Material properties

Working properties

Consider the different properties when selecting your material

Strength
The amount of load or compression it can withstand

Elasticity
Will it return to shape after being compressed?

Toughness
Absorption of energy through shock before splitting

Malleability
Ability to deform under compression without cracking, splitting or tearing

Ductility
Ability to be stretched out or drawn into a thin strand without snapping

Hardness
How resistant is the surface? Will it survive scratches, knocks and abrasion?

Physical properties

Consider the different properties when selecting your material

Absorbency
The tendency to attract or take on an element-usually liquid

Fusibility
Ability to be converted through heat into a liquid state and combined with another material before cooling as one

Density
The mass of material per unit of volume-how compact the material is

Thermal conductivity
Can conduct heat

Electrical conductivity
Can conduct electricity?

Forces and stresses

Tension: Pulling force on either end of material

Torsion: Twisting of the material

Compression: Pushing force on either end of a material

Bending: Tension and compression either side of its neutral axis

Shear: A force perpendicular to its length

TIPS FOR THE EXAM

Length: 2 hours

Sections

A-core technical principles (20 marks)
Requires recall knowledge and includes multiple choice

B-Specialist technical principles (30 marks)
Requires you to name and explain. You must show understanding of what the question is asking

C-Designing and making principles (50 marks)
Requires you to understand, justify, make links and complete extended answers. This section contains the majority of the math's content.

Equipment needed

Black pen
Pencil
Calculator
Protractor
Ruler
Eraser
Pencil sharpener

Top tips

- ✓ **Begin with section C (we advise 60 minutes, then B 40 minutes, then A 20 minutes)**
- ✓ *When given a choice of materials choose polymers or timbers*
- ✓ *Show your workings in full for all math's questions*
- ✓ *All dimensions are given in mm unless stated otherwise*
- ✓ *Do all drawing work in pencil only*
- ✓ *Pay attention to how many marks a question is worth. A 2 mark question will require more than one sentence*
- ✓ *Decode longer questions by simplifying the language at the top of the page or use BUG (Bubble, Underline, Go back)*
- ✓ *For extended questions plan out your question by putting subheadings down the page and how many bullet points you will need to make in each section*

Improving functionality

Strengthening and enhancing materials Reinforcing, Webbing
Stiffening materials Laminating, fabric interfacing
Folding and bending Reshaping to improve properties, A net

Product miles
The journey that all materials and components have to have travelled during production and delivery to the customer. Having high product miles will affect the environment more.

Ecological and social footprint

Carbon footprint
The amount of carbon dioxide emitted during a process.
There are 6 greenhouse gases which are damaging our atmosphere

Social footprint
A measure of a companies social policies and the impact that has on its employees and society

The 6 Rs

By using the 6R's designers and manufacturers will be able to analyse how sustainable their solutions are and what savings they can make towards their carbon footprint

- Reduce
- Refuse
- Re-use
- Repair
- Recycle
- Rethink

Scales of production

One off
Small highly skilled workers, Constant communication with client, Specialist materials, High level of skill-results in higher cost, High standard of quality control

Batch
Production line system with workers doing a task each, Semi skilled flexible workers, Changes can be made eg, colour, Parts bought in and assembled

Mass
Heavily automated, Many items made identical, High initial costs, Uses lots of energy, Assembly lines used to assemble pre-manufactured parts

Continuous
Relying on automation and computers, meaning workers less flexible, Limited training available, Runs 24 hours a day, 365 days a year, Costly machinery

SPECIALIST TECHNICAL PRINCIPLES

EXAM COMMAND WORDS

State or give
Write a fact or single piece of information

Which
Multiple choice question
Shade in the lozenge

Describe
Give a detailed factual account of what something is or how it works
Write in full sentences using good SPAG
Make one point per mark

Explain
Write the reasons or causes of something
Use examples and justify your response
Write in full sentences using good SPAG

Discuss
Write about the key points around the different sides of a topic
It should be balanced and come to a conclusion
Write in full sentences using good SPAG

Evaluate
You should write about the importance, success of or overall worth of different options. The evaluation should come to a conclusion where appropriate
Write in full sentences using good SPAG

Thermoforming

Polyethylene terephthalate PETE	High density Polyethylene HDPE	Polyvinyl Chloride PVC	Low density polyethylene LDPE	Polypropylene PP	High impact polystyrene HIPS	Acrylic PMMA	Acrylonitrile butadiene styrene ABS	Nylon Polyamide
Clear, easily coloured with a smooth finish	Opaque, takes colour well, can be textured	Good range of colours with a high gloss finish. Available as sheets or shaped as rigid PVC	Clear, thin to medium thick film with a smooth finish that takes colour well	Available in sheets or shapes that are easily coloured	Flat, clear or coloured sheets for vacuum forming	Thick to thin sheets, bars and tubes in huge ranges with a smooth finish. Can be spun into thread and woven	Very smooth finish, can be textured and easily coloured	Smooth, easily coloured, available in various thicknesses of sheet, bar, film or thread
Dimensionally stable, easily blow moulded, chemically resistant and fully recyclable	Lightweight, rip and chemical resistant, premium price paid when recycled	Flexible, high plasticity, chemically resistant, tough and easily extruded	Very flexible and tough with a high strength to weight ratio, blow mouldable and easily extruded	Flexible, tough, lightweight, chemically resistant, easily cleaned and safe with food	Flexible, impact resistant, lightweight, can be food safe, sheet used for vacuum forming, very toxic when burnt	Tough but brittle when thin, Easily scratched, formed and bonded, Common in school with laser cutting and line bending	Tough, hard, good chemical resistance, good impact resistance, can be 3d printed, injection moulded and extruded	Self-lubricating, very low friction, hard wearing, easily machined, can be woven into fabrics
Bottles, food packaging, sheeting and some food wraps	Milk bottles, pipes, storage crates, hard hats and wheelie bins	Raincoats, pipes, electrical tape, air mattresses and self-adhesive vinyl	Carrier bags, refuse sacks, piping, bottles and some plastic food wraps	Kitchen, medical and stationary products, rope	Vacuum formed products such as yoghurt pots, food containers	Car lights, display stands, trophies, table tops, modern baths, jumpers, hats, gloves	Electronic casing, 3d printed products, hard hats, lego	Clothing, tights, rope, cogs, gears, brushes, pipes, tents, parachutes

Common drill bits for plastics

Twist drill bits
General purpose drill bit, also used on metal and wood

Countersink bit
Used to ensure countersunk screw heads are flush to the surface

Hole saw
Used to cut large holes. Can overheat easily due to fast peripheral speed

Cutting and sawing plastics

Hacksaw/junior hacksaw
Cut straight lines

Coping saw
Cut curved lines in thin material

Wasting and abrading methods

Bobbin sander

Belt sander

Disc sander

Brasso

Files

Wet and dry paper

Plastic finishing techniques

Painting-spray, Vinyl decals, Flocking, Engraving and frosting, heat transfer printing, tampo printing, hydrographic printing, electro plating, rubberising spray

SPECIALIST TECHNICAL PRINCIPLES

Bioplastics

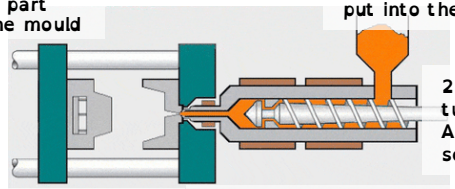
Some plastics can be made from vegetable starches and can be fully biodegradable of composted. Bioplastics are non toxic but cannot be recycled.

PLA (Polyactid acid)-smooth or textured and easily coloured, used in 3d printing
Polymorph-A mouldable translucent pellet which can be hand shaped and coloured, reusable
PHB (Polyhydroxybutyrate)-smooth or textured and easily coloured, brittle with little chemical resistance, easily processed and moulded, bottles and disposable food containers

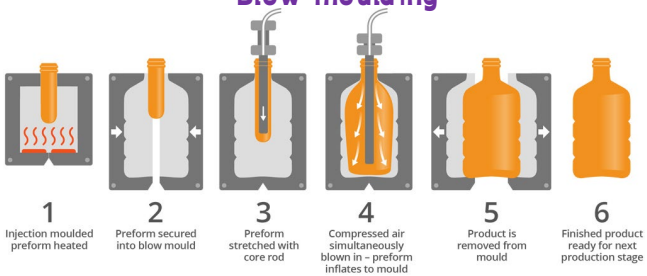
Commercial production techniques

Injection moulding

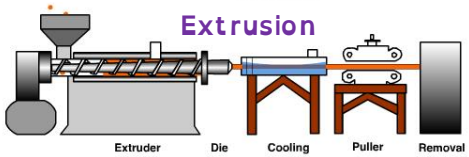
1. Plastic granules are put into the hopper
2. A motor turns the Archimedes screw
3. The granules are heated along the chamber until they become plasticised
4. The plastic gets forced into the mould with a hydraulic piston
5. Air or ejector pins force the moulded part out of the mould



Blow moulding



Extrusion

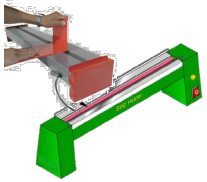


Plastic is heated and pushed through a die to create specific profile like pipe or trunking. Flow rate, temperature and tolerance are all very important.

Laminating

Involves bonding strips or sheets of material together in layers. It can be done with thick materials to create strong structures or thin materials to create tough and flexible products. Laminated glass is now used in all windscreens. It contains a thin film of plastic which holds the inner and outer glass layers together when it is cracked and shattered.

Line bending

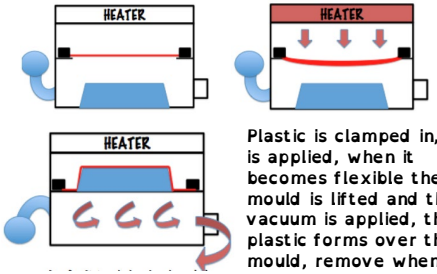


Bending most plastics involves heat. Strip heaters are used to create permanent folds in thermoplastics like acrylic.

Vacuum forming

This can be used to create products as small as Easter egg packaging to baths. HIPS is the most common polymer used in schools but polyester, ABS and acrylic are used in industry. To ensure a good outcome you need:

- A positive draft angle >3° so mould can be removed
- Avoid undercuts-to remove mould
- Not too deep a profile so it does not stretch material too thin
- Vent holes drilled to avoid air pockets
- Have a smooth finish so it does not adhere to the hot plastic



Plastic is clamped in, heat is applied, when it becomes flexible the mould is lifted and then a vacuum is applied, the plastic forms over the mould, remove when cool

3d printing

This is done by creating STL or VRML CAD files input into a printer, which uses reels of thermoplastics. Fused deposition modelling (FDM) is the most common method in schools but other methods include Stereo lithography, digital light processing and laser sintering. ABS and PLA plastic are most commonly used. You can print in metals, paper, ceramics and food. Bio printing is being developed so in the future we may be able to print replacement body parts.

Addition, deforming and reforming

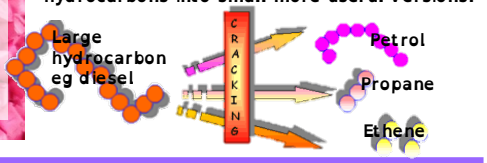
Stock forms

Most plastics come in a wide range of standard shapes and sizes. It can come in a wide range of forms including:

- Sheets, rods, tubes
- Powder, granules, foam and films

Where is plastic from?

Polymers come from crude oil in a process called fractional distillation. The separated fluids that are separated are not suitable at this stage to be turned into plastic due to the large hydrocarbon molecules which do not flow well. Cracking is the process of converting large hydrocarbons into small more useful versions.



Thermosetting

Epoxy resin ER	Melamine formaldehyde MF	Urea formaldehyde UF	Polyester resin PR	Phenol formaldehyde PF
Supplied as two liquids-a resin and a hardener. Sets clear with a smooth finish. Can be coloured	Formed and moulded into a variety of shapes, smooth, available in many colours and can be printed	Very smooth finish, mainly white, limited colours available, very versatile	Similar to epoxy resin, supplied as 2 liquids. Sets very clear and smooth and can be coloured	Frequently injection moulded, limited colour palette with a high gloss finish achievable
				
Stronger than other resins, better strength to weight ratio, expensive, heat resistant, good electrical insulator	Food safe and hygienic, lightweight, hard, brittle but not microwave safe	Heat resistant, very good electrical insulator, hard, brittle, easily injection moulded	Reasonable strong, heat resistant, good electrical insulator, high VOCS when curing similar to Epoxy resin	Formerly known as Bakelite, very rigid, hard and brittle, excellent electrical insulator with good chemical resistance
Bonding materials together, electronic circuit boards, waterproof coatings, fibre glass	Kitchenware and heat resistant surfaces bonded to worktops and flat pack furniture	Electrical fittings and casings, buttons, handles, fabric treatment	Encapsulating artefacts, waterproof coatings, flooring, lamination of fibreglass	Electrical components, mechanical parts, casting resin

SPECIALIST TECHNICAL PRINCIPLES