Knowledge Organiser: KS4 Engineering Design – Design Cycle & Strategies

The Design Cycle

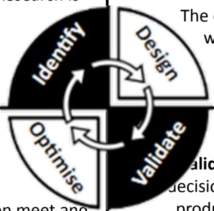
The **design cycle** is the process that a designer follows when developing a new product.
There are **4 phases** of the **design cycle** and specific activities happen at each stage.
The Design Cycle includes the Identify phase, Design phase, Optimise phase & Validate phase. An easy way to remember the stages of the design cycle is **IDOV**, each letter standing for each stage of the cycle.

1. Identify Phase

Identify phase: The designer gets a clear understanding of what the client wants from their product. Research is carried out to fully understand what the client wants and then produces a design brief for the project.

2. Design Phase

Design phase: The designer will begin to create ideas for the client through hand drawn and 3D CAD designs. The designer will also deconstruct the design brief and write a design specification to follow like a checklist to ensure the design requirements are met.



3. Optimise Phase

Optimise phase: The designer will make physical and virtual prototypes of the ideas they have created for the client. They will then meet and discuss the ideas with the client before redesigning and improving their ideas to meet the needs of the client.

4. Validate Phase

Validate phase: The designer reviews and justifies their decisions, suggests final modifications and evaluates the product against the specification needs from the client.

Identify Phase

- The designer will talk to the **client** to find out their needs and wants
- The designer writes a **design brief**. The brief outlines the clients needs & is an overview of the product
- Initial **research** will be conducted, including both primary & secondary research
- The designer begins process planning where the designer plans out timescales for making the product

Design Phase

- Initial design ideas will be drawn up using a variety of drawing methods
- Models will be created via **CAD** & by **physical modelling** using materials such as cardboard
- The designer writes a **design specification**. This is like a checklist of requirements that must be included in the design of the product.
- **Engineering drawings** will be drawn up to give to the manufacturers

Optimise Phase

- They look at how the design can be further improved
- Considerations such as **DFMA** & **DFD** are incorporated into the design
- They make a final prototype to check working components, sizes, assembly and mechanisms etc
- They carry out **error proofing** of the final product and of the manufacturing processes

Validate Phase

- **Evaluate** the design solution against the design brief and specification
- This is where they review and justify their design decisions
- **Market testing** (using the product) & **physical testing** (using destructive & non-destructive tests)
- Evaluate the impact of the design solution (by completing **Life Cycle Analysis LCA**)

Client

A **client** is a person or an organisation that wants a product to be designed and manufactured.

A **user** is a person who will use the product.

Client-centred design is a style of designing where the design of a product is based around the needs of the client. The client is consulted throughout the design development

Types of Research

Primary Research

Primary research = research you conduct yourself, you collect the data first hand In primary research, you conduct the research by collecting data by doing your own surveys/ questionnaires, interviews, focus groups and primary product analysis tasks.

Secondary Research

Secondary research = research that pre-exists and has already been conducted. In secondary research, you're looking at existing data from other researchers either online, books or articles. Existing date can be found in academic journals, government agencies or national statistics.

Error Proofing

Error proofing is when a design has been carefully planned out so that it can't be used incorrectly. It is based around preventing errors from taking place so the product is not damaged or any defects occur. E.g. a plug and a plug socket can only be used correctly one way – the three prongs of the plug only fit in one way. This means it cannot be used in error and there is only one way to insert it correctly.

Design Strategies

Linear Design Strategy	The **linear design** strategy is where you are given a design problem & then work in a step-by-step way until you have a solution to the problem and then you stop. This is a simple start to finish process which is easy to follow but lacks flexibility.
Inclusive Design Strategy	The **inclusive design** strategy is centred on designing for as many people as possible. When you design in this way you aim to create solutions that can be used by as many different people as possible e.g. a ramp entrance to a building.
User-centred Design Strategy	The **user-centred design** strategy is centred on products that are designed and manufactured by considering the individual needs of the client. A product that is customised has been specifically designed for a user e.g. a prosthetic leg.
Sustainable Design Strategy	The **sustainable design** strategy is centred on minimising the environmental, social & economic impacts. When we design using this strategy, we think about the impact that making the product will have during & at the end of its life.
Ergonomic Design Strategy	The **ergonomic design** strategy is centred on designing products that consider how we use them & how comfortable they are is Ergonomic design. Ergonomics is all about how we make products that are optimised for human use (making them accessible and easy to interact with).

Design Brief

A **Design brief** is a general overview or a summary of the clients needs and wants. A design brief outlines what the client wants in terms of design, product, function and aesthetics. The client and the designer write this together to outline what product needs designing. The design brief is then deconstructed into the design specification check points.

Design Specification

A **Design specification** is a list of requirements or criteria a product must meet. It is a checklist that must be checked against all the way through the designing & manufacturing process. This can include aspects from ACCESS FM - aesthetics, cost, customer, environment, size, safety, function and material.

Knowledge Organiser: KS4 Engineering Design – Design Decisions

Design Principles

ACCESS FM

A	Aesthetics	**Aesthetics** refers to the 'look' of a product. Aesthetics includes features such as the colour, the texture, the design, the shape, the pattern, the theme, the age e.g. does it look modern or more traditional? Is it aesthetically pleasing?
C	Cost	**Cost** refers to the price of a product. How much does the product cost to make or to buy? Is it expensive, is it affordable, is it a suitable price for the intended buyer? Are there any particular features that are increasing or decreasing the overall cost
C	Customer	**Customer** refers to Who is the target market for your product? Who will use it? Who will buy it? Why will the product appeal to them? How have the customer needs been considered or met?
E	Environment	**Environment** refers to what are the environmental impacts of this product? Is it made from sustainable materials? Can it be recycled or will it end up in landfill? Is it biodegradable? Does it's manufacture cause pollution? (*E can also be Ergonomics)
S	Size	**Size** refers to what are the dimensions of the product? Is it small & portable? Large & heavy? Does it meet the needs of the customer? What is the length, width, depth, weight, diameter or circumference? This is linked with anthropometrics
S	Safety	**Safety** refers to what are the health & safety features? Is it safe to use? Are there any risks or hazards with the product? How have safety factors been considered to protect the intended user?
F	Function	**Function** refers to what does the product do? How does it work? Does it work correctly? Does it perform exactly as intended? Are there additional features included on the product that makes it multifunctional? Does it differ to other similar products?
M	Material	**Materials** refers to what has been used to create the product? What materials have been chosen and why? What material properties have been selected and why does this suit the needs of the product? (*M can also be Manufacture)

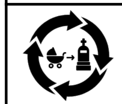
Ergonomics

Ergonomics is the process of optimising products for a user. This can involve making a product more comfortable, easier to use or more accessible to a wide range of users. Ergonomic features can focus on a product's shape, size, material choices, texture and increased accessibility. An example of making a chair more ergonomic could be to include softer material, add arm rests & a neck rest to increase comfort. Ergonomics utilises anthropometric data to help with making designs more ergonomically friendly.

Anthropometrics

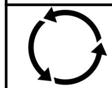
Anthropometrics is the study of body measurements which can be used to ensure products will fit a variety of users and suit their needs e.g. for a watch - wrist measurements would need to be collected. Anthropometric measurements refers to the measurements taken from the body e.g. hand size, leg length, head circumference. Anthropometrics & ergonomics work together to produce an enhanced product.

Life Cycle Analysis



Life Cycle Analysis or **LCA** for short. A life cycle analysis is where the entire life cycle of product is considered. It considers the products impact on the environment so that designers can make informed decisions on their products design and manufacture. LCA can also be referred to as the Life Cycle Assessment.

Life Cycle Stages



A products life cycle is all the stages of a products life. From the creation of the product to the end of its life when the product needs to be disposed of. Life cycle stages include Material Extraction, Manufacture, Distribution, Usage & End of Life

Scales of Production

Scales of production are the different sizes of production required to make a set amount of products manufactured at one time. There are four different scales of production, ranging from smallest to largest the scales of production are: one-off production, batch production, mass production & continuous production.

One-off production is where one product is made at a time. One-off products tend to be products that are either bespoke, handmade, customized or prototypes.

Examples of one-off products are customized products such as custom wedding dresses & rings, handmade items like paintings & specialised products like prototypes.

Batch production is where a small group of products are made at a time, a batch usually ranges from 2-100 products. Batch production tends to be used for products that change often e.g. food flavours, news stories, trends.

Examples of batch products are bakery goods such as cupcakes, printed publications such as newspapers, alongside clothing & furniture collections.

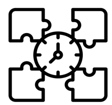
Mass production is where a large quantity of identical products are made utilising automated technology. Products range from 100-1000s to meet large demands.

Examples of mass produced products are popular food & drink brands such as Coca Cola, electronics such as phones & car manufacturing.

Continuous production is non-stop production that runs 24/7 & producing over 100,000 products. Products tend to be simple, easy to duplicate & needed in large supply.

Examples of continuously produced products are paper, toilet roll, bricks, screws, nuts & bolts

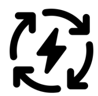
JIT production



JIT = **Just in time** production. JIT Production is where products are only made once an order has been placed. Orders are made 'just in time'. Advantages of JIT production include products are made to order, saves on storage space, stock doesn't become old or out of date and materials are only ordered when they are needed so there is no waste. Disadvantages include that sales can be affected by delays in delivery or manufacture and costs are higher when making in smaller quantities.

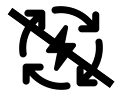
Environmental Impacts

Renewable Energy



- Wind (Wind Turbines)
- Solar (Sun Energy: Solar Panels)
- Tidal (Ocean/Tide Energy)
- Hydro-electrical (Water: Dams)
- Biomass (plant/animal material)

Non-Renewable Energy



Fossil fuels
- Coal
- Oil
- Natural Gas

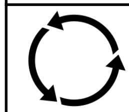
Global Warming

Global warming is the warming of the earth due to greenhouse gases (e.g. carbon dioxide or methane) being released into the atmosphere by the burning of fossil fuels.

Carbon Footprint

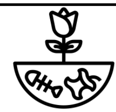
A carbon footprint is the amount of greenhouse gases released into the atmosphere by making, converting materials, using, transporting, recycling and disposing of products.

Sustainable



For something to be sustainable it must be able to be maintained at a certain rate or level. Conserving an ecological balance by avoiding depletion of natural resources.

Biodegradable



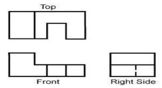
The ability to break down and decompose naturally. Natural resources are the only materials that naturally biodegrade.

6 R's

Recycle = If you really can't reuse something, recycle it.
Reduce = reducing the amount of stuff you no longer need. The idea is: consume less, waste less.
Reuse = Before throwing something away, think can it be reused/repurposed
Repair = Can you fix it? Expand the shelf life of your possessions.
Rethink = Do you really need that? The question you should be asking yourself to avoid waste
Refuse = Refrain from buying stuff you don't need. Consider the impact of buying a new product

Knowledge Organiser: KS4 Engineering Design – Engineering Drawings

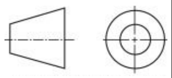
Orthographic Drawing



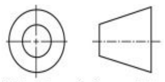
A type of drawing that represents a 3D object by using several 2D views of it Orthographic drawings show three different views. These views are called projections. Views: front, side, plan (top). Orthographic drawings are also known as Engineering drawings

The benefits of Engineering drawings are they show: Dimensions / measurements/sizes, tolerances, material used, assembly information, sectioned views , scale/proportions, labelling of parts/annotation, units, placement of components, exploded view and it allows you to observe different projections (plan (top), side, front views).

Projections

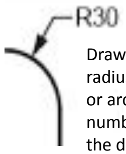
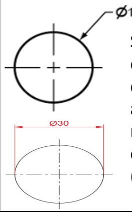


First Angle Projection
Drawing a design in first angle projection shows the right hand view first following by the front view. When drawn like this top view comes below front view, right side view drawn to the left of the elevation.



Third Angle Projection
Drawing a design in third angle projection shows the front view first following by the right hand view. When drawn like this top view comes above front view, right side view drawn to the right of the elevation

Engineering Orthographic Standard Conventions (Drawing Key)

Name	Example	Name	Example
Radius	 Drawn to show a radius on a curve or arc. The number is half of the diameter	**Centre Line**	Thick dot and dash sequence showing the centre of a part or centre of a hole.
Diameter	 Shows the entire distance across a round shape or hole (diameter).	**Projection**	Continuous thin line showing how the edges of parts line up with each other. Shows the alignment of parts
Outlines	Solid thick line showing the outline of a product or part	**Leader Line**	Connects the drawing of the product to some text information e.g. a label, radius or diameter measurement
Hidden Detail	Thick dash line showing anything hidden in the view such as a hole or gap	**Dimension**	30mm Medium line with solid, sharp arrows at each end. The measurement goes in the middle

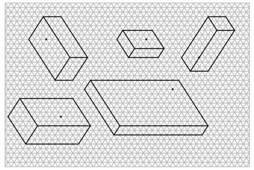
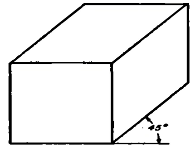
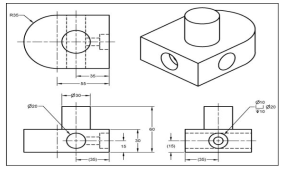
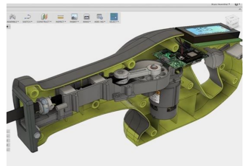
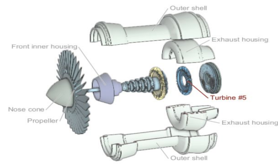
Abbreviations

Designers use standard abbreviations to communicate their drawing requirements to the manufacturers. An abbreviation is a shortened form of a word or phrase.

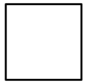
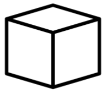
The full list of abbreviations is in the British Standard BS 8888 is attached below:

Term	Abbreviation
Across flats	AF
Centre line	CL
Diameter ... in a note	DIA
Diameter ... preceding a dimension	Ø
Drawing	DRG
Material	MAT
Square ... in a note	SQ
Square ... preceding a dimension	□

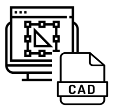
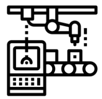
Types of Drawing

Name	Example	Name	Example
Isometric	 Usually used to show technical features of a design in 3D	**Oblique**	 Usually used to create 3D views quickly and to present initial concept design ideas
Freehand Drawing	 Usually used to present initial concept design ideas	**3rd Angle Orthographic**	 Usually used to aid manufacturing & to show different sides & projections
CAD	 Usually used to present final design ideas	**Exploded View**	 Usually used to show how a design is assembled & show both internal & external parts

Drawing Dimensions

	**2D**	A two-dimensional (2D) object is an object that only has two dimensions, length and a width, and no thickness or height. It often appears 'flat'. <u>Benefits of drawing in 2D include</u>: quicker to produce, easy to understand, requires less technical expertise, allows for clear presentation of essential design elements like dimensions/lines/ annotations, avoids the added complexity of depth perception in 3D drawings.
	**3D**	A three-dimensional (3D) object is an object with three dimensions: such as a length, a width, and a height. <u>Benefits of drawing in 3D include</u>: 3D drawings are more realistic, provides a more realistic view of how the product will look in real life, shows different perspectives of the design, can show how a product might be held or used, can show how a product is assembled, 3D drawings are easier to understand how to assemble the design/product, they show different parts/components and they provide detail of sizes and proportion.

CAD & CAM

	**CAD**	**Computer Aided Design** (CAD) refers to the use of computer software to design products. Software's such as Techsoft 2D Design, Google Sketchup, TinkerCAD & Photoshop. Advantages of CAD include being able to make changes easily, to duplicate designs, delete or undo mistakes, the ability to share & email designs around the world. Disadvantages include power-cuts, unsaved work being lost & potential hazards of being hacked online by hackers.
	**CAM**	**Computer Aided Manufacture** (CAM) refers to the use of computer controlled machinery use to manufacture and make products. CAM machinery includes laser-cutters, 3D printers & CNC routers/milling machines. Advantages of CAM include increased speed of manufacture, higher accuracy, machines run 24/7. Disadvantages of CAM are machines, machines breakdowns & repairs are expensive, errors in designs are repeated if not spotted.

Tolerances

±	**Tolerance Symbol** ±	A tolerance shows the amount of variance allowed in a given dimension of a part/component.e.g. what the maximum and minimum dimensions can be. Tolerances are provided within Engineering drawings. The plus represents the maximum dimension a part can be and the minus the minimum dimension a part can be. A tolerance could be shown like this 4.00 ± 0.02 (This means the maximum would be 4.02 and the maximum would be 3.98).