Year 13 unit 3 **Engineering Product Design and Manufacture** knowledge organiser

You have to know detailed information about the properties and uses of a range of materials . This is *not* an exhaustive list

- **Ferrous Metals** contain iron. Ferrous metal include mild steel, cast iron and stainless steel.
- **Non – Ferrous** metals do not contain iron. Non ferrous metals include aluminium, titanium, copper, silver and zinc
- **Alloys** are a mixture of 2 or more different metals that have combined together to create an material with specific properties.

Materials

Metals

Aluminium, Copper, Titanium, Zinc—Non Ferrous

Mild Steel, Stainless steel, High carbon steel, High speed (tool) steel—ferrous

Cast Iron—Ferrous

Brass—Alloy

Plastics

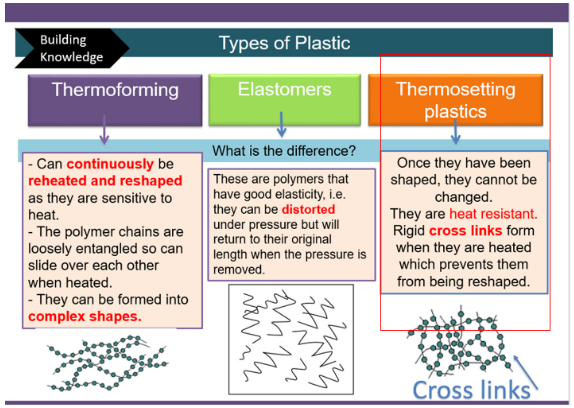
PET, LDPE, PP, HDPE, PMMA, ABS, Nylon, PS—Thermoplastics

Epoxy, Urea formaldehyde, Melamine—Thermosets

Timbers

Beech, Ash, Oak, Mahogany, Balsa—hardwoods

Pine, Spruce Yew—softwoods



https://www.youtube.com/watch?v=INS7TwWmlrg

- **Conductors** are materials that transmit heat or electricity.
- **Galvanising** is the process of providing a protective zinc coating to steel. Products tend to be hot dipped to provide the coating.
- **Electroplating** can be used to deposit a range of metals on the surface of another metal to provide corrosion resistance and/or a decorative finish.
- **Malleability** is the ability of a material to be permanently deformed on all directions without breaking apart.
- **Ductility** is the ability of a material to be deformed by bending, twisting or stretching. This ability increases in metals at higher temperatures.

PET (Polyethylene terephthalate)	LDPE (low density polyethylene)	PP – Polypropylene	HDPE
• Excellent wear and tear • Transparent • Good chemical resistance • Thin walled and can be brittle	• Low density (lightweight) • Flexible sheets • Hard to tear • Printed on using offset lithography	• Very durable • Holds a rigid form but is flexible and can be manipulated without cracking • Waxy feel and translucent look • Food and chemical safe	• Very tough • Lightweight • Rigid • Can be pigmented • Ideal for large, outdoor products

Most metals …

- Have a hard surface
- Are dense due to their tightly packed crystalline structure
- Have high melting and boiling points – starting from 200'C but on average, around 1000'C
- Are good thermal and electrical conductors
- Have a lustrous finish (shiny)

Some metals are …

- Malleable
- Ductile
- Tough
- Strong
- Brittle
- Plastic
- Stiff

Year 13 unit 3 **Engineering Product Design and Manufacture** knowledge organiser

Learners understand the process of designing and then manufacturing a product. They must be able to both problem solve and suggest solutions using real materials and processes whilst relating it to the customer requirments

A1 Design triggers

The triggers that stimulate engineering design activity, including:

- market pull/technology push (product and process)
- demand
- profitability
- innovation

A4 Material properties

Properties, modes of failure, protection and lubrication of engineering materials and components

that impact upon their selection when designing an engineering product, including:

- mechanical properties
- physical properties
- thermal properties
- electrical and magnetic properties
- behaviour of advanced materials (bio materi-

A2 Design challenges

Commercial-, regulatory- or public policy-based trends that challenge current technology

or design, including:

- reduction of energy wasted during design of an engineered product
- reduction of energy wasted during operation of an engineered product
- reduction of physical dimensions
- reduction of product mass
- increase in component efficiency
- energy recovery features
- reduced product life cycle costs
- integration of different power sources for vehicles

A5 Mechanical power transmission

Characteristics of an engineering system that makes use of forces and movement that impacts

on mechanical power transmission component selection when designing an engineering product,

including:

- linkages (types, mechanical advantage, examples from nature)
- mechanical motion (linear, rotary, reciprocating, oscillating)

A3 Equipment level and system level constraints and opportunities

Factors that place limitations and offer opportunities at equipment level on the design of

engineering products, including:

- reasons for selecting different solutions for equipment interfaces (mechanical, electrical,

hydraulic, software)

- systems integration compromises (cooling, location for optimum equipment performance,

bonding, centre of gravity, electrical and electronic compatibility)

A6 Manufacturing processes

Characteristics and effects of manufacturing processes that impact on the selection of engineering

materials and components when designing an engineering product, including:

- processes for metals (additive, moulding, machining, forming, casting, powder metallurgy,

joining, assembly)

- processes for polymers (additive, casting, moulding, extrusion, thermoforming)
- processes for ceramics (additive, casting, forming)
- processes for composites (layup, moulding, automated tow placement)

Year 13 unit 3 **Engineering Product Design and Manufacture** knowledge organiser

Learners understand the process of designing and then manufacturing a product. They must be able to both problem solve and suggest solutions using real materials and

B1 Design for a customer

Meeting customer needs during engineering design activity, including:

• types of customer (internal, external)

• product and service requirements (performance specifications, compliance to operating

standards, manufacturing quantities, reliability/product support, product life cycle,

usability, anthropometrics)

• product design specification/criteria (cost, quantity, maintenance, finish, materials, weight,

aesthetics, product life cycle, sustainability, carbon footprint, reliability, safety, testing,

B2 Regulatory constraints and opportunities

Regulatory factors that place limitations and opportunities on the design of engineering products,

including:

• legislation, standards, codes of practice, national and international certification

requirements

• environmental constraints (sustainability, carbon footprint, product life

B3 Market analysis

Engineering goals in terms of marketing when designing an engineering product, including:

• unique selling point (USP)

• benefits of the design

B4 Performance analysis

Engineering goals in terms of performance when designing an engineering product, including:

• product form

• product functionality

• technical considerations

• choice of materials and components

• environmental sustainability (impact, carbon footprint)

B5 Manufacturing analysis

Engineering goals in terms of manufacturing when designing an engineering product, including:

• processes for manufacturing/assembly

• manufacturing requirements

Year 13 unit 3 **Engineering Product Design and Manufacture** knowledge organiser

Processing materials

Polymer processing—plastics

Injection moulding

Blow moulding

Extrusion

Thermoforming

3D printing

Joining—plastic weld and glues

Metal Processing

Casting , Forging, Extrusion

Drilling, Turning, Milling

Additive manufactures—welding

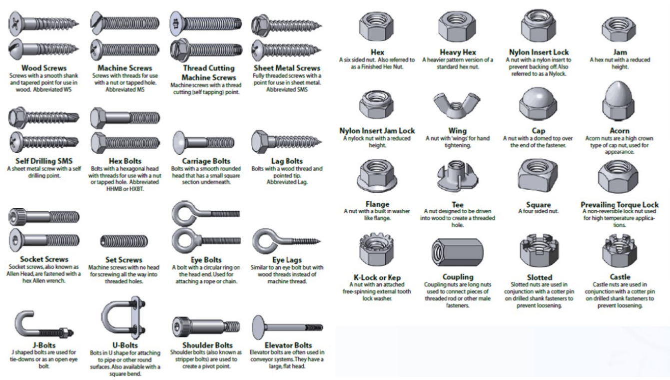
Joining—nuts bolts rivets

Timber Processing

Machining -drilling, routing, planning

Finishing—drying and preparation

- https://www.youtube.com/watch?v=vbNHCn2gHQ4 - cool new technologies for the future
- https://www.youtube.com/watch?v=zCzLDIn5VGM
- https://www.youtube.com/watch?v=y7ewda7ECHo
- https://www.youtube.com/watch?v=J0ZMi83oUjk – graphene update
- https://www.youtube.com/watch?v=lvtfD_rJ2hE
- https://www.youtube.com/watch?v=29Az-dPwtg8&list=PLDE5A69832ECC4D26 - plastics
- https://www.youtube.com/watch?v=Yw75R-o4UJc&list=PLDE5A69832ECC4D26&index=5 - videos on different plastics
- https://www.theguardian.com/science/2014/apr/15/five-wonder-materials-graphene-shrilk-spider-silk-stanene-could-change-world
- https://www.youtube.com/watch?v=aRn7hoUiKIU
- https://www.youtube.com/watch?v=az6oYcd-SfU – 9 new materials
- https://www.youtube.com/watch?v=FSu19nz7NIE - cool 3D printing



Year 13 unit 3 **Engineering Product Design and Manufacture** knowledge organiser

One-off Production

Also known as Bespoke or Prototype manufacture
Generally, specialist workers create, custom-made products and can uses specialist machines and materials. High Quality but expensive and involves individual client consultation and design work.

Advantages	Disadvantages
• Custom made • High Quality Materials • High Quality Craftsmanship	• Time consuming • Specialist training for workers • Expensive to buy

Quick Response Manufacturing (QRM) Production

This strategy is used to reduce time taken to respond to orders. Rapid completion of design and development processes to minimise delays. However, quality and customer needs are still a high priority

Advantages	Disadvantages
• High product turnover • Generally makes smaller batches, so lower storage costs • Efficient use of materials minimises waste	• If there is a large variation in demand, then can cause problems if the manufacturer can't react to meet it • Managing and planning can be difficult • Highly dependent on suppliers to react to demand changes

Batch Production

Uses a mix of workers and machinery with jigs, moulds and templates to help make identical products. Stations of workers e.g. cutting station, painting station, etc.
Can have some variation e.g. colour, finish, flavour.

Advantages	Disadvantages
• Lower cost than one-off • Jigs, moulds and templates help products look identical • Can have some variety	• High storage costs • Jugs, moulds and templates have to be checked • Workers can become bored on their station

Unit Production Systems (UPS)

Used in textiles manufacturing. Computer controlled and incorporates hanging carriers to carry garments from station to station.

Advantages	Disadvantages
• Quick and efficient transfer of garments • Product output is easily tracked and recorded • Multiple styles of garment can be used in the system	• High investment and set-up costs • High maintenance cost • Pre-production planning is essential

Mass/Line Production

Workers carry out a single process in the production line, but generally manufacture is heavily automated. Production is linear with sub assembly lines working parallel to the main production line.

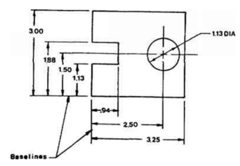
Advantages	Disadvantages
• Large amounts made at once • All products are identical and to same standard • Using automation reduced human error	• Initial starting costs are high • If production line stops, the product can't be made • Workers become bored monitoring machines and repetitive tasks

Vertical In-House Production

This is where the company owns its supply chain, which minuses dependency on external suppliers. Factories must then have the ability to manufacture all components required

Advantages	Disadvantages
• Reduced risk of component prices changing • Less impacted by suppliers going out of business • Protects the brand and improves security of intellectual property rights • QA is easier to implement	• Specialisation reduced, potentially diluting expertise • Increase in administration • Reduction is flexibility

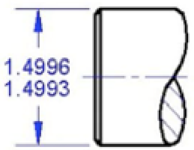
Year 13 unit 3 **Engineering Product Design and Manufacture** knowledge organiser

Importance of Accuracy	
Accurately fitting parts to ensure the correction function of products. The acceptable range of accuracy is known as the tolerance. The use of datum edges and surfaces, aw well as vertical and horizontal lines a generated by laser levels, provide reference points to facilitate improved accuracy	

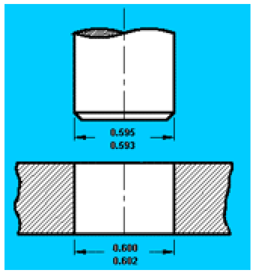
Testing Eliminating Errors
• Dials on machine controls allow precise movement on tools • Digital test gauges are very accurate and are often computer linked • Profile inspectors measure fine details • CNC machines use computer codes to control their movement and ensure accuracy • Laser micrometres, material thickness sensors and alignment systems are examples of non-contact testing devices

What do we mean by the terms **tolerance and fit?**

- **Tolerance** is the total amount a specific dimension is permitted to vary (difference between the maximum and minimum limits).
- The dimension below has a tolerance of ***.0003***.



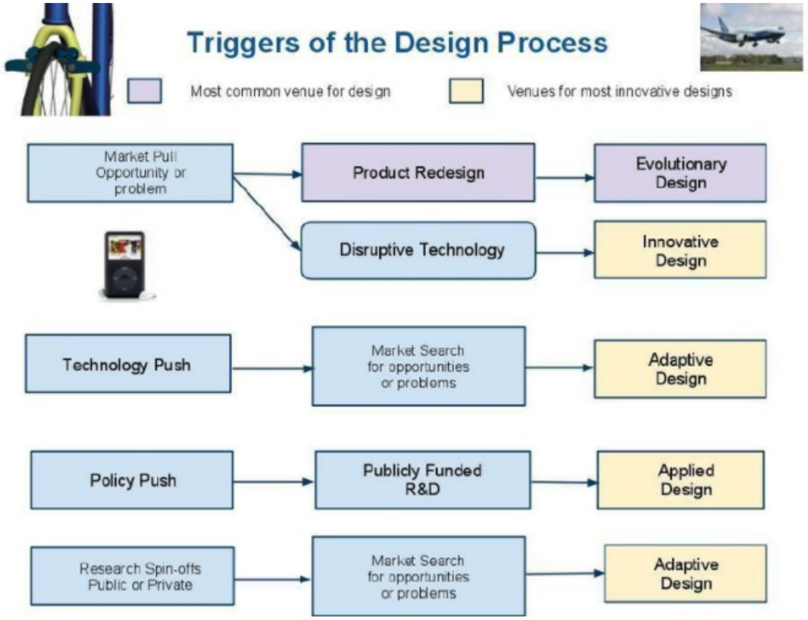
- Fit is defined as the degree of freedom of tightness between the mating parts in an assembly. Fit obtaining parts are either movable joint or fixed joint.



https://tarkka.co/2019/02/20/fits-and-tolerances-how-to-design-stuff-that-fits-together/

Measuring Aids	
Jigs are guides for cutting tools. They help tools, such as drills, for repetitive machine operations without needing to mark out. This helps reduce the need for skilled workers and reduces the chance from human error.	
Fixtures hold work in place for processes such as welding. They maintain the accurate alignment of parts by providing framework into which they are securely clamped during manufacture. They are often designed so that parts can only be fitted the right wat round, they ensure that every manufactured assembly is of high quality.	
Templates ensure the consistent repetition of the same outline, by providing of a consistent, rigid, profile of a shape. This helps create identical pieces and are incredibly common in batch production.	

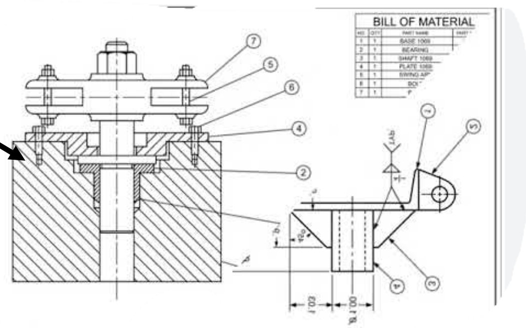
Year 13 unit 3 **Engineering Product Design and Manufacture** knowledge organiser



Year 13 unit 10 **Computer Aided Design in Engineering** knowledge organiser

2D Design Keywords

- Sectional view
- 3rd angle projection
- Dimensions
- Tolerance
- Assembly drawing
- BS8888 drawing standards
- Construction lines
- Projection lines
- Centre lines
- Hidden detail lines



Assembly Drawing

Solidworks Keywords

- Thin walled component
- Fabricated components
- 2D orthographic views
- Shell
- Assemble components
- Aligning components
- Coordinates
- Origin
- Planes of work

Drawing standards

Drawing standard BS8888—all orthographic drawings must be drawn and dimensions to BS8888 standards

https://resistantmaterials.weebly.com/uploads/1/1/5/8/11587226/guide-to-british-standards_1.pdf

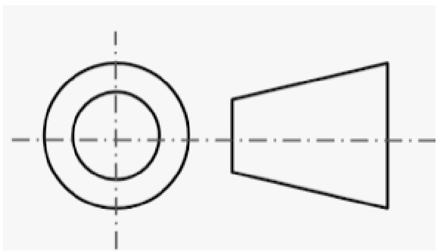
Know basic views

Front , plan and end (side) elevation

Detailed views, Sectional views, assembly drawuings

Be able to space the view correctly to match 3rd angle projection

Export views from solidworks and be able to select the correct views and orientations



Year 13 unit 10 **Computer Aided Design in Engineering** knowledge organiser

Line Types

Line	Description	Application
	Continuous thick	Visible outlines and edges.
	Continuous thin	Dimensions, projection and leader lines, hatching, outlines of revolved sections, short centre lines, imaginary intersections.
	Continuous thin irregular	Limits of partial or interrupted views and sections if the limit is not an axis.
	Continuous thin with straight zigzags	Limits of partial or interrupted views and sections if the limit is not an axis.
	Dashed thin	Hidden outlines and edges.
	Chain thin	Centre lines, lines of symmetry, trajectories, loci, pitch lines and pitch circles.
	Chain thin thick at ends and changes directions	Cutting planes.

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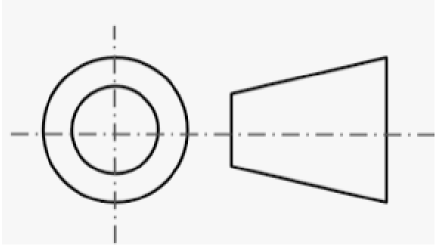

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Unit 1 lego car