GCSE – GCE Transition

Product Design Textiles

Preparation Work

Name:

From Fibre to Fabric

Fibres are the basis for all textiles. You need to know the difference between natural and synthetic fibres, how each fibre is used, and which fibres can be combined together.

Types of fibre

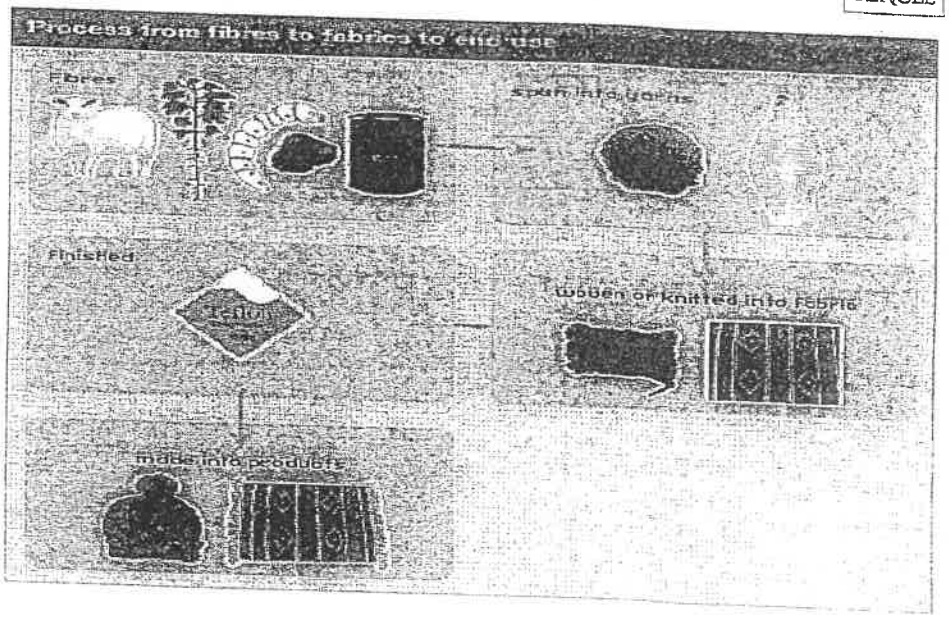
Textile materials are made in three stages:

1. *Spinning* fibres into yarns
2. *Weaving* or *knitting* yarns to make fabrics
3. *Finishing* fabrics to make them more useful

There are two types of textile fibres: *natural fibres*, *synthetic* and *regenerated*. Synthetic and regenerated fibres are *continuous filament* fibres, while natural fibres are usually short *staple fibres*. The exception to this rule is silk – a natural fibre whose continuous filaments are up to one kilometre in length!

Where fibres come from:-

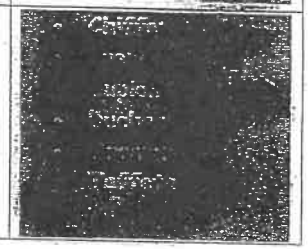
- Natural fibres come from plants and animals: cotton from the cotton plant, linen from the flax plant, wool from sheep, silk from silkworms.
- Synthetic fibres are manufactured using plant materials and minerals: acrylic, nylon and polyester come from oil and coal.
- Regenerated fibres come from pine trees and chemicals: Viscose uses wood pulp and caustic soda. Lyocell and Tencel are biodegradable and really strong so they are also used for non-woven fabric for wipes and swabs, disposable gowns for medical staff. Acetate uses wood pulp and acetone to make a lustrous fibre often used for lining and ball gowns. It's crisp and taffeta like.



GLOSSARY	
Handle	*how a textile feels when touched such as soft, rough, smooth, warm or cool*
Drape	*the supple and flexible characteristics of a fabric - how it hangs or behaves when pleated or folded*
Poor/ Good Absorbency	*able to take in and hold moisture and consequently drying properties*
Durable	*able to withstand wear, especially as a result of weathering.*
Breathable	*Can let perspiration out and air in*
Lustrous	*A fabulous shine*
Fibre	*A fine hairlike structure in staple or filament form*
Fabric	*Is made from yarns either through knitting, weaving or bonding*
Biodegradable	*Can be broken down naturally through the action of bacteria*
Bonded	*Webs of fibre pressed together using adhesives or heat.*
Closed-loop process	*A manufacturing process where all waste is reused in the production system (used for Acetate for example)*
Blended Fibre	*Two or more fibres spun together to make a yarn*
Mixed fabric (sometimes called fibre although that is wrong!)	*Two or more yarns mixed together in the production of the fabric*
Organic fibres	*Fibres grown using natural fertilisers, pesticides and herbicides to protect the biodiversity of the environment and workers' health*
Recycled	*The product has bee re-used in some form*
Target market	*The end-user or consumer group to whom the manufacturer aims to sell*

Natural Fibres

1. Natural fibres from plants (cellulose):
   - Cotton is used for making jeans, t-shirts and towels. It is cool to wear, has a soft handle, a good drape, and is durable. It can be washed and ironed, but it creases easily, is very absorbent and dries slowly.
   - Linen is used for summer clothing, tea towels and tablecloths. It is fresh and cool to wear, has a stiffer handle, and a good drape. It is durable, but can be washed and ironed. It creases badly and is very absorbent, but is also fast drying.
2. Natural fibres from animals (protein):
   - Wool is used for jumpers, suits and blankets. It is warm to wear, absorbent, dries slowly, is breathable, repels rain and can be soft or coarse to handle. It does not have good drape, and is not durable; however, creases tend to drop out. If it is not dry-cleaned it may shrink.
   - Silk is used for evening wear and ties. It is warm to wear, absorbent, has a soft handle and a good lustre and drape. It is durable and creases drop out. It needs to be dry cleaned.

Fibre	Properties	Qualities	Fabrics Trade Name
Cotton  Natural	• Very absorbent, dries slowly • Durable • Creases easily • Wash and iron • Sustainable • Flammable	• Cool and comfortable to wear • Soft handle • Good drape	• Calico • Denim • Poplin • Corduroy • Drill • Velvet 
Linen 	• Absorbent • Good drape Durable • Creases badly • Wash and iron • Breathable	• Fresh and cool to wear • Stiffer handle • Dull lustre	• Duck • Huckabuck 
Wool 	• Can shrink, dry clean • Durable • Creases drop out • Absorbent, dries slowly • Breathable, repels rain • Natural elasticity	• Soft or coarse handle • Good drape • Warm to wear 	• Lambswool • Merino • Superwash • Felt • Tweed • Gaberdine 
Silk	• Absorbent • Durable • Weaker when wet • Dry clean • Creases easily	• Cool and Warm to wear (depends on weave or knit) Soft handle • Good lustre and drape	

Regenerated Fibres

The main regenerated fibres are:

- Viscose
- Acetate
- Lyocell and Tencel

Fibre	Properties	Qualities/Aesthetics	Trade Name
Viscose	• low warmth • absorbent, dries slowly • not durable • creases easily • easy care (wash & iron)	• soft handle • good drape • versatile	
Acetate	• creases easily • easy care • breathable and absorbent • durable	• stiffer handle taffeta • good drape • elegant drape • lustrous	
Tencel & Lyocell	• soft • absorbent • very strong when wet or dry • resistant to wrinkles • it can be machine- or hand-washed or dry-cleaned • it can be dyed many colours	• drapes well • can simulate a variety of textures like suede, leather, or silk	
Rayon	• Dyes easily • Poor insulator (ideal for hot weather • Not very durability • Lowest elasticity retention of any fibre • Very high appearance retention • Dry clean only	• versatile fiber can imitate silk, wool and cotton or even linen • soft, smooth, cool, comfortable	

Synthetic fibres

The main synthetic fibres are:

- **Acrylic** is used for jumpers, *fleece* [**fleece**: *fleece is a modern polyester fabric that is warm and easy care.*] jackets and blankets. It is warm to wear, non-absorbent, and fast-drying, with a soft handle like wool, and a good drape. It is easy to care for, durable and crease-resistant.
- **Polyester** is used for raincoats, fleece jackets, children's nightwear, medical textiles and working clothes. It has a soft handle, a good drape, is very durable, crease-resistant, easy-care, non-absorbent, and fast drying. It can be recycled, but has low warmth.
- **Nylon** (Tactel) is used for active sportswear, fleece jackets, socks and seat belts. It has a soft handle, a good drape, is non-absorbent, fast drying, very durable, crease-resistant and easy-care. However it has low warmth.

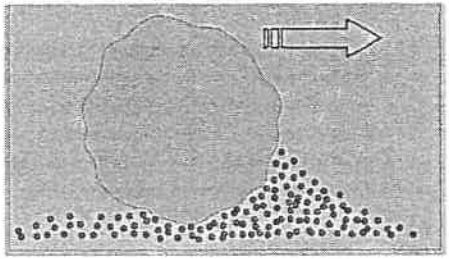
Fibre	Properties	Qualities/Aesthetics	Trade name
Acrylic	• Warm to wear • Non-absorbent, fast drying • Crease resistant • Weaker when wet • Burns slowly then melts	• Good drape Durable • Easy care • Stiffer handle like wool	• Courtelle • Amicor 
Polyamide	• Warm to wear • Absorbent, dries slowly • Breathable, repels rain • Durable	• Soft or coarse handle Can shrink, dry clean • Good drape • Creases drop out	• Nylon • Tactel • Tactel Micro • Aramids Like Kevlar Nome 
Polyester	• Low warmth • Non-absorbent, fast drying • Very durable • Creases resistant • Can be recycled • Strong when wet • Resists bacteria	• Soft handle • Good drape • Easy care • Versatile	• Trevira • Finesse • Miratec • Dracon • Terylene • Polyester fleece 
Elastane	• Very elastic • Lightweight • Strong • Resists sunlight and biological damage Medium to coarse filament fibres • Used only as blend 2%-5% • Very poor absorbency	• Blended to make clothes more comfortable (cotton and Lycra in Jeans for example)	• Lycra • Spandex 

Modern fibres

Micro-fibres:
Polyester or nylon micro-fibres are 60-100 times finer than a human hair (the diagram below shows what they look like up close):

- Micro-fibres can be blended with other synthetic or natural fibres.
- Micro-fibres are used for outdoor-pursuits clothing and active sportswear.
- Thermoplastic polyester or nylon micro-fibres can be heat-treated to give them coils, crimps and loops, which makes these textured yarns stretchy and warm. They are used for underwear, sportswear, knitwear and carpets.

Cotton versus Tactel Micro



Speciality Fibres:

Polyethylene microfibers make the strongest fibres you can imagine. They are from the family of polyamides.

Nomex: Flame resistant
Kevlar: Bullet proof

BIO Fibres

In recent years, there has been much interest in looking at new ways to create fibres and fabrics which are environmentally friendly and made from renewable resources.
Synthetic fibres are usually made from crude oil which is a non-renewable resource.
Environmental and sustainable problems:
1) Oil used to make fibres is a *non renewable resource* – it cannot be replaced
2) The production of some chemical fibres pollutes the environment.
So scientists and technologists are developing new, more environmentally sustainable fibres which are

- *developed from low cost natural resources using sustainable plants and trees*
- *produced by clean processes which are environmentally friendly.*

Bio fibres include a range of fibres which have been developed and manufactured from natural resources. Most of these resources are renewable and include soya, sweetcorn, bamboo and wood.

- **Sweetcorn fibre** is a *polylactic acid fibre* (PLA) made by fermenting the corn.
- **Soya bean protein fibre** is a type of *regenerative plant fibre* made by extracting then changing the protein, and wet spinning to make fibre.
- **Milk fibre** (casein fibre) is made from casein into a *polyamide* like nylon - but should milk protein be used for fibre?
- **Bamboo fibre** is a *regenerated cellulose fibre*

Fibre	Properties	Qualities	Uses
Sweet Corn Fibre Polylactic acid fibres (PLA) 	• High strength, high dimensional stability, and high resilience • Resistant to ultraviolet light - more than most other synthetics • Lightweight • Good wickability • Biodegradable • Thermoplastic	• Comfortable 	Ingeo • clothing, • bedding • household textiles items such as cleaning cloths.
Soya Bean Fibre 	• Absorbs moisture similar to cotton • Eco-friendly since • it's a renewable natural resource • Filament	• Luxurious appearance and is soft, smooth and light • Good anti-pilling and drape properties	• Used for spinning and knitting • Mixing with other fibres 
Bamboo Fibre 	• It wicks away moisture from the body keeping you dry and comfortable • Absorbent • The fibre is naturally antibacterial • Bamboo fibre is 100% biodegradable. • Grows very fast hence its sustainable	• Bamboo fabric is smooth and very soft • The fabric is 3-4 times more absorbent than cotton 	• Mixed with cotton, hemp and silk • Clothing • Towels
Milk Fibres **Protein fibre like silk and wool** 	**Properties** • Smooth and soft • Expensive as not much produced • Durable	• Retains shape • Very comfortable to wear	• Socks • flannels • Knit wear 

YARNS

Yarn is a continuous length of fibres or filament, with or without twist. Fibres made from staple fibres like cotton are called **staple yarns**, the ones made from filament fibres, **filament yarns**! The twist makes yarns stronger and prepares them for their end use.

Fibres are often blended to:

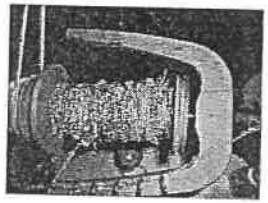
- **Improve in strength**
- **combine properties of each**
- **Create an effect** (fancy or novelty

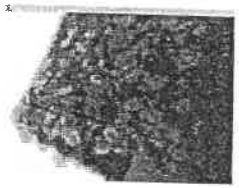
component fibre yarns)

- **Improve the appearance, performance, comfort and aftercare of fabric.** A shirt made from polyester / cotton blend is more easy-care and crease-resistant than a shirt made from 100 per cent cotton.
- **Reduce the cost of an expensive fibre.**
  Cotton / Lycra blend jeans are more comfortable, stretchy and fit better than cotton jeans. Acrylic / wool blend trousers are less expensive than 100 per cent wool trousers.

Examples of yarns:

Single yarn: One yarn is twisted around itself to make a yarn (cheaper yarns)
Ply yarns: Two or more yarns are twisted together (wool for suiting, fine cotton)
Core-spun yarn: A core spun yarn is a multi component yarn, in which the core stays at the centre of the yarn. (Fancy yarns like Bouclé, cotton Lycra mixes in denim)





Bouclé

Exam tip
Make sure that you know the **properties and end-uses** of fibre blends such as polyester / cotton. You'll get extra marks for being able to a fibre's properties to the product it's used for.

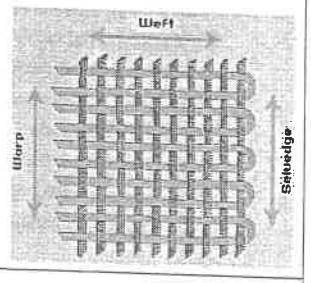
Popular blends:
Elastane/Cotton
Nylon/Lycra
Polyester/Cotton
Cotton/Linen
Silk/Viscose

FABRIC CONSTRUCTION

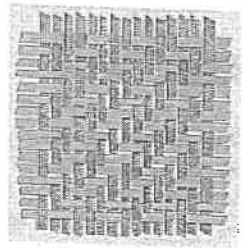
Most fabrics are made by weaving or knitting yarns together. Non-woven fabrics are made by bonding or felting fibres together. A fabric's appearance, properties and end-use can be affected by the way it was constructed.

Woven fabrics
Woven fabrics are made up of a weft - the yarn going across the width of the fabric - and a warp - the yarn going down the length of the loom. The side of the fabric where the wefts are double back to form a non-fraying edge is called the selvedge.
Here are two of the main types of woven fabrics:

Plain-weave fabric
In plain-weave the warp and weft are aligned so that they form a simple criss-cross pattern. It is strong and hardwearing. It is used for fashion and furnishing fabrics.

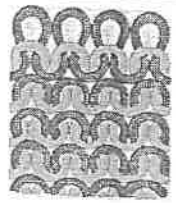


Twill-weave
In twill-weave the crossings of weft and warp are offset to give a diagonal pattern on the fabric surface. Twill weave is strong and *drapes* well. It is used for jeans, jackets and curtains.



Knitted fabrics
There are two types of knitted fabrics weft-knitted and Warp-knitted.
Weft-knitted fabrics

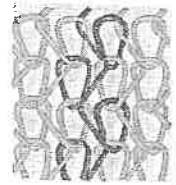
Weft knitted fabric
Weft-knitted fabrics are made by hand or machine.
Weft knits are used for socks, T-shirts and jumpers.
Weft-knitted fabric is made by looping together long lengths of yarn. This makes the fabric stretchy and comfortable
The yarn runs in rows across the fabric. If a stitch is dropped it will ladder down the length of the fabric.



Warp-knitted fabric
Warp-knitted fabric is made by machine and is used for swimwear.

- Warp-knitted fabric is made by machine.
- The loops interlock vertically along the length of the fabric. Warp knits are slightly stretchy and do not ladder.

They are used for swimwear, underwear and geotextiles

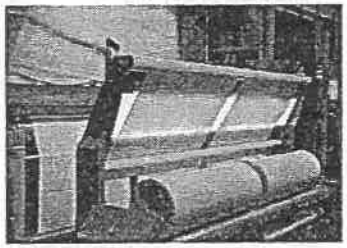


Non-woven fabrics

Non-woven fabric is made by bonding or felting:

- Bonded-fibre fabrics are made from webs of *synthetic* [synthetic: *man-made - usually from chemical sources*] fibres bonded together with heat (using their thermoplastic properties) or adhesives. They are cheap to produce, but not as strong as woven or knitted fabrics. Bonded-fibre fabrics are mainly used for *interlining* [interlining: *layer of fabric sown into the neck or armholes of a garment to protect and strengthen it. Also called interfacing.*]. They are easy to sew, crease-resistant, do not fray and are stable to washing and dry-cleaning.
- Wool felt is a non-woven fabric made from animal hair or wool fibres matted together using moisture, heat and pressure. Felt has no strength, *drape* [drape: *the supple and flexible characteristics of a fabric - how it hangs or behaves when pleated or folded*] or elasticity but is warm and does not fray. Wool felt is expensive. It is used for hats and slippers and in handcrafts.

Fabric Finishes



When a fabric is woven it's usually some shade of beige or grey depending on the fibre. This is called the 'greige'. It has to be treated to make it into a fabric ready for use. It can be washed (to clean away impurities), bleached (to make the colour uniform) and *mercerised* (to make the fibres round and filled out).

Methods:

Piece Dyeing: A roll of fabric is dyed

Continuous Dying: fabric passes through a dye bath. The fabric is then squeezed between rollers to spread the dye evenly and remove excess dye. Continuous dyeing is used for colours that do not need to change too quickly with fashion.

Yarn Dying: The yarns are dyed before the cloth is woven (Gingham etc)

Over Dying: Different yarns are used in the fabric and when its dyed it reacts differently to the dye creating an effect.

Garment Dyeing/ Batch Dyeing: Items are dyed in a certain colour after they have been made. (T-Shirts for example) They are then dyed to order in large batches according to the colours required. Batch dyeing is used for colours that need to change frequently with fashion.

Printing

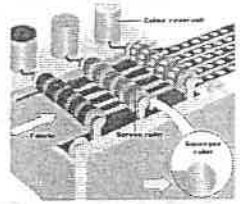
Fabrics are printed by block or screen printing:

- Block printing is done using metal or wooden blocks, one for each colour. The background shapes are cut away to leave a raised design on the block. Dye is applied and stamped onto the fabric. This is a very slow process used by specialised craft industries.
- In screen printing a pattern is printed onto fabric through a *stencil* held in place by a screen. Each screen prints one part of the design in one colour. After printing the dyestuff must be fixed using steam or dry heat.

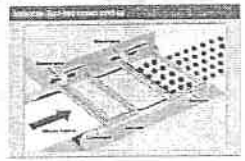
Within screen printing are a whole range of options depending on purpose.

Printing Methods:

Rotary screen printing: The dye is applied through a roller. The ink is pressed from reservoirs inside the roller onto the fabric. It is fast and suited to continuous production.

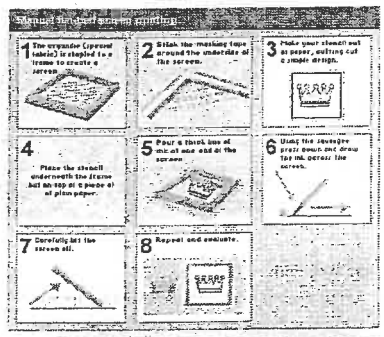


Machine screen printing/ Flat-bed screen printing: Very detailed patterns, top of the range, very expensive. Fabric is moved along on a conveyor blanket and moved along the printing table. It accounts for 20% of the market



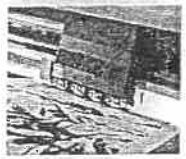
Manual flat-bed screen printing:

Designer and T-shirt prints mainly. Expensive.



Discharge printing: A plain dyed fabric is printed with a resist paste which removes the colour and adds another. Most commonly used on dark fabrics (t-shirts)

Digital printing: In this form of printing micro-sized droplets of dye are placed onto the fabric through an inkjet print head. This is the latest development in textile printing and is expanding very fast.



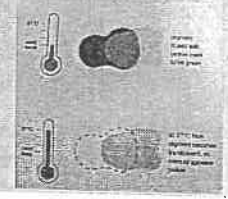
Finishes that enhance the Performance of Fabrics

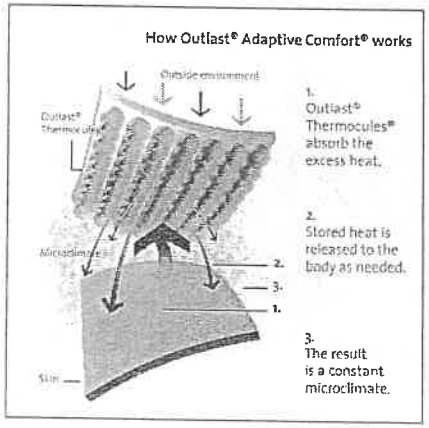
A finish is always given to a fabric to give it certain properties that make it suitable for its end use.

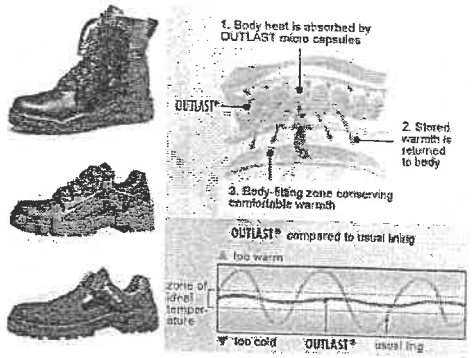
Name	How it's done	Different Types
Physical Mechanical	A machine or tool physically changes the fabric in some way. 	• **Brushing** to create a raised nap (fleece) • **Calendering** is a finish where the fabric is made smoother by heavy rollers pressing the surface. This also creates a lustre or sheen. (Fashion & Interiors) • **Engraved calendar** rollers are used to emboss *relief* patterns on the fabric surface. (Fashion) • **Pressing** is used to smooth the surface of the fabric. This is done with most fabric products at some point to help improve the handle and aesthetic appeal of a product. (fashion & interiors) • **Heat-setting** is used for thermoplastic fabrics (polyester and nylon). The fabrics are set in permanent shapes or pleats.
Chemical	A chemical is used to alter or change the fabric in some way. 	• **Water repellent.** To create this finish, silicone is sprayed on to the fabric's surface to repel water (sportswear). • **Flame resistance** is important for all sorts of products (children's wear, this often makes the fabric stiffer and weaker), (protective work wear). • **Smart Finish**, a finish that can react to the environment (household, fashion, interiors) • **Bleaching**, cotton and synthetic fabrics are bleached before dyeing. This makes it easier to dye pastel shades. • **Mercerising**, cotton or linen fabrics using caustic soda. Mercerised fabrics are stronger, dye well and have improved lustre. Fibre is plumped up it expands and becomes rounder. • **Resin**, cotton and viscose fabrics, crease-resistant finish. This makes them easy-care. They dry fast and smooth and need little ironing. • **Teflon/Silicone**, wool, shrink-resist finish. This results in soft, smooth, lustrous yarns and fabrics that are machine-washable. •
Biological	Bacteria and enzymes are used on plant-based fibres to change them in some way.	• Distressing (jeans) • Bio stoning (stone wash)
Coated	Fabric is coated on one side with a layer of polymer to add a surface that might repel stains or water.	• **Polyurethane coating** is usually applied for water proofing or repelling (Awnings, swimming pools, raincoats) • **Teflon/Silicone**, wool, shrink-resist finish. This results in soft, smooth, lustrous yarns and fabrics that are machine-washable.

Smart Fabric Finishes

Smart finishes are those that can react to the environment. Additives are added to microscopic (tiny) bubbles. These are added to the fibres.
There are three ways in which this can happen:

1. Embedded in fibre or fabric <u>reacts to pressure</u>	• Gives off aromatic scent • Can reduces body odour • Can provide vitamins or reduce skin irritation	• Underwear • anti-bacterial socks • medical textiles • Outlast (absorbs and releases energy) 
2. *Thermochromic* <u>reacts to heat</u>	• Dye can change colour in response to heat. Lasts for 5-10 washes Gives off aromatic scent 	• Children's clothes • sports clothing • fire-fighter's clothing 
1.Photochromic <u>reacts to light</u>	• Smart pigments change colour in response to sun light	• T-shirts; military clothing 





Smart Interactive Fabrics

ON THE FOREFRONT OF NEW TEXTILE TECHNOLOGY

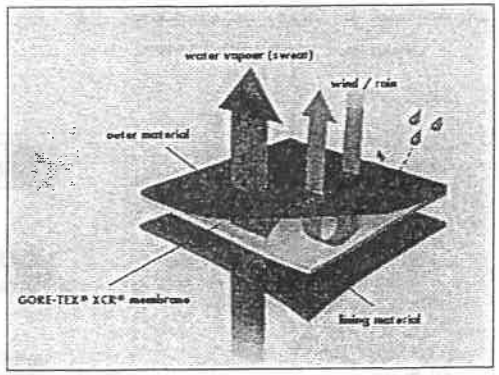
These fabrics incorporate electronics that are activated by a power source. To be interactive you need electronics which need conductivity. It can either be the fabric by use of metallic thread or conductive printing inks. In the yarn by use ofconductive threads.

Example	How it works	Examples of fabrics using the technology
Gorix	Carbonised fibre with conductivity	• The life shirt which monitors blood pressure • Tagging technology which can track a garment • Heated gloves • A track suit that monitors performance
Softswitch	Conductive threads	

Modern Fabrics

Usually made from micro-fibres which are 60 times thinner than human hair. When they are closely woven they are already fairly windproof. However as in Gore-Tex if they are also laminated that makes them super fabrics for sports wear.

Fabric	Technology	Fabric properties	End-use
Polar fleece	Brushed polyester warp knit	Lightweight soft breathable warm	• Fleece jumpers and jackets • blankets
Gore-Tex	Teflon *laminated membrane*	• Breathable • lightweight • waterproof	• All-weather jackets and shoes



Computer-aided design (CAD)

The term computer-aided design includes all the computer applications and hardware devices that can be used to aid digital design. CAD speeds up the design process by making it quick and easy to test and modify ideas before production starts, thus reducing mistakes and cutting costs. Uses of CAD in textiles design include:

- *Wire-frame modelling* [wire-frame modelling: *using a grid of lines to represent a 3D product on a computer screen.*], *surface modelling* [surface modelling : *adding colour, shading and texture to the surface of a 3D virtual product to make it look realistic.*] or *solid modelling* [solid modelling: *use of digital drawings based on geometric shapes, used for solid objects such as car components.*] can be used to *texture map* [texture map: *a computer 'relief map' of a garment design, as if the fabric had been draped onto the design to show how the finished garment will look on screen*] or simulate *virtual products* [virtual products: *3D versions of products shown on a computer screen.*] in 3D, from which clients can choose one to be sampled in fabric. This saves the time and cost of sampling a large selection of real products.
- Graphics applications enable ease the production and storage of accurate *working drawings* [working drawings: *an accurate line drawing to show the back and front views of a product, used on a manufacturing specification sheet.*] and *lay plans* [lay plans: *the laying out of pattern pieces of a fabric to work out the quantity and cost of material required for a product.*]
- *colour ways* [colour ways: *combinations of colours used in a fabric design.*] can be accurately modelled at the design stage
- Material quantities and costs and be easily calculated
- Computer networks improve communication between designers, clients and manufacturers - thus speeding up the design feedback loop.

Designing

Designing is about more than drawing a few products. It involves much knowledge and skills. The first thing is to understand who you are designing for, the target market and its needs. Secondly you have to consider the financial constraints on the product, profit to be gained and volume to be produced. All these considerations impact on the choices you make. When making fabric choices, ask your self the following questions:

- **Fibre content** - should you use *natural* [natural: *derived from animal, vegetable or mineral sources*] or *synthetic* [synthetic: *man-made - usually from chemical sources*] fibres?
- **Fabric construction** - should you use woven, knitted or non-woven?
- **Manufacturing processes** - should you use dyeing, printing, *physical finishing* [mechanical finishing: *treatment of a fabric by a machine, using heat and pressure to improve the fabric's appearance.*] or *chemical finishing* [chemical finishing: *applying a chemical solution or resin to improve the appearance, handle or performance of a fabric.*]?

- **Maintenance.** What are the *aftercare* [aftercare: *how a textile should be washed, ironed, dried or dry-cleaned to maintain its properties.*] requirements of the product?

Combining Fabrics

Fabrics can be layered and combined to improve their handle, appearance or performance. For example:

- An interfacing fabric such as Vilene can be stitched or *laminated* to other fabrics. This reinforces, stiffens and gives strength to collars and cuffs and prevents the fabric from stretching or sagging.
- A quilted fabric has two or more layers sewn together to give an attractive appearance and added warmth.
- Gore-Tex can be laminated to another fabric using *adhesive* or heat. Gore-Tex is used for all-weather clothing and shoes because it is breathable and waterproof.

Aesthetics & Function

The fibre content, fabric construction and finishing processes determine the fabric's *aesthetic* [aesthetic: *relating to shape, style, colour, pattern and other aspects of a product's visual appeal*], *functional* [functional: *relating to the performance of a product - its 'fitness for purpose'*] and comfort properties.

Properties of fabric

Aesthetic properties	Functional properties	Comfort properties
• *Handle* [handle: *how a textile feels when touched such as soft, rough, smooth, warm or cool*] • *Drape* [drape: *the supple and flexible characteristics of a fabric - how it hangs or behaves when pleated or folded*] • Colour • Appearance	• Strength • *Durability* [durability: *the ability of a material to withstand wear, especially as a result of weathering.*] • Crease-resistance • *Flame-resistance* [flame-resistance: *the ability to resist catching fire*] • *Stain-resistance* [stain-resistance: *the ability to resist absorption of water-based or oil-based liquids.*] • Water-resistance • *Aftercare* [aftercare: *how a textile should be washed, ironed, dried or dry-cleaned to maintain its properties.*] • Cost	• Absorbency • *Breathability* [breathability: *the characteristic of allowing perspiration to evaporate*] • *Elasticity* [elasticity: *the ability of a fibre, yarn or fabric to stretch and return to its original shape.*] • Softness • *Stretch* [stretch: *the ability to be pulled out of shape and then recover the original shape. Lycra is a stretch fabric.*] • Warmth

It is important to match fabric properties to the requirements of the product. For example:

- Cycling jackets need to be made from warm, breathable, elastic, windproof, water-resistant fabric.
- Children's jumpers need to be made from soft, colourful, stretchy, warm, easy-care fabric.
- Seat belts, airbags or conveyor belts need to be made from strong, durable, flame-resistant materials.
- Fire protective clothing needs to be strong, durable, flame- and water-resistant. It may also need to be breathable and elastic.
- *Geotextiles* [geotextiles: *textile materials used in contact with soil or rocks in the construction of roads or embankments. They stabilise the land and enable water to filter through.*] need to be strong and durable so they stop embankments from slipping.

Product analysis and evaluation

Designers and manufacturers use product analysis to help them develop ideas for new or improved products. Products are evaluated using standard evaluation criteria for establishing how well a product's design meets the needs of its target market.

Evaluating the Success of the Product

When a product has been designed and prototyped it has to be tested to ensure its actually what the designer set out to do. As a consumer you are relying on their expertise when you buy the product.

Three questions to do just that!

1. Is it fit for purpose?
2. Does it meet the needs of the target market?
3. How well is it designed and made?

Answering the three questions above will normally involve an evaluation of the following *criteria*:

- the product's *design specification*. Does the product measure up to it?
- the product's target market. What are their needs?
- the product's performance, how suitable it is for its end-use, and what its aftercare requirements are
- the quality of the fibres, fabrics and manufacture. For example, how adequate is the stitch type or length, fastenings and *seam allowance*?
- the product's *aesthetic* appeal or stylistic qualities
- the product's price. Does it give value for money?

- any safety or moral issues there might be. Does the product conform to safety regulations? What is its impact on the environment?

Quality of design and manufacture

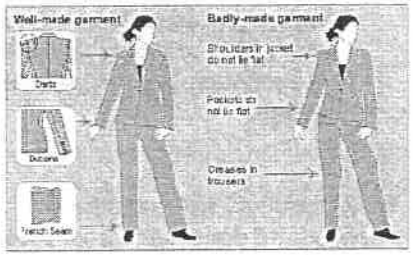
Among the most important design evaluation criteria are those of quality of design and quality of manufacture. These are not the same thing:

Quality of design refers to how attractive a product is to its target market, how well chosen its materials and components are, and how easy the product is to manufacture and maintain.

Quality of manufacture has a more specific meaning. Well-made textile products (ones with a high quality of manufacture) will have the following characteristics:

they use materials that are suitable for the end-use
they match the product specifications
they meet performance requirements
they are manufactured by safe production methods
they are made within budget limits
they sell at an attractive price, and
they are safe for the environment

The graphic shows some of the differences between a well-made and a badly-made garment (one with a low quality of manufacture).



Quality Control & Quality Assurance

Quality assurance is a system of checks and inspections to ensure high standards throughout design and manufacture. QA involves quality control checks which take place a critical control points. Quality assurance assures the costumer that the product will be the same every time it's bought. This is done through rigorous testing and quality checks.

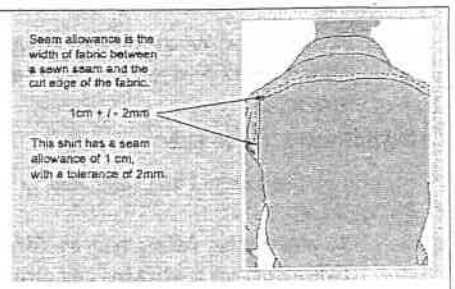
Quality Control are the quality control checks which take place a critical control points. These involve

Critical control points

Quality-control checks take place at *critical control points* (CCPs) in a product's manufacture. The following are typical CCPs in textiles manufacture.

Raw materials: They are tested to make sure they are the correct width, colour, weight and fibre content. Depending on the product end-use, the fabric may be tested for strength, *durability*, crease-resistance, stretch, *shrinkage* or its water-repellent properties.

Prototype: This is a mock-up of the product used to trial a design or pattern, see how materials and components behave, try out an assembly process, work out costs, and test *fitness-for-purpose* in everyday use. *manufacturing specification.*



Production: During production there will be checks for stitch and seam strength, and *seam allowances* are tested to check if they meet the *tolerance* stated in the specification

Final product. This is inspected for size and fit, and to see if the 'look' of the product meets the specification.

Exam tips

1. Make sure you know what a product's *design specification*/ design criteria [design specification: *document containing details of a product's required characteristics, and all the processes, materials and other information needed to design the product*] is - and the difference between this and its *manufacturing specification* [manufacturing specification: *document containing clear and detailed instructions for the manufacture of a product.*]. This is a favourite question of examiners!
2. You need to know the difference between *quality assurance* [Quality Assurance: *procedures put in place at the very beginning of the design and manufacturing process - eg training staff, having common procedures and planning for quality checks - to ensure appropriate standards are met.*] and *quality control* [Quality Control: *the checks made during manufacture to ensure that a product is being made to the appropriate standard.*]. Make sure that you can give examples of the use of quality control in textiles production.

CAD & CAM in Manufacture

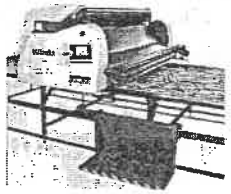
ICT and computer-aided manufacture (CAM)

ICT and CAM play a vital role in modern textiles production. For example, they enable :

- designs to be sent electronically to the print manufacturer and stored on computer to ease repeat printing orders. The printing would be CAM.
- colours to be matched to the design, dyes weighed and dispensed and the fabric printed automatically. CAM
- ICT makes possible the just-in-time ordering of materials and components so they arrive at the factory as they are needed, ie just-in-time for production to start.
- ICT enables companies to transmit information between plants, and manufacture on a global scale.
- Electronic Data Transfer (EDT) such as Epos tills transmit what's sold to central computer and reorders can be placed in an instant. It shortens the TTM time (time to market).

Computer Aided Manufacture CAM

Computer-aided manufacturing involves the use of CAM machines for printing, cutting, joining and many other textiles processes. CNC-automated machines can repeat processes with accuracy and reliability, and are easily re-programmed when changes to design or production run are needed. The graphic shows some of the uses of CNC machines.



- Pick up fabric from the store room
- Spread and cut the fabric
- Label, bundle and transport cut-fabric pieces ready for assembly
- Move cut-fabric pieces around the factory on an overhead conveyor
- Automate processes like buttonholing, inserting pockets or embroidery

Computer-Integrated Manufacturing (CIM)

CIM systems integrate or link CAD and CAM systems. These combined systems link design development, production planning and manufacturing systems together. Companies that use CIM are able to design a product in one country and manufacture it overseas where labour costs are lower.

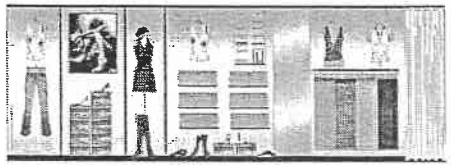
Computer-Aided Design (CAD)

The term computer-aided design includes all the computer applications and hardware devices that can be used to aid digital design. CAD speeds up the design process by making it quick and easy to test and modify ideas before production starts, thus reducing mistakes and cutting costs. Uses of CAD in textiles design include:

- *Wire-frame modelling* [wire-frame modelling: *using a grid of lines to represent a 3D product on a computer screen.*], *surface modelling* [surface modelling : *adding colour, shading and texture to the surface of a 3D virtual product to make it look realistic.*] or *solid modelling* [solid modelling: *use of digital drawings based on geometric shapes, used for solid objects such as car components.*] can be used to *texture map* [texture map: *a computer 'relief map' of a garment design, as if the fabric had been draped onto the design to show how the finished garment will look on screen*] or simulate *virtual products* [virtual products: *3D versions of products shown on a computer screen.*] in 3D, from which clients can choose one to be sampled in fabric. This saves the time and cost of sampling a large selection of real products.

- Graphics applications enable ease the production and storage of accurate *working drawings* [working drawings: *an accurate line drawing to show the back and front views of a product, used on a manufacturing specification sheet.*] and *lay plans* [lay plans: *the laying out of pattern pieces of a fabric to work out the quantity and cost of material required for a product.*]

- *colour ways* [colour ways: *combinations of colours used in a fabric design.*] can be accurately modelled at the design stage
- Material quantities and costs and be easily calculated
- Computer networks improve communication between designers, clients and manufacturers - thus speeding up the design feedback loop.



Health & Safety and Consumer Protection

Consumer rights

Consumer choice and consumer rights

Consumers are influenced by a number of societal, cultural and moral factors, and textiles designers use market research to find out about the wants and needs of their target market. Consumers have rights in law, and you need to know what these are.
Textiles products need to be cared for, and manufacturers use standard symbols to show consumers how to do this. Health and safety are important to textiles designers and manufacturers, as all products must conform to safety standards to ensure they are safe to make and safe to use. Designers have to think carefully about the needs and wants of their target market, and investigating what consumer's value and desire in a product is called *market research*.

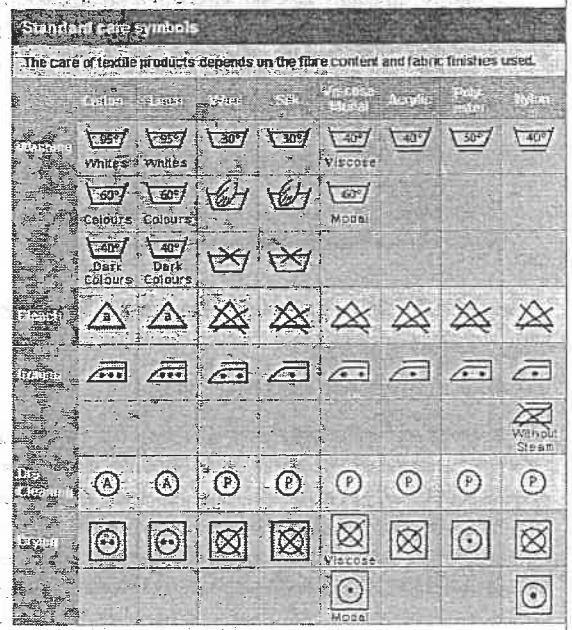
Type of legislation	How it protects you	Example
Trade Descriptions Act	Statements about the product must be true	A 'waterproof' product must not let in the rain
Sale of Goods Act	The product must be of satisfactory quality	The product must perform as expected, eg it should not fall apart after being worn only once
Consumer Safety Act	Nightwear Safety Regulations protect children between three months and 13 years old from fire hazards	Children's nightwear including threads and decoration must carry a permanent label to show that they meet the *flammability* standard

Textile product maintenance

A care label on a textile product gives the consumer useful information about product maintenance. Good labels provide details on:

- *Fibre content* [fibre content: *the percentage of each fibre used to make a fabric, e.g. 50% cotton, 50% polyester.*] (a legal requirement)
- *Flammability* [flammability: *The extent to which something burns with a flame.*] (a legal requirement for children's nightwear)
- Standard care symbols (see diagram below)
- *Standard size* [standard size: *standard measurements of the human body such as size 10, 12, 14, 16.*]

All manufacturers use similar symbols to tell you how to look after your product. The graphic shows these symbols.



- Washing instructions are shown as a washing bowl. Similar symbols are found on washing machines to show different cycles. The number in the washing bowl shows the maximum temperature; the line underneath the washing bowl tells you to use a special wash for *synthetic* [synthetic: *man-made - usually from chemical sources*] fabrics. A hand in the bowl means you can only hand-wash the product.
- Bleaching instructions are shown with a triangle: a cross over the triangle means do not wash with bleach.
- Ironing instructions are shown by a picture of an iron. The dots on the iron show the maximum temperature at which it is safe to iron the product: three dots is very hot, one dot is pretty cool. A cross over the iron means do not iron.
- Dry-cleaning instructions: a circle symbol signifies that it's safe to dry-clean the product. The letter inside tells the dry-cleaners what method should be used. A cross over the circle means do not dry-clean.
- Tumble-drying instructions are shown by a square with a circle inside. The dots show the temperature at which it is safe to dry the product. A cross over the symbol means do not tumble dry.

Exam tip

Exam questions about care symbols are popular. Make sure that you can use the standard care label symbols to explain the aftercare for products made from natural and synthetic fibres.

Health and Safety at Work

The other aspect of safety you need to know about is the law covering the health and safety of those working in textiles production. The most important piece of legislation is the the Health and Safety at Work Act (1974).

The Act makes it a legal requirement for manufacturers to undertake a risk assessment of all the stages of product manufacture; to ensure the safety of workers and prevent industrial accidents. The Act specifies that

- safety procedures must be displayed for all to see
- workers must be trained to use machines and equipment
- appropriate protective clothing must be worn, and
- all risks must be controlled and monitored

How to stay safe in your school workshop

Safety with people	Safety with materials	Safety with machines
Follow safety rules	Wear protective gloves when using dyes	Keep hands away from sharp scissors
Tie back long hair	Take care with hot wax used for batik	Turn machines and the iron off after use
Wear safety goggles	Keep workshop clean and tidy	Put tools away after use

Social, Moral and Ethical Implications of Manufacture

Consumer values and choices are influenced by societal, cultural, moral and environmental issues.

Societal, cultural, and moral factors that impact on textile design.

Societal / cultural / moral factor	Impact
Lifestyle and fashion Gender images and peer group pressure. Fashionable celebrities. Brand loyalty	Development of new street fashions, style and colour trends. Development of new marketing strategies
Globalisation Availability of cheap labour in developing world. New global market for textile fashions. Increasing awareness of textiles from other cultures. Consumer reaction against 'corporate' trends	Textiles costs driven down in a global marketplace for textiles. Growing demand for traditional and 'ethnic' textiles as well as modern ones
Environmental concern Worries about pollution of rivers and beaches from textile processes. Growing support for recycling	Development of new recycled fabrics (eg Polartec, Tencel). Preference for higher-cost traditional fabrics (eg wool) over synthetic ones. Enforcement of laws to protect the environment

There are many companies developing ethical trading policies. That means they that the workers are treated fairly, paid a living wage and profit when a company does well. Traders that are ethical care about their workers.
Not all companies that have an ethical policy can also the fair trade label. That is restricted to the following:
It means someone checked that the company is treating their workers well that the conditions are as good as they can be. It ensures disadvantaged farmers and workers in developing countries get a better deal through the use of the international FAIRTRADE Mark. The FAIRTRADE Mark is a registered certification label for products sourced from producers in developing countries.

ethical trading initiative

The ETI is an excellent website to find out about all the different initiatives and companies. You can also check out the folder with newspaper articles kept at school.

Systems and Practices

Industrial practices are designed to ensure that quality products are manufactured efficiently at a profit. They involve designers working together with clients and manufacturers - all of whom need to keep the needs of the consumer in mind. All production systems consist of inputs, processes and outputs, and there will usually be feedbacks and subsystems as well.
Production methods vary according to the scale and type of textile being produced and range from one-off to mass production, but they all need production plans and a work schedule. ICT and computer-aided manufacturing (CAM) play a vital role in modern textiles production.

Industrial practices

Industrial practices are the designing and manufacturing processes used by manufacturers to ensure that products are made efficiently and at a profit for satisfied consumers. Industrial practices bring together a number of different people and roles, and you need to understand what each of them does and how they relate to each other.

The Client

The client's role is to identify the need for a product (perhaps commissioning some market Research: *Market research is the gathering of data or information concerning consumer opinions about a product or service*), drawing up a *design brief* [**design brief:** *a set of instructions given to a designer by a client.*] for the designer, setting production deadlines and the price of the product. The client is usually a manufacturer or retailer.

The designer

The designer's role is to agree the design brief, and then research market trends, fabrics and processes - taking into account any relevant societal, cultural, moral or safety issues to ensure the product is right. The designer will work to a *design specification*/criteria [**design specification:** *document containing details of a product's required characteristics, and all the processes, materials and other information needed to design the product*], produce a costing for the product, and help plan the product's manufacture.

The manufacturer

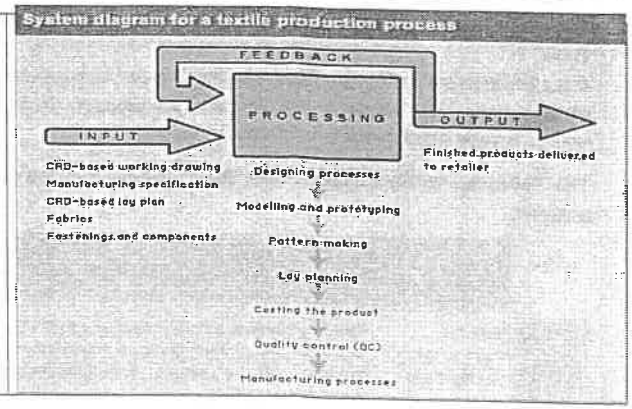
The manufacturer's role is to look any models or *prototypes* [**prototypes:** *one-off working models of a product to find out if the idea works.*] made by the designer, and work out the most efficient way of manufacturing the product. They will then produce a production plan and a *work schedule* [**work schedule:** *a written breakdown of the processes needed to manufacture a product.*]. During manufacture their aim will be to keep material and labour costs down, while producing a high-quality, safe product on schedule in a safe environment.

The user/consumer

The user or consumer's role is to demand a high-quality, value-for-money product, which meets their requirements, is enjoyable to wear, and is safe. Oh yes - and to pay for it when it comes to market.

Systems in textile production

All production systems consist of inputs, processes and outputs. Usually there is a feedback loop as well, to enable the inputs and processes to be modified as a result of quality control checks or feedback from customers. Production systems can be modelled with a system diagram like the one opposite.



Systems and sub-systems

In a production system, a number of different designing and manufacturing processes or sub-systems take place at the same time. Examples of sub-systems are:
Lay-planning is the laying out of pattern pieces of a fabric to work out the quantity and cost of material required for a product.
Costing is working out how much each product costs in terms of including materials, labour, rent and energy costs.
Quality control refers to the checks that take place at all stages.
Some of these sub-systems take place in turn - lay-planning usually takes place before costing, for example - while others will overlap. The entire processing depends on each of these processes being completed correctly, so if one goes wrong the whole system may break down and production may be held up.
Clearly complex production systems need to be controlled, and in textile manufacturing systems control can be carried out with the help of mechanical, electric, electronic or computer control devices.

Production methods

Different scales of textiles production call for different production methods. The main ones are:

One-off production

One-off production is designing and making a single textile product to a client's specification. The garment design is developed from a *basic block pattern* [basic block pattern: *pattern made with standard-sized pattern pieces*], with a *prototype* [prototype: *a one-off working model of a product to find out if the idea works.*] made from inexpensive fabric to test the *drape* [drape: *the supple and flexible characteristics of a fabric - how it hangs or behaves when pleated or folded*], fit and *assembly* [assembly: *the process of joining pattern pieces together to make a product.*] of the garment.

Batch production is manufacturing set quantities of a textile product to order. The prototype is made up in a medium size from the intended fabric. The prototype is checked for quality of design and manufacture, then put into production in a range of *standard sizes* [standard sizes: *standard measurements of the human body such as size 10, 12, 14, 16.*]. The quantity of products can vary from a set of four cushions made by a designer-maker, to 20,000 jumpers made for a department store.

Mass production is industrial-scale manufacture of large quantities of products, usually on a production line. Mass production is suitable for products that seldom need to be redesigned and are needed in very large numbers, eg socks or jeans.

The following table explains how these production methods are used in the textile industry:

system	Product market	Design and production	Skill level and cost
One-off	Made-to-measure, eg suit, wedding dress;	Made-to-measure garments are made to fit the measurements of an individual *client* [client: *person or organisation that wants a product manufactured - eg a retailer.*]; the garment design is developed from a *basic block pattern* [basic block pattern: *pattern made with standard-sized pattern pieces*] and a *toile* [toile: *a prototype garment made from low-cost fabric.*] is made to test the fabric drape, *the fit* [the fit: *how well the size and shape of a garment fits a human body.*] and order of assembly	Very high-level skills in design and manufacture; high-cost materials; high labour costs
One-off	Haute Couture, eg made by fashion houses	Fashion designers such as John Galliano design Haute Couture garments for individual clients	Very high-level skills in design and manufacture; high-cost material and labour costs
Batch production	Ready-to-wear (RTW) designer label, eg Designers at Debenhams	Garments are designed to fit a range of standard sizes and shapes. Garment patterns are developed from a basic block using CAD: *Computer Aided Design - a system which helps the user produce accurate drawings.*. A sample garment is made up in a medium size, from the intended fabric. Once the design has been approved it is put into production in a range of standard sizes. They are sold through up-market retailers.	High-level design, pattern making and sampling skills; cost-effective materials and lower manufacturing costs
Mass production	Mass-market retailers, eg Top Shop	Similar production methods to batch production: garments produced in limited range of sizes; standardised production methods are used to produce a wide range of styles. Most fashion products are batch produced in large batches eg 20,000. Some classic products like jeans are mass produced for a world market.	High-level design, pattern making and sampling skills; cost-effective materials; products often made overseas where labour costs are low

Production planning

Production plans and work schedules are important planning tools in batch and mass production.

The production plan should set out information about all the stages of production, so that every product is made to the same quality. See example below:

The manufacturing specification
The pattern pieces
The lay plan
Work schedule
A flow diagram to show where and how to check for quality

Each production plan should include the following stages:

- The preparation stage details the amount of materials to buy-in, preparation of *garment patterns* [garment patterns : *the separate pattern pieces of a garment such as the back, front and sleeves*], *templates* [templates: *making aids which help you put the same things in the same place on each item. They can be cut out of wood, card or other materials. In textiles for example a template will help you place buttons.*] and *lay plans* [lay plans: *the laying out of pattern pieces of a fabric to work out the quantity and cost of material required for a product.*].
- The processing stage details the *fabric spreading* [fabric spreading: *spreading out fabric in layers ready for cutting.*], cutting, labelling and *bundling* [bundling: *putting cut fabric pieces into identical bundles ready for assembly.*] of the fabric pieces.
- The assembly stage contains instructions for *fusing* [fusing: *a method of joining two materials together. In textiles this involves joining fabrics together using an adhesive resin.*], *joining* [joining: *attaching to materials together. In textiles this involves stitching, fusing or heat-sealing the materials together.*] and *pressing* [pressing: *using dry heat or steam to shape, stabilise and set textile materials.*] the separate product parts.
- The *finishing* [finishing: *final processes in garment manufacture - including overlocking, pressing, and decoration*] stage gives instructions for decorative/functional finishing and final pressing.
- The packaging stage explains how to label, hang, fold, and cover the product ready for transport to the retailer.

Some manufacturers use computer software to handle the detailed information in the production plan. Any changes made to the plan are quickly available to each member of the production team.

Work schedule:

A work schedule sets out instructions about the order of *assembly* [assembly: *the process of joining pattern pieces together to make a product.*], the stitch type, the processes to be used, the time each process will take and the *seam allowance* [seam allowance: *the amount of material between the edge of a fabric and the seam line.*]. See the example of a work schedule below:

Work schedule below for a skirt

Order of assembly	Stitch type	Process	Process time in minutes	Seam allowance
1	Lockstitch	Stitch pockets	2.00	1.00cm
2	Lockstitch	Stitch pockets to front	2.00	1.00cm
3	Overlock	Join back seam	1.00	1.00cm
4	Lockstitch	Insert zip	2.00	0.20cm
5	Overlock	Join side seams	1.50	1.00cm
6	Lockstitch	Join waistband to top	2.50	0.60cm
7	Blind hemming	Turn up hem	1.50	0.20cm
N/A	N/A	Total process time	12.50	N/A

Industrial sewing machines

In industry a range of different sewing machines are used for stitching seams, embroidery, buttonholes etc. The main ones are listed in the table below:

Machines and there uses

Industrial machine	Method of control	Joining process	Used for
Lockstitch	Electric	Lockstitch	Straight seams
Lockstitch	Electric	Zigzag stitch	Stretchy knits; finishing edges
Overlocker	Electric	Stitches, cuts and finishes seams in one process	Non-fraying seams; stretchy seams
Seamcover	Electric	Flat seam	Knitted hems; belt loops on jeans
Linking	Electronic; CAM	Joins knitted fabric stitch by stitch	Knitted seams
Automatic buttonhole	Electronic; CAM	Lockstitch; chainstitch	Buttonholes
Computer Numerically Controlled (CNC)	Computer software; Electronic; CAM	Lockstitch; zigzag; embroidery	Making collars; labels; logos; embroidery

Pressing

Pressing is done to shape, *stabilise* and *set* textile materials using dry heat or steam. In industry pressing can be done using specialist equipment or by hand. The main methods for pressing are outlined in the table below:

Methods for pressing

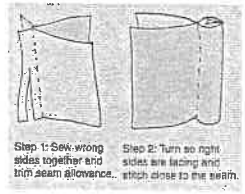
Stage of manufacture	Pressing operation	Equipment	What it does
Product assembly	Under pressing	Pressing unit	Reduces shrinkage; removes creases; makes sewing easier
Product assembly	Moulding	Pressing unit; ironing and sleeve boards	Stretches and sets 3D shapes in fabrics eg at top of sleeve
Product assembled	Top pressing	Steam dolly; tunnel finisher; flat-bed press for trousers	Final pressing makes the product ready for sale

Methods of joining Materials

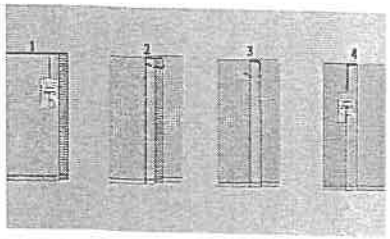
There are different seams to join materials. Some materials like wetsuits are actually heat sealed through their thermoplastic properties. Most things still require the sewing machine. Depending on the thickness of material you can use:

Plain or flat seam: For most fabrics lightweight to heavy weight. Most commonly used seam. It's also the fastest and hence the cheapest.

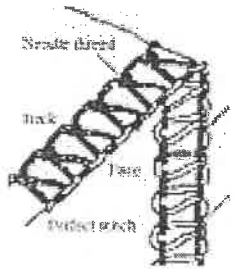
French seam: For very light fabrics that tend to fray such as chiffon

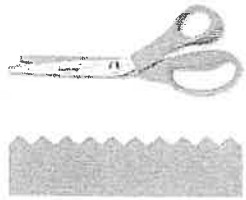


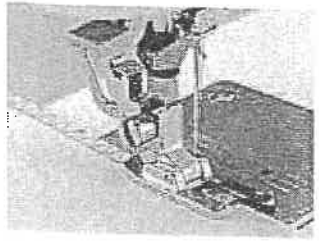
Flat fell seam: Gives strength to a heavier weight product such as denim.



You can neaten seams using the over-locker, zigzag stitching or pinking with pinking shears. The seam allowance is vital to make an accurate product and describes the distance from the edge of the fabric to the stitching line.

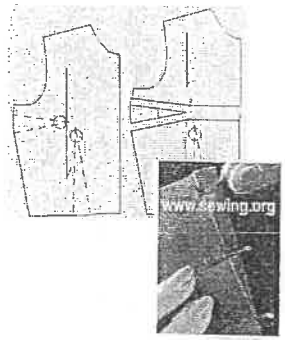


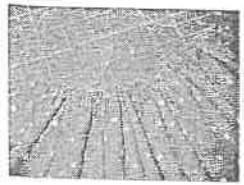




Shaping Techniques

Fabric is shapeless, you give it shape! How?
Darts, pleating, gathering that's it, easy!





Information sheet: Cotton fibres

Cotton fibres come from the seed pod of the cotton plant. It is grown in over 80 countries including the USA, China, India and Pakistan. Usually grown as an annual shrub, its height varies from 25cm to over 2m; it needs plenty of water during growth and heat for ripening. After flowering, the seed pod, or **boll**, develops. The cotton fibres grow around the seeds inside the boll; the outer casing cracks to reveal the cotton fibres.

Cotton production

The bolls can be harvested by hand or machine. In hand picking, only the ripe bolls are collected, not leaves and it is labour intensive. Harvesting by machine is quicker, but collects all of the bolls, whether ripe or not, as well as leaves and twigs.

Next is **ginning** which removes the seeds and other parts of the plant, and separates the very short, downy fibres (**linters**) which are too short for cotton yarn. The longer fibres called **lint** are 15 to 50mm long. They are compressed into bales for transportation to the mill.

There, some bales are opened and the fibres mixed together. The rollers and beaters are fitted with spikes to tease the fibres out, removing lumps and loosening impurities. Jets of air move the cotton fibres along, fluffing them and allowing any impurities to separate. Then, the fibres are formed into sheets known as **laps**, like cotton wool. These are passed into a scutcher which has a revolving beater with two or three blades fixed over a grill which loosens the fibres and removes any remaining impurities.

The carding machine has wire-covered rollers which pull and brush the cotton fibres so that they lie in the same direction and form a soft rope. This is passed through a comb which stretches it out into a thin loose rope called a **sliver** that is wound into a metal can. The cans are transferred to another machine called a **drawframe**, six at a time. The six slivers are twisted together, pulled and drawn out to form a single, stronger sliver. This may be repeated a number of times to achieve the desired effect. The fibres may be **combed** using fine needles if the yarn is to be used for fine fabric.

During **roving**, six slivers are put into the machine and mixed together, stretched and twisted and wound onto bobbins. Now known as **rovings**, they are put through two more machines, two at a time, which pull and twist the rovings further, making them even thinner. They are then spun into yarn.

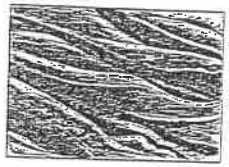
Bobbins are placed on top of a spinning machine, and the rovings are drawn downwards through rollers which stretch and twist the yarn, winding it onto revolving spindles at the bottom of the machine. The amount of twist in the yarn is determined by the speed at which the rollers turn. This is known as **ring spinning**. The yarn can then be woven or knitted into fabric.

The structure of cotton fibres

Cotton fibres are made from cellulose, the building material of all plants. The fibres are strong because of the highly organised cellulose molecules in their structure. The fibres have a kidney-shaped cross-section, and are twisted along their length. The centre of the fibre is hollow, so the fibre can absorb moisture. Cotton can absorb up to 65 per cent of its own weight of water without dripping. Water absorbed in the fibre makes it swell and therefore stronger. Cotton fibres wash well.

Cross section

Longitudinal



Cotton fibres as seen under a microscope

Fibres vary in length between 20 and 40mm. Those less than 16mm long are not spun into yarns. Longer fibres make better quality yarns and are usually finer than shorter ones. Cotton fibres are quite fine and flexible so they will lie close together without trapping much air. This makes cotton cool to wear. Cotton fibres have low elasticity which means that they crease easily.

Information sheet: Flax fibres and linen

Linen yarns and fabrics are made from flax fibres, which come from the stem of the flax plant. The flax plant is grown in about 20 different countries, the major producers being China, Russia, the Ukraine and France.

The flax plant is an annual plant that grows best in temperate climates. It grows to a height of 80–120 cm and has blue or white flowers. The plant reaches maturity after flowering and the seeds produced can be used to make linseed oil.

The plants are harvested in July and August. They are pulled from the ground either by hand or machine, taking the roots as well to ensure the stem is as long as possible.

The first stage of fibre production is **roughing out** or **rippling**. This involves removing leaves, flowers, seeds and other debris from the stems. Next the fibres need to be separated from the woody parts of the stem. The plants are placed in tanks of warm water for five to eight days. The outer stem rots away from the fibres without damaging them. This process is known as **retting**. The stalks are then dried in warm air ovens.

The fibres are separated from the woody parts of the stem by machines that have fluted wooden rollers (a process known as **scotching**). The rollers break down the other woody parts of the stem without damaging the fibres.

During **hackling**, the fibres are combed by machine to straighten them and make them lie parallel. The longer fibres are known as **flax lines** and are used for making twine and lower quality products. The fibres are now formed into slivers and are processed into yarn in a similar way to cotton fibres. They are drawn out and twisted until the required strength and thickness is achieved. At this stage, the yarn is still in its natural and unbleached stage and is known as **grey yarn**. This yarn is treated with mild bleaches or boiled to make it as white as possible so it can take dye.

Once the yarn has been made it is knitted or woven into fabric.

The structure of flax fibres

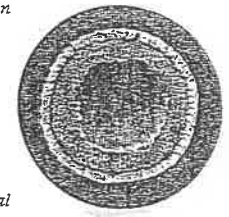
The flax fibres are found in bundles around the outer edge of the plant stem and run from the top of the stem to the root. The bundles are made from individual fibres from 25mm–40mm in length. The fibres are held together by a natural 'cement' to form bundles. This means that, although they are made from cellulose like cotton fibres, they are slightly stiffer and stronger. They are also less supple and have a firmer handle.

Flax fibres are smooth, round tubes with a hollow centre. At intervals, they have joints rather like bamboo canes. They have no elasticity, which means that they crease easily and will split both downwards and across. The hollow centre allows water to be absorbed easily, which also strengthens the fibre making it easy to wash. Linen fabrics dry quickly.

Flax fibres are smoother than cotton fibres, which results in less air being trapped within linen yarn, as the fibres have closer contact. This means that they are cool to wear. The non-fluffy nature of the yarn results in a lustrous fabric that does not attract dirt easily.

The fibres are kept together in their bundles to form long lengths. This improves the quality of the yarns and fabrics produced. The points where the bundles overlap are slightly thicker than the areas in between, and this gives the yarns an uneven texture characteristic of linen fabrics.

Cross section



Longitudinal

Flax fibres as seen under a microscope

Information sheet: Wool fibres

PURE NEW WOOL

Wool fibres are the hairs of animals, usually sheep, although other animals also produce wool fibres. This fact sheet will deal with sheep's wool.

Sheep are found in almost every country in the world, and there are hundreds of different types and breeds of sheep. The best type of wool, soft and fine, is from the merino sheep which is a Spanish breed. The major wool producers are Australia, the former USSR, New Zealand and China.

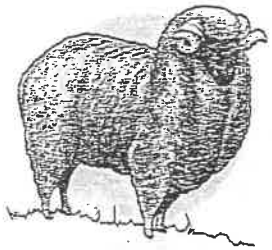
Wool production

The first stage of production is to shear the sheep. This is done using electric shears, and care has to be taken not to injure the sheep, or damage the fleece. The wool from the legs of the sheep is of a lower quality than the rest and is separated out at this stage.

The wool is graded further by dividing it into four categories: 1 for best, 4 for worst. Aspects such as fineness, crimp, length, impurities and colour are considered.

The next stage is to wash the fleece, a process known as **scouring**. The fleece will contain soil, burrs and twigs, as well as grease (lanolin) and sweat. The fleece is washed several times in warm soapy water and rinsed thoroughly.

Once clean the fibres are ready to be spun into yarn. Two different systems can be used. The **woollen** system uses the shorter fibres to produce a hairy yarn. The longer fibres are processed using the **worsted** system that produces a smoother, better quality yarn.



The woollen system

The bales of fibres are broken open and the fibres from various bales mixed together. Any remaining impurities will be removed at this stage. The fibres are treated with oil to help them withstand the various processes involved in spinning.

The fibres are carded by passing them through pairs of rollers covered with fine wires. This combs the fibres, removing lumps and impurities. The fibres are combed to lie in different directions, and they leave the machine as a fine film or web.

The web is then divided into slivers, which are doubled and drafted into thinner rovings ready for spinning.

The rovings are spun by being twisted together and pulled and twisted again until they are the required thickness.

The yarns can then be woven or knitted into fabric.

The worsted system

The longer wool fibres are used for this process, the bales being broken open, mixed and the fibres oiled as in the woollen system.

The next stage is **carding**, where the fibres pass through a machine that combs them to make them lie parallel to produce the smooth yarn.

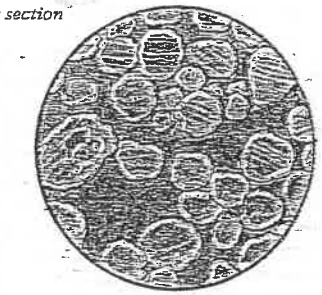
The fibres then go through a **gilling** machine where they pass through a series of rollers which draws the fibres out thin enough to be wound into balls. The fibres are combed again at this stage to improve the alignment of the fibres and to remove any remaining short ones forming the slivers.

The slivers are fed six at a time into a drawframe, which mixes them together ready for spinning. The slivers are placed into cans ready for the next process. The slivers go through a further drawing process to make the yarn smoother and more regular. They are made into **rovings** by more drafting and twisting.

The final spinning process pulls and twists the fibres to the required thickness and strength. They are then wound onto cones ready to be woven or knitted into fabric.

The structure of wool fibres

Cross section



Longitudinal

Wool fibres as seen under a microscope

Wool fibres are made from protein (keratin). The protein molecules run along the length of the fibre, held together in bundles. This gives wool fibres good elasticity, making them resistant to creasing and comfortable to wear.

Heat and moisture can relax the bonds between the protein molecules, which re-form on cooling and drying. This means that wool fabrics can be moulded and shaped to form products such as hats. Care must be taken when washing wool fabrics to avoid damaging the fabric.

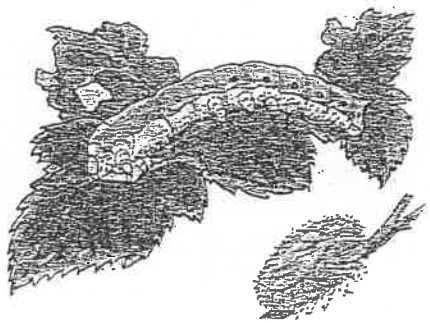
Wool fibres are very absorbent. They can absorb up to 30 per cent of their mass of water vapour without feeling wet. It is the centre of the fibre that attracts the water vapour; the outer surface is in fact water repellent. A thin layer of 'skin' covers the surface of the fibre, which causes the water to form droplets on the surface rather than being absorbed, making wool garments slightly water repellent.

Wool fibres have scales on their surface which hold the wool fibres apart slightly within the yarn. This allows air to be trapped, making wool fibres warm to wear. If the fibres are rubbed and pressed together whilst warm and wet, as may happen during washing, the scales on the surface become entangled with each other. The fabric becomes dense and thickened, losing its warmth. Great care needs to be taken when washing wool garments to prevent this. This characteristic of wool fibres is used to make felt fabrics. The scales on the fibres are made to interlock to form the fabric.

Wool fibres have a natural 'crimp' – they are wavy. This improves their insulation properties as air is trapped between the fibres which are held slightly apart by the crimps. The crimp also improves the elasticity of wool fabrics.

Information sheet: Silk fibres

Silk fibres come from the cocoon of the silkworm. The caterpillar spins a cocoon around itself and changes from a caterpillar, or pupa, into a moth. Silk can only be produced where the mulberry tree grows, as the caterpillars feed on the leaves. The major silk producers are China, India, Japan and the former USSR.



Silkworm Bombyx Mori *and cocoon*

How silk fibre is produced

When the silkworm, **Bombyx Mori**, emerges from its egg it is about 2mm long. It feeds for around 30 days on mulberry leaves and grows to approximately 8cm long. It is then ready to spin a cocoon.

The pupa has two glands that run the length of its body, with openings close to its mouth. These glands produce a sticky protein fluid called fibron, which dries when it comes into contact with the air to form the silk fibre. Two further glands produce a gum called sericin, which sticks the two fibres together as they emerge from an opening just under its mouth.

The pupa fixes a thread to a twig, then using circular movements of the head, winds the thread around its body to form the cocoon. This process takes about three days, and about 3000m of thread.

Inside the cocoon, the pupa becomes a chrysalis then a moth, a process that takes about fourteen days. When it is ready to emerge, the moth produces a substance to soften the cocoon so that it can break out. This breaks the silk threads into short lengths. If the cocoons are to be used for silk production the chrysalises are killed before they are ready to emerge so that the fibres remain intact. This is done using steam or hot air.

The cocoons are placed in hot water to loosen the gum that sticks the cocoon together. The surface of the cocoon is brushed gently to find the end of the thread. As the threads are so fine, between seven and ten threads are twisted together as they are unwound. As the gum hardens again, it sticks the threads together. These threads are wound onto a reel, and are known as raw or greige silk. The reeled silk is a bundle of continuous filaments about 1000m long and is ready to be made into yarn.

Producing yarn

Converting the raw silk into yarn is known as **throwing**. Two different types of yarn can be produced. **Organzine yarn** consists of two or three lengths of raw silk twisted together loosely. This yarn is not particularly strong, but has a good lustre. Doubling the lengths of raw silk and twisting them, then doubling and twisting them again in the opposite direction makes a stronger yarn. This is known as **tram yarn**, and is a stronger, duller yarn than organzine. Both of these types of yarn are known as **nett silk**, and they are used to make high grade, expensive silk fabrics.

Spun silk

A lot of short, waste silk fibres are left over after the longer fibres have been used to make nett silk. These are made into **spun silk yarns**, or **Schappe silk**, which are a lower quality than nett silk and are cheaper to buy. The fibres are washed and the gum removed. They are placed into a machine which combs them straight and cuts them to a uniform length of 15cm. These fibres are separated again into lengths of 15cm and 10cm. Fibres which are even shorter than this are removed and are processed in a different way.

The longer fibres are placed into a machine that makes them into a lap of 90cm wide. This is pulled out into slivers, which are doubled and drafted to make the fibres lie parallel.

The slivers are drafted into rovings ready for spinning, using a similar process to cotton spinning. The yarn produced may be passed through a flame to singe off projecting fibres that would make it fluffy.

Noil silk

Noil silk is made from silk fibres that are too short to be made into spun silk. They are carded and spun into yarns. These yarns are coarser than nett and spun silk yarns and have no lustre. They are also known as **bourette silk** and are used for industrial purposes and sometimes for garments.

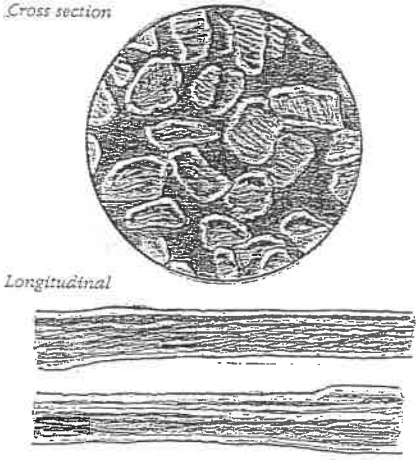
Wild silk

The mulberry silkworm is cultivated for the production of silk fibres. There are also many wild varieties, the most significant of which is the **Tussah**. The cocoons of these silkworms are gathered from trees and bushes in the wild, and often the moth has already emerged from the cocoon, breaking the long fibres in the process. The fibres are coarser and less even along their length than cultivated silk and are difficult to degum. They are heavier and have a harder, less regular feel. They are less shiny their colour is more red/brown than cultivated silk due to the gum which remains on the fibres.

The structure of silk fibres

Cross section

Longitudinal



Silk fibres as seen under a microscope

Silk fibres are made from the protein fibron. They are the only natural filament fibre and are smooth like glass rods. The cross-section of the fibre is rather irregular.

Silk fabrics have the unusual characteristic of being both cool and warm to wear. Filament, or nett, silk is made into fine fabrics which have a small volume of air trapped in them making them cool next to the skin. The layer of air trapped between the skin and the fabric provide a layer of insulation.

Silk is an absorbent fibre. It can hold up to 30 per cent of its weight of water vapour without feeling wet. Liquids are absorbed quickly into the fibres interior. Silk fabrics dye well.

As the fibres are long and smooth, they need little twisting to form a yarn. This means that silk fabrics are very lustrous and soft.

Silk fabrics have good resistance and therefore do not crease easily. They are also the strongest natural fibre.

Information sheet: Man-made fibre production

The production of man-made fibres is based on the way the silkworm makes silk fibres (see page 70). First, a thick, sticky liquid is formed by mixing substances together. This is then forced through a device called a spinneret which acts rather like a watering can, creating strands of fibres rather than jets of water. The fibres are solidified either in warm air, cold air or a special liquid. They are then wound onto a bobbin ready for transportation.

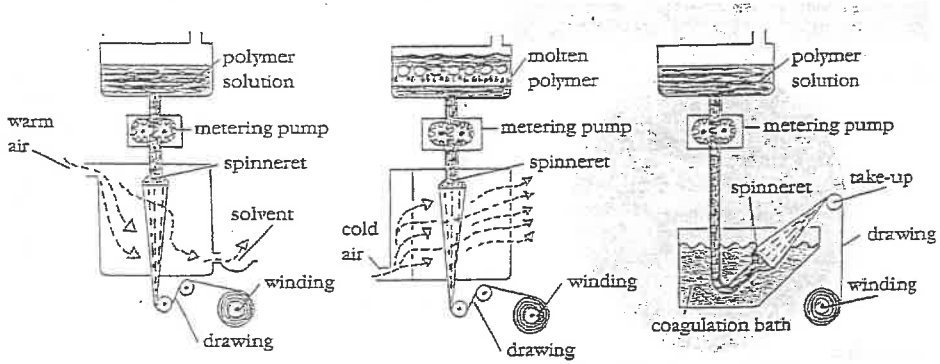
Man-made fibres can be divided into two groups depending on what they are made from.

Cellulosic fibres

These are made from cellulose extracted from plants, for example from wood pulp or cotton linters. A chemical can be added to the cellulose to modify it in some way, or it can be used as it is. In either case, a chemical will be added to dissolve the cellulose so that it can be spun. Examples of regenerated or cellulosic fibres are viscose, modal, acetate and triacetate.

Synthetic fibres

These fibres are made entirely from chemicals. Petroleum is the main source of these chemicals. Synthetic fibres are made from a number of small, simple molecules which have been joined together to form one long polymer. Once the polymer has been formed, it can be dissolved in a solution and passed through the spinneret, or melted. Examples of synthetic fibres are polyester, polyamide (nylon), acrylic and elastane.



Dry spinning – used for acrylics and acetate fibres

Melt spinning – used for polyamide (nylon) and polyester fibres

Wet spinning – used for acrylics and viscose fibres

The production of man-made fibres

Information sheet: Texturing man-made fibres

Continuous filament fibres and yarns which are thermoplastic (can be set in shape by heat) can be given a finish to improve their bulk. This is known as texturing and is done for a number of reasons:

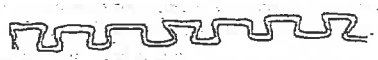
- to increase the volume of the yarn
- to increase the elasticity of the yarn
- to reduce the shine of the yarn
- to improve the insulation properties of the yarn
- to allow moisture to pass through the yarn more easily
- to improve the softness and comfort of the fabric produced from the yarn.

There are a number of ways to texture the yarn:

False-twist

Yarn is passed through a heated chamber and twisted. When the yarn cools, the twist is permanently set in place.

Knit-de-knit

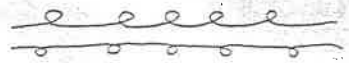


The yarn is knitted into fabric on a circular knitting machine, heated and allowed to cool. The knitting is then unravelled. The loops created by the knitting are permanently set in place, giving a crinkled appearance.

Crimping

Yarn/fibre is warmed and bent over metal. It is left in hot water, and when it has cooled, the crimps are permanent. This adds stretch to the fabric.

Air-jet texturing



Jets of air are directed at the fibre/yarn causing loops and crimps to form. The jet of air is usually cold, but hot air or steam can be used. As this method does not rely on heat setting the finish to make it permanent, it can also be used to add bulk to non-thermoplastic fibres/yarns.

Finishes to man-made fibres

Man-made fibres are made as a continuous filament. That means one long length of fibre is produced which is usually very regular along its length. This gives it a smooth texture. By cutting the fibres into staple lengths and spinning them, the yarn feels more like a natural fibre and has a different set of performance characteristics. Synthetic fibres can also be treated to give them more bulk, improving the stretch and warmth of the yarn produced.

Information sheet: Cellulose fibres

Viscose fibres

These fibres are made from eucalyptus, pine or beech wood. The bark is stripped away and the wood cut up into pieces like matchsticks. Impurities such as resins are removed; the wood is purified and then bleached before being pressed into sheets.

Next, the sheets are soaked in sodium hydroxide solution to make soda cellulose. Excess liquid is removed; the soda cellulose is shredded and allowed to age so that it dissolves more easily.

Carbon disulphide is added to convert the cellulose into a form which is soluble in dilute sodium hydroxide. This is to create the sticky liquid ready for spinning. At this stage, the fibres can be coloured by the addition of dyes, or made less shiny by the addition of chemicals. The viscose is then degreased and filtered before passing through the spinneret immersed in a coagulation bath (see page 72). The liquid in the coagulation bath causes the cellulose fibres to regenerate and become solid. They can then be wound onto a spool.

The fibres are washed and dried ready for use. The long lengths can be cut into short or staple fibres to create different qualities to those the filament yarn has.

Modal fibres are made using a slightly modified viscose process. The spinning process is slightly different and the coagulation bath contains different chemicals. These modifications change the structure of the fibres, improving the strength and properties of the fibres. Modal fibres are used in staple fibre form.

The structure of viscose fibres

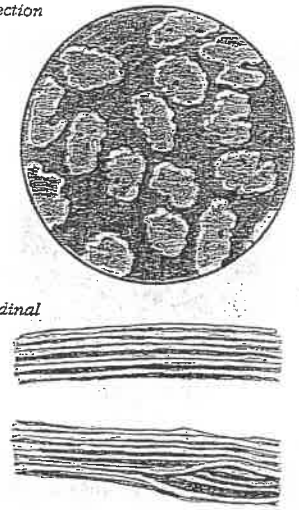
Viscose fibres are made from cellulose. They are very similar to cotton fibres, although the structure of the fibres is slightly different. These differences make viscose fibres weaker than cotton fibres. Unlike cotton fibres, viscose fibres are weaker when wet than when dry. Viscose fibres crease easily, as do all cellulose fibres.

The filament fibres produced by the spinning process are made into smooth viscose yarns that trap little air. This makes them cool to wear.

Cutting the fibres into staple lengths improves the texture and increases the amount of air trapped, improving insulation properties.

Cross section

Longitudinal



Viscose fibres as seen under a microscope

Viscose and modal fibres are very absorbent, more so than cotton fibres. This, plus the fact that the fibres are fine and soft, makes them comfortable to wear.

Viscose and modal fibres take colour and dyes well. They can be made matt or shiny depending on the final treatments given to the fibres.

Environmental considerations

Recent developments have made the viscose production process more environmentally friendly. An organic solvent is used which, when mixed with water, will dissolve the cellulose in a single step. This chemical is less harmful for the environment than carbon disulphide, and the process enables most of the solvent to be recovered and re-used. The fibres produced have a slightly different structure to viscose fibres, and therefore different properties. They are known as lyocell fibres (see page 86).

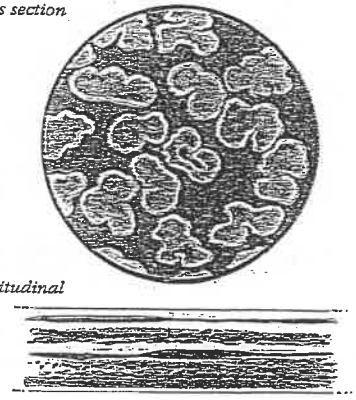
Acetate fibres

These are made from cotton linters dissolved in a solution of acetic acid and acetic anhydride together with a catalyst. Water is then added to the solution and cellulose acetate is deposited as white sediment. This is dried out to form a powder which can be dissolved in acetone. The solution is filtered to remove any impurities and passed through the spinneret. The fibres are dried in warm air to evaporate the acetone and solidify the fibres. The fibres can be twisted to form a continuous filament, or cut into staple yarn and spun.

The structure of acetate fibres

Cross section

Longitudinal



Acetate fibres seen under a microscope

Acetate fibres are a derivative of cellulose, which is modified during the manufacturing process. The fibres are naturally white and do not required bleaching. They can be coloured easily, and the colour can be introduced into the spinning solution. The fibres do not shrink or stretch. Acetate fibres are not harmed by most dry cleaning chemicals, but acetone will dissolve the fibres.

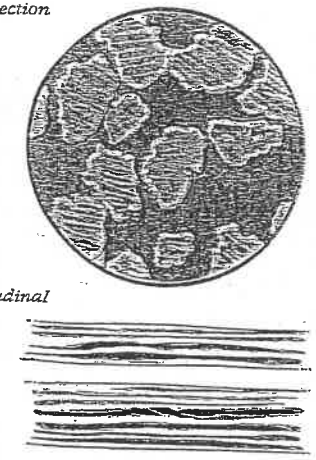
Triacetate fibres

These are a development of acetate fibres. The yarn is made from cotton linters, and the first stage of production is similar to that of acetate fibres. The reaction of the chemicals with the cellulose is complete, and the substance deposited is not soluble in acetone. The powder is dissolved in dichloromethane to form the solution to pass through the spinneret. The fibres are dried in warm air to solidify them.

The structure of triacetate fibres

Cross section

Longitudinal



Triacetate fibres seen under a microscope

Triacetate fibres are a cellulose derivative like acetate and so have similar properties. One difference is that triacetate fibres are less absorbent and so do not take dyes as easily – special dyes have to be used. These fibres are thermoplastic and can be permanently creased or pleated. For this reason they are often mixed with other fibres.

Cupro fibres

Cotton linters are dissolved in a solution of copper and ammonia. This is filtered and passed through the spinneret into a tank of water to solidify the fibres. The bright blue fibres are put into a bath of sulphuric acid to wash out the copper which causes the colour. Cupro is a cellulose fibre with similar properties to viscose. It is not harmed by alkalines, but acids will cause deterioration of the fibres which are weaker when wet. These are not widely used, and production has stopped in some countries due to concerns for the environment. It is mainly used for lining fabrics.

Information sheet 1: Synthetic fibres

Textile fibres are made from linear polymers, very long chain molecules built up from large numbers of simpler, smaller molecules. Plants and animals make linear polymers that are used as natural fibres. Making linear polymers in a laboratory led to the development of synthetic fibres.

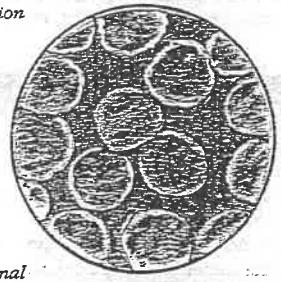
Polyamide (nylon) fibres

This was the first fibre to be made entirely from chemicals. Hexamethylene diamide and adipic acid are combined to form a hot sticky liquid called a polymide. This polymide is forced through a spinneret and into a stream of cold air to cool and solidify the fibres. The filament fibres are drawn, stretched and combined to form a yarn.

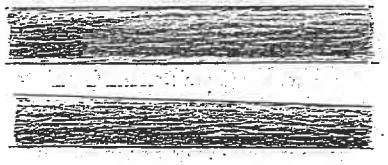
Alternatively, the hot polymide is poured onto a revolving roller while cold water is sprayed onto it. As it cools it solidifies and turns into a solid white strip called a polymer. The strip is cut into 'chips' which can be stored for later use. The chips are re-melted by heating them to form a liquid ready for spinning. The two most important polyamides are nylon 6 and nylon 6.6.

The structure of polyamide fibres

Cross section



Longitudinal



Polyamide (nylon) fibres seen under a microscope

Polyamide fibres are usually smooth and regular with a circular cross-section, but this depends on the spinneret and any treatments that have been given to the fibres. The shape of the cross-section affects the lustre of the fabric produced.

Flat filaments trap little air and therefore are poor insulators. Texturing the yarn allows more air to be trapped, improving insulation. It also creates spaces to transport moisture, improving absorption and comfort. The chemical structure of the fibres makes them resistant to mould and fungi. This means that they do not decompose.

Polyamide fibres are thermoplastic, which means that they can be set in shape by heat. This is a useful property when pleating a fabric for example, and can be used to texture yarns. However, nylon fabrics can be damaged by excessive dry heat, so care has to be taken when ironing polyamide fabrics. The naturally low moisture absorption of the fibres means that polyamide fabrics develop an electrostatic charge. Applying an anti-static treatment can reduce this.

Aramids

These fibres are a development of polyamide fibres and are used mainly for industrial applications. The molecules within the fibre are more organised, improving strength and resistance to high temperatures. They are used for fibre-reinforced plastics and protective clothing such as bulletproof vests, fencing suits, clothing for forestry workers, racing drivers and firefighters. Kevlar and Nomex are examples of aramids (see page 87).

Polyester fibres

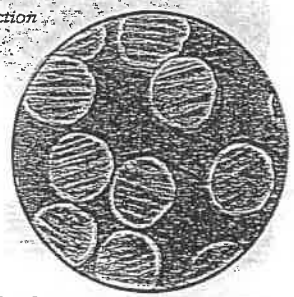
Polyester fibres are made from terephthalic acid and ethylene glycol, which combine to form dihdroxyethyl terephthalate. A series of complex chemical processes result in the formation of polyethylene terephthalate, or polyester.

The liquid is poured onto a roller where it cools to form an ivory-like polymer which is then cut into chips. The chips are melted at about 280°C to form the spinning solution which is forced through the spinneret. The filaments formed are allowed to harden in the air, formed into yarn and wound onto cylinders. The yarn is stretched and drawn and wound onto bobbins.

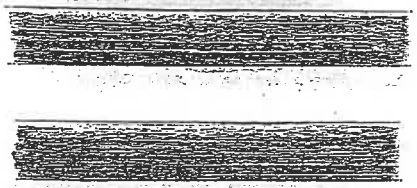
The yarns are usually textured or cut into staple fibres before use.

The structure of polyester fibres

Cross section



Longitudinal



Polyester fibres seen under a microscope

The structure of polyester fibres is very similar to that of polyamide fibres, therefore the performance characteristics are similar too. Polyester fibres are usually smooth and regular with a circular cross-section, but this depends on the spinneret. The fibres may have been adapted for a particular use and have a triangular or five-point star cross-section. The shape of the cross-section will affect the lustre of the fabric.

Flat filament fibres trap little air and therefore are poor insulators. Textured yarns and staple yarns have air spaces and are warmer to wear.

Polyester fibres absorb little water, but the transport of liquid in the spaces between the fibres in a polyester yarn is good. This is known as **wicking** and it makes the fabric more comfortable to wear next to the skin. The low moisture absorption allows the build up of an electrostatic charge, but this effect can be reduced by the application of a finish.

The chemical structure of the fibres makes them resistant to mould and fungi. This means that they do not decompose. Polyester fibres are thermoplastic which means they can be set into shape by heat. As with nylon, this is useful for permanently pleating fabrics or texturing yarns.

Microfibres

Microfibres are very fine, less than one denier thick. (A denier is the weight in grammes of 9,000 metres of yarn. If 9,000 metres weighs 15 grammes, it is a 15-denier yarn.) They are often made from polyamide or polyester fibres as these fibres lend themselves to this process. Microfibres produce a fabric which is lightweight, strong, crease resistant, soft and with excellent draping qualities. A fabric made from microfibres is very dense but still fine.

Many smart fabrics have been developed from microfibres as the hollow centre can be filled with chemicals which will react to the environment in some way (see page 85).

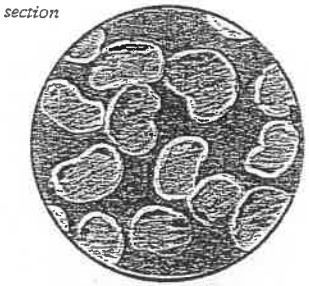
Information sheet 2: Synthetic fibres

Acrylic fibres

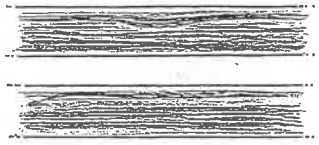
Acrylic fibres are made from propylene and ammonia which are combined to form acrylonitrile. This is made into a polymer – polyacrylonitrile powder – which is then dissolved into dimethylformamide or dimethylacetamide. The solution can be wet or dry spun to form acrylic filament fibres. The filaments are combined to form a tow, crimped and then cut into staple fibres.

The structure of acrylic fibres

Cross section



Longitudinal



Acrylic fibres as seen under a microscope

The crimping of the fibres and cutting them into staple lengths improves the insulation properties of acrylic fabrics by trapping air between the fibres. They are soft and warm, similar to wool.

Acrylic fibres are thermoplastic and can be set into a shape by heat. They are, however, damaged by heat and will shrink badly if overheated, for example if washed at high temperatures or tumble dried.

Acrylic fibres have a low absorbency so dry quickly, but are subject to the build up of static electricity. This can be minimised by an anti-static treatment.

Common cleaning agents, mildew and moths do not harm these fibres. They are not damaged by sunlight, which makes them suitable for furnishing fabrics.

These fibres have a low density, which makes even bulky fabrics light in weight. Acrylic fibres take dyes well, better than most of the other synthetic fibres.

Trade names

Acrylic fibres are manufactured by a number of companies, and many use a trade name for their fibre. These include Acrylan, Courtelle ®, Dolan ®, Draylon ®, Orlon.

Modacrylic fibres

These are modified acrylic fibres. Between 50 per cent and 80 per cent of the fibre must be acrylic polymer, the remainder being made up of chemicals needed to provide the additional properties required. These fibres have similar properties to acrylic fibres, but in addition they are flame resistant. They are used for protective clothing and furnishing fabrics.

Another type of modacrylic fibre is Dunova ®. This is a porous acrylic fibre that contains many micro-capillaries (spaces in the fibres) which can absorb liquids. Fabric made from these fibres is used for thermal underwear that is absorbent and therefore comfortable to wear.

Information sheet 1: The definition of smart and technical textiles

Fibre and fabric technological developments have produced a range of smart, technical and modern textiles with many uses and definitions. This is a summary of some of the definitions of smart and technical textiles:

- **Technical textiles**: These may be defined as 'materials and products manufactured primarily for their technical performance and functional properties'.
- **Interactive or smart materials**: These may be defined as 'fibres, yarns or fabrics which have attributes and functions that protect or aid our bodies or our environment', or as 'materials that can sense and react to environmental conditions and that are produced to perform a particular function'.

Technical materials

These are fibrous materials designed for functional applications. They are found all around us in clothing, upholstery, drapery and carpeting. They are also used within the engineering and medical industries. Technical textiles are not always visible and may form only part of a product.

Examples of the use of technical materials

- house insulation
- strengthening of tyres on cars, hoses, tarpaulins, transmission belts
- for repairing damaged organs or tissues in people – vascular grafts
- medical applications – surgical gowns and masks, casts, bandages, dressings
- agricultural applications – greenhouses, soil cultivation
- air purification
- protective clothing for the emergency services – firefighter jackets, bullet-proof vests
- for providing the correct bounce in a tennis ball
- used in the manufacture of paper
- used in dyeing and finishing of apparel grade fabrics
- used in the manufacture of liquid crystal displays
- used in sporting equipment – bungee cords, climbing ropes, fishing nets.

Information sheet 2: The definition of smart and technical textiles

Smart materials

These are materials that sense and react to environmental conditions and are produced to perform a particular function. There are three groups:

- **passive smart** – which can only sense environmental conditions
- **active smart** – which will sense and also react to environmental conditions
- **very smart** – which can sense, react and adapt to environmental conditions.

An **interactive (smart) textile** involves the integration of a conducting network and a microchip into a fabric to:

- perform computational operations
- conduct electricity
- collect and store energy.

Examples of this are the power-generated gloves and the 'E'-type jacket discussed on page 81.

The development of smart materials has led to a wide range of new products being produced in the following areas:

- aerospace and transport
- telecommunications
- the home and other buildings
- clothing.

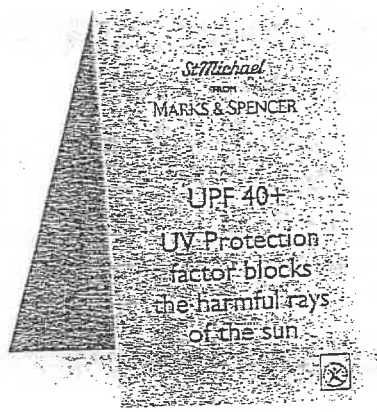
Examples of the use of smart materials

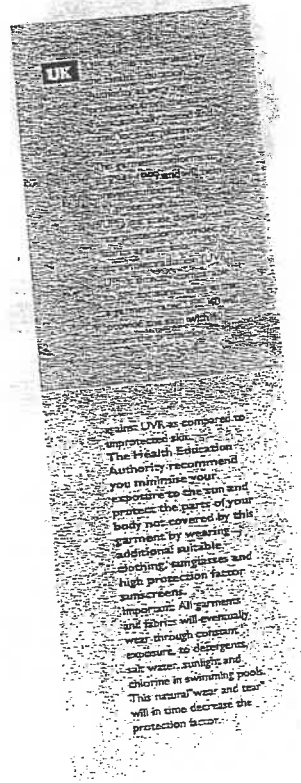
- Smart skins for sound absorption and vibration control are used mainly in transport, e.g. plane seats that can adjust to the shape of the user.
- Micro-encapsulated fabrics are used to enhance the 'feel good' factor, e.g. tights that react to body heat and movement to release vitamins, moisturisers or fragrant oils onto the skin.
- Heat-generating fibres that respond to the environment by changing colour to fit the surroundings are used for combat uniforms in the army.
- Thermo-chromic dyes react and respond to temperature, are used, for example, in children's swimwear to warn of overexposure to sunlight.
- Intelligent polymer systems that measure and respond to movement in the wearer, e.g. the smart bra that changes properties and shape to give better support when needed.
- In the manufacture of artificial muscles – a synthetic silk fabric that has been baked (to strengthen it) and then boiled in a chemical solution to give it elasticity. An electrical charge is used to produce material that expands and contracts like living tissue and muscle.

Information sheet 2: Smart textiles

Marks & Spencer have introduced some ideas based on modern and smart fabrics:

1. Lycra® swimwear designed for children now has UPF 40+ protection from the harmful rays of the sun. The garment will also keep its shape through use and is crease resistant.
2. The use of thermoplastic yarn made from chlorofibre mixed with other materials is a new twist to an old technique. The resulting yarn has the ability to shrink and set but still remain soft and structured. These yarns have been successfully used for hats. The chlorofibre helps the shape of the hat to retain its memory, so that it is more crushable than most hats on the market.
3. Body sensor tights have been developed through an Aristoc (M&S hosiery suppliers) partnership with the Lycra® and Nylon divisions of DuPont. They have developed tights that can respond to changes in the temperature and therefore keep the wearer comfortable at all times.





The Harley Designer Pillow is a unique product that has been developed to help people who suffer from neck and back problems. It is based on material that was originally designed for NASA, who used it to reduce pressure in the space suits of astronauts. The material is very expensive to produce.

Reed Chill Cheater Limited has produced an innovative stretch lightweight fabric that adds to their range of super lightweight wetsuits. The fabric is less restrictive than traditional fabrics and is made from a stretchy, laminated polyurethane outer with a flexible knitted weave inner. The fabric:

- gives the wearer full 100 per cent UV protection from the sun
- is windproof
- is water shedding
- is thermal
- is super flexible, easy to get in and out of and stylish. It is also fast drying and machine washable.

Information sheet 1: Smart textiles

The student book outlines the meaning of a smart material and gives examples of recent developments. However it is important to keep up to date with rapid changes in this area:

- Newspapers are quick to inform the consumer of future smart developments so it is useful to watch the columns.
- Textile magazines and websites are also a valuable resource – see the Heinemann website for lists/links to relevant textiles websites.

Smart clothing on the market

One interesting new development is the smart Anorak, created through a Sony/Philips partnership and it is already on the market. The anoraks or 'E-Jackets' cost from £600, which includes a fitted MP3 player and Xenium phone. The jacket has wires incorporated into the lining to form a complete body area network (BAN) for attaching various pieces of electronic equipment.

Levi and Philips have attached a mobile phone (Xenium GSM) and music player (Rush MP3) into the jacket with a remote control. Microphones and headphones are stored in the collar, which can be extended while the music is playing or the wearer is making a phone call. If the phone rings when the player is in use, it will automatically cut out.

The jackets are not only smart but also fashionable and functional. Unfortunately the cost inhibits many consumers.

Indicator gloves have been manufactured for cyclists based on a padded Tefion and Thinsulate fabric. The gloves are activated by flicking a switch on the index finger of either hand – this sets the four red LED lights flashing which allows the cyclist to be seen. Look up the website for further details at www.indicatorgloves.com.

Finding out more

Two sources that are informative and provide actual examples of smart textiles are:

- *Textile Innovation – traditional, modern and smart textiles*, Ros Hibbert, ISBN 0-9540-1100-7, Line
- 'Get Smart' pack, Michael Woods Ltd, Pickering Croft, Chapel Lane, West Bradford, Clitheroe, Lancs BB7 4SN.

Worksheet: Medical textiles

Fabrics used for medical purposes can be woven or non-woven and need to be suitable for re-use after laundering and sterilising.

Woven medical fabrics

Polyester continuous filaments with tightly woven constructions are the most frequently used fibres in medical textiles because they are low in cost, provide good protection against particles and fluids and are comfortable to wear.

Non-woven fabrics

Polyolefine resin is spun bonded to produce a popular non-woven fabric used in medical textiles. The fabric is formed using a laminate or sandwich construction with a melt blown web.

Function of medical textiles

These textiles have a wide range of applications within the medical field and also in other non-medical areas such as:

- super-absorbents – in nappies, sanitary towels, incontinence pads and wound dressings
- ligaments, arteries and artificial organs
- surgeons' gowns and clothing worn by patients in the operating theatre and hospital
- linen items used during surgery
- vascular grafts, valve replacements, knitted prostheses (replacement body parts) probably one of the strongest ways to join a new part to the body through suturing (stitches).

For further information see the website www.cardiostart.com.

Tasks

1. Explain what you understand by the term 'medical textiles' using the information on this page.
2. Collect a sticking plaster and look carefully at the central fabric part of the structure (use a microscope if you can). Draw carefully what you see and mount the plaster onto your page next to your drawing. Answer the following points:
   a. Is the structure of the fabric centre made from a woven or non-woven fabric?
   b. How would this fabric be made?
   c. What are the advantages of having this type of fabric for a medical aid like a plaster?

Worksheet: Geotextiles

Geotextiles are permeable, natural or synthetic membranes that are flexible and porous (they let water through). They are used in or on soil. The fibres of a geotextile can be either woven or non-woven (bonded).

Woven geotextile fabric

This fabric is made from polymeric tapes that are woven together. Natural fibres are extracted from coconut husks to make coco-fibre geotextiles.

Non-woven or bonded geotextile fabric

This is fabric often made from manufacturer's waste products. It is made from polypropylene used in bottle and fabric manufacturing. The fibres are carded and textured with needles. These break the fibres down and make them stick together. No heat is used. The fabric can be made in different thicknesses.

Function of geotextiles

Geotextiles have a wide application in many areas. A major world-wide use has been in road maintenance and construction.

- They are used in paved and unpaved roads between the base soil and the first layer of road to prevent the loss of sub-base material and to act as a filter and reinforcement for the road.
- They are used as filters in drainage in highway embankments and in repair work.
- This type of fabric filter may be used in household gardens to act as a barrier underneath decking and other platforms. It can also be used to line garden pools.
- They may be used to help with land reclamation, land-fill and waste disposal sites and for erosion control. Coco-fibre geotextiles are used as riverbed and ditch liners. The fabric is non-polluting and natural and can be used on any type of soil.
- Geotextiles have also been used as a protection layer on all-weather surfaces, particularly equestrian.

Tasks

1. List the words in a dictionary that start with the prefix 'geo-'. Explain what these words have in common.
2. Explain what you understand by the term 'geotextile' using the information on this page and from your findings to question 1 above.
3. Using the information on this page and any additional research from the Internet, library, reference books, etc, complete a report about the performance characteristics of a geotextile. Present your report using an ICT method.

Information sheet 1: Smart and modern materials

It is important to have a knowledge of what smart and modern materials are and to be aware of new technological developments in textiles as they become available.

Microfibres

They are man-made from synthetic polymers that come from crude oil. These are fine fibres that can be woven or knitted into fabric. They have the following special qualities:

- microfibres are soft, lightweight, strong and crease-resistant
- maintain even body temperature
- windproof
- breathable
- stop water entering but allow perspiration (as water vapour) to pass out.

Function

- To produce sportswear – particularly for sports in extreme weather conditions.
- For fashion lingerie and leisurewear.
- In interior design.

Micro-encapsulated material

This type of fabric is made from microfibres with a hollow centre. The centre of the microfibres can be filled with tiny crystals of chemicals, vitamins, perfume or anti-bacterial substances. These crystals gradually break down as the fabric is worn and the substances within the crystals are slowly released.

Function

- To promote healing if used in bandages and dressings.
- To promote a feeling of well-being. Aristoc are producing tights that have been encapsulated with specialist treatments. The fibres are micro-encapsulated with special oils and vitamins and are part of the new trend of 'well-being' of clothing.
- To stop odours in clothing – particularly useful in sportswear. There is also a capsule available that stops clothes smelling of smoke.
- To give added attraction – fashion names like DKNY and Calvin Klein are developing capsules that encapsulate their perfumes into clothing fabrics.

Information sheet 2: Smart and modern materials

Lyocell – Tencel

Lyocell is man made from cellulose in wood using a solvent spinning process. It is a biodegradable and environmentally friendly fibre – the wood pulp used to make the fibre comes from managed forests and the manufacturing process uses non-toxic chemicals. It is a strong and durable fibre. It is comfortable and soft to wear because of its natural qualities. It is breathable and absorbent.

Function

- As a fabric on its own or blended with cotton, wool or any other man-made fibre.
- For all types of fashion wear – suits, knitwear.
- For apparel fabrics, especially outerwear.

Teflon fibres

Teflon fibres were founded by Dupont. Teflon is made up of long chain polymers and is called a fluorofibre. This is because of its special qualities:

- stable, tightly packed structure
- good physical, thermal and chemical fibre combination
- low friction and extremely high loading capacity
- heat tolerance
- resistance to water and solvents, so it can be bleached but not dyed.

Function

- Mainly to produce high-performance sewing threads for use in making hot-gas filtration equipment.
- As a non-stick surfacing compound.

Sympatex

This is a very thin **hydrophilic** (water-loving) membrane or laminate, made from polyester and polyether. It has the following special properties. It is:

- breathable
- windproof
- waterproof
- flexible
- lightweight.

Function

- For outerwear and weather wear, Sympatex Healthcare, a manufacturer of scooter and wheelchair weather gear, has introduced a product which provides insulation and comfort through the use of a **Thinsulate** microfibre inner membrane used alongside other fibres to produce a more effective product.
- For sportswear in extreme weather conditions, e.g. mountain bike multi-sportswear allowing for comfort and movement as well as providing protection.
- Bonded onto other fabrics as a lining or insert, to make a textile product more windproof, waterproof or breathable.

Information sheet 3: Smart and modern materials

Kevlar

This is a man-made fibre that is five times stronger than steel but much lighter. As well as being very strong it has cut-resistance properties.

Function

- In construction and body armour protection because it can guard against cuts, abrasions and heat.
- An important component in the production of bullet-proof vests, because of its exceptional strength.
- In the auto industry for products such as tyres, belts, hoses, transmission parts and brakes.

Nomex

This is a man-made fibre that has excellent fire-resistant properties. It can be mixed with a range of different fibres to make a range of fabrics.

Function

Nomex provides the wearer with protection against heat and flames, which is why it is mainly used in areas such as:

- firefighting, racing car driving and plant operatives
- in the interiors of trains and aircraft, car interior textiles and upholstery
- floor coverings and contract furnishings in hotels, offices and hospitals
- oven gloves!

Synchilla

This is a man-made fibre using polypropylene (as most fleece materials are). It is made from recycled fizzy drink bottles that have been chopped, washed and converted into flakes. They are then melted and spun into fine fibre. These are knitted into a fabric which is then brushed to raise the surface and give the feel of fleece.

Function

- Like other fleece fabrics for outerwear, sports and fashion.
- Synchilla Snap-T garments (fleece effect pull-on tops etc.).