The most common tools are:

- ruler - for measuring shorter lengths, widths and thicknesses

- tape measure - for measuring long distances, particularly in the building trade
- try square - for marking out angles that are 90 degrees to an edge
- mitre square - for marking out angles that are 45 degrees to an edge
- sliding bevel - to mark an angle that you set to an edge
- marking gauge - to scratch a line that is parallel to an edge
- mortise gauge - to scratch a set of parallel lines to an edge

There are a great many saws used to cut timber - some suit long straight cuts on thicker planks, and others suit curves and complex shapes:

- rip saw
- tenon saw
- coping saws, jig saws and scroll saws - all for cutting thinner pieces of timber
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Timber can also be drilled by using a variety of different drill bits, which work by twisting into a piece of timber:

- twist drills
- countersink bits

To ensure accuracy, jigs and formers can be used during the process of drilling, bending and cutting wood. Jigs and formers can also be reused to repeat the processes to produce identical products.

As well as marking, cutting and drilling, there are other skills to develop to shape timber:

- chiselling
- planing
- Sanding

Wood joints

Frame joints

- dowelled
- corner halving
- mortise and tenon
- bridle
- Mitre
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Box joints

- butt - a simple join where the edges of the timber are glued together, so it is easy to make but weak
- housing
- lap
- dovetail
- comb

Joining methods

Permanent fixings

- Polyvinyl acetate (PVA)
- Epoxy resin (ER)
- Contact adhesive

Temporary fixings

- Knock-down fittings
- Screws

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Wood processes

Veneering
Veneer is the term used to describe a thin sheet of timber, usually made from an expensive hardwood.

Laminating
Wood is usually bent by laminating. This is done by cutting thin strips of wood, putting glue on the strips and clamping them into a former or jig.

Steam bending
Wood can also be bent by applying steam. This technique involves thin strips of wood being heated in a steam box.

Lasers and CAM
In modern products, designers and manufacturers use specialist equipment, known as computer aided manufacture (CAM) machines. These machines are controlled through a computer, and are used in modern high-volume production.

- Laser cutter - A laser is directed from a precise length onto a material which can either cut or etch.
- Computer numerical controlled (CNC) miller - Similar to a pillar drill, a milling machine uses a rotating cutting tool.