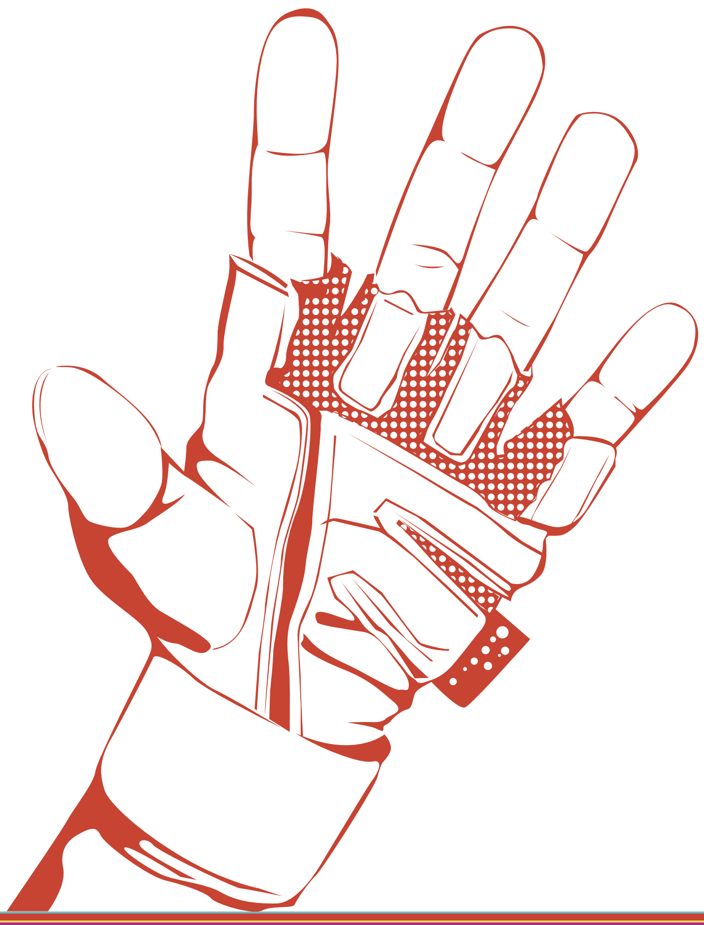
DESIGN A SPORTS GLOVE



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CONTENTS

There is a lot of material in this pack. Teachers might find it useful to first read the Teacher notes introduction, and the student Challenge brief.

CHALLENGE BRIEF

YOUR CHALLENGE

Gloves are not just for wearing in the winter to keep your hands warm. There are many different types of glove to cater for a variety of purposes. For example, gloves are used in a huge range of sports.

Your challenge is to design a glove to be used in a sport of your choice. You should create a presentation with your proposal for the glove.

THINGS TO CONSIDER

The sport – A basic understanding of either rowing, sailing or canoeing will help

The athletes – A basic understanding of the activity and techniques used in your chosen sport will help

Properties – Consider what properties your glove will need. Don't forget comfort!

Gloves – You could consider what gloves already exist. What is their function/s? What materials are they made from? What design features do they have?

Test – How can you test the appropriateness of different materials for making your glove?

You can now begin to use your researching and testing to inform some initial design ideas.

Designs – Keep a record of all your design ideas making sure they are clearly labelled and annotated. Usually many thoughts and ideas are needed before deciding on a final design.

Aesthetics – What will your glove look like? What colour/s will it be?

Price – While you may not be able to comment on the actual production costs (labour etc.), you could estimate costs of the materials required to make your glove. How much should the gloves be sold for?

PRESENTATION ADVICE

Teams must clearly show how they arrived at their final choices. All proposals and recommendations must be justified – these justifications should form the main part of the presentation.

Communicating and, where possible, modelling ideas in a range of ways, is important to achieve this.

SOME HINTS AND TIPS

Before starting the challenge, think about how to record and log work as it is carried out.

- Think about how to present useful information – the process is just as important as the final proposal
- Use a mixture of verbal, written and visual communication
- Present scientific and technological information, rather than emotive arguments
- Use scientific and technological language and terminology correctly
- Be able to talk knowledgeably about every aspect of your challenge

Consider

- Video recordings and photographs
- Other forms of ICT
- Diagrams and sketches – originals as well as 'worked up' final copies
- Charts and graphs
- Posters, leaflets, handouts
- Swatches (small examples) of the types of materials to be used for the glove
- Live demonstrations

CHALLENGE BRIEF

- **Models 1**

  You may wish to attempt to make a prototype of your glove. If you don't have the skill, or time, to do this from scratch, you could adapt a plain, cotton glove (by cutting, stitching and glueing, including the addition of other materials) . The glove does not have to be ready for use – it can just be another way to illustrate your design.

  You may find these websites useful:

  http://www.glove.org/default.php

  http://www.ehow.com/how_2351991_make-gloves.html

  http://diyfashion.about.com/od/diyaccessories/tp/how_to_make_gloves.htm

- **Models 2**

  If you produce a glove of some kind, you could think about making a mould of your own hand which you could use to model your glove.

  YOU WILL NEED TO ASK YOUR TEACHER ABOUT HOW TO DO THIS.

These are just some things to think about – you may think of more!

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RECORDING SHEET 1: REQUIREMENTS OF SPORT

You have chosen which sport to design a glove for. What does the athlete need the glove to do? Your glove should meet those needs. These are the properties it must have. How might you achieve these properties?

This table may help you to set out your thoughts and findings clearly.

Chosen sport	

Requirement of sport	**Property of glove**	**Ways to achieve property**

RECORDING SHEET 2: PURPOSE OF DESIGN FEATURES

You could use this table to help organise and record your research findings.

Some design features may do more than one thing. You could record just the main purpose or note all of them (you will need to find a way to do this).

Design feature	Purpose
Full-fingered	
Open-fingered thumb and index	
Completely open-fingered (fingerless)	
Mesh	
Cut out sections	
Padding (gel or foam)	
Reinforced areas	
Lining	
Silicone dots	
Elastic wristbands	
Velcro wrist closure	
Pre-curved/bent (ergonomic) shape	
Open palm	
Others ...	

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RECORDING SHEET 3: PROPERTIES OF MATERIALS

You could use this table to help organise and record your research and test findings.
Write in any other properties you want to include. For each of the listed properties, note whether or not the material meets your requirements (possibly with a tick or cross). You might use a rating system, for example: 1 = poor, through to 5 = very good.

	Abrasion resistance	Breathability	Elasticity	Grip	Insulation	Weight	Shrinkage	Tensile strength	Stretch resistance	Water repellency	Waterproof	Wickability	Washability	*Others ...*					
Leather																			
Synthetic leather																			
Synthetic suede (Polysuede)																			
Fleece																			
Nylon																			
Towel																			
Neoprene																			
Spandex or Elastane (eg. Lycra)																			
Others ...																			

{FACTSHEET} BLISTERS AND CALLUSES

Athletes can suffer from blisters and calluses caused by their hands rubbing on the equipment they use

Blisters are the result of short term, very forceful friction (rubbing). Calluses develop over time from less forceful friction. The body forms blisters and calluses to protect the skin.

A 'broken' (or popped) blister can lead to a bacterial infection. Sometimes this can become so bad that it needs to be treated with oral antibiotics.

WHAT IS A BLISTER?

A blister is a small fluid-filled area between two layers of skin; the upper layer is called the epidermis and the lower layer, the dermis.

The fluid is called serum, and is found in blood. It seeps out of tissue surrounding the injury. This cushions the tissue underneath in an attempt to prevent further damage. The epidermis can then heal underneath the fluid.

Sometimes the fluid may contain blood - this occurs when a blood vessel has also been damaged. Sometimes it contains pus - if the blister has become infected.

If infected, the skin around the blister turns red or thin red streaks appear. Medical attention should then be sought.

CAUSE

In addition to friction, blisters can also be caused by burns (hot and cold), chemical exposure or infection.

PREVENTION

Athletes can prevent blisters if skin on the hand is allowed to toughen slowly through gradual training. Calluses (see below) will then form rather than blisters.

Blisters are more likely to form, in moist warm areas, so keeping the skin dry can also help their prevention.

TREATMENT

Blisters should be treated to stop them getting larger and prevent infection. There is conflicting views on whether blisters should be left alone or drained by making a small hole with a sterile needle. Either way, the skin over the blister should not be removed.

{FACTSHEET} BLISTERS AND CALLUSES

WHAT IS A CALLUS?

A callus is a toughened, thicker area of skin, which protects the layers underneath.

It is caused by long term repeated friction, or pressure, on that part of the skin.

Calluses can cause discomfort, and it is possible for blisters to form underneath them!

PREVENTION

Gloves can help to prevent calluses. However, some athletes are reluctant to wear gloves because they find it reduces their feel and grip on equipment. Furthermore, ill-fitting gloves can make the problem worse.

Calluses can be useful. If looked after correctly, they prevent the skin being damaged. However, they should not be allowed to get too thick, particularly at the edges.

Calluses can be filed or trimmed (cut with a scalpel blade) by a trained medical professional. Chemicals are sometimes used to thin the unwanted skin.

USEFUL WEBSITES

NHS advice on blisters

http://www.nhs.uk/Conditions/Blisters/Pages/Introduction.aspx

Blister treatment advice

http://www.treatblisters.com/

{FACTSHEET} CANOEING

Canoes were first made thousands of years ago in Canada, by the native Indians. They were used for fishing, hunting and transport.

Nowadays, canoeing is enjoyed by many. It can range from a fun, family activity, to a sport in which serious competitors race. Canoeing can be enjoyed on lakes, the sea and rivers, from gentle waters to white-water rapids.

Competitive canoeing requires a great deal of strength, stamina and skill.

The various types of canoeing is, collectively, 'paddling', with the people inside the canoe called 'paddlers'. This is because of the equipment used to move and steer the canoe (see below).

CANOE OR KAYAK?

Canoes are generally open topped and able to hold more than one paddler. The paddlers each use a single-blade paddle. It is these canoes that families will commonly use on their gentle journey down a river. You may also have used one with your mates on a school trip. However, originally people would kneel in the canoe, whereas now, many have bench-type seats.

Canoes built for more adventurous pursuit and competition are enclosed (if not, the water would lap up over the sides and into the canoe). They are still considered canoes though, because the paddler has to kneel and uses a single-blade paddle.

Kayaks are similar to this enclosed canoe. However, the paddler sits with their feet out in front of them, and uses a paddle with a blade at both ends.

CANOEING IN THE UK

The British Canoe Union (BCU) is the umbrella organisation for Canoe England, Canoe Scotland, Canoe Association of Northern Ireland and the Welsh Canoeing Association. It is the governing body for canoeing and kayaking in the UK, responsible for promoting all aspects of the sport, including competition.

The BCU also has a 'World Class Programme' which supports the most talented British athletes, with the aim of winning more medals at the highest level.

{FACTSHEET} CANOEING

CANOEING EVENTS

There are two types of competition canoeing – sprint and slalom.

Canoe Sprint is a race over 500 m or 1000 m, on flat water.

Canoe Slalom involves travelling down a 300 m stretch of rough, white-water rapids. In addition, the paddler has to guide the canoe through a series of poles (gates). If any gate is missed, or a pole touched, penalty times are added.

The different slalom events are called K1, C1 and C2. The letter represents the type of 'canoe' (i.e. K = Kayak and C = Canoe). The number refers to how many paddlers are in the canoe or kayak. There are both men's and women's K1 events, but only men compete in the single and paired canoes (C1 and C2).

THE PADDLES

Paddles can be made from wood, plastic or glass fibre. The material of choice for top athletes is carbon fibre. It is significantly more expensive, but it is stronger and lighter than any other material used for making paddles.

Ergonomics is important in the manufacture of paddles. Designs may include ...

- Moulded T-shaped grips, Mushroom grips, or Palm grips
- Dimple patterns and Finger recesses

USEFUL WEBSITES

BCU – www.bcu.org.uk

Canoe England – www.canoe-england.org.uk

Canoe Scotland – www.canoescotland.com

Canoe Association of Northern Ireland – www.cani.org.uk

Welsh Canoeing Association – www.welsh-canoeing.org.uk

GB canoeing – www.worldclass-canoeing.org.uk

International Canoe Federation – www.canoeicf.com

www.gpower.pl

www.kayaksandpaddles.co.uk

www.olympic.org

{FACTSHEET} GLOVES

Gloves come in a variety of designs for a variety of purposes, such as fashion accessories (to keep your hands warm in cold weather), gardening gloves (to protect your hands from dirt and prickles), and oven gloves (to prevent burning your hands on hot trays and dishes).

Gloves are also used in a huge range of sports, including football, cricket, cycling, skiing, baseball, golf, hockey and many more. .

PROPERTIES

When designing gloves, some or all of the following properties are considered:

- Comfort
- Insulation
- Flexibility and suppleness
- Breathability and ventilation
- Water resistance
- Washability
- Weight
- Anti-microbial treatment
- Grip
- Sensitivity and tactility ('feel')
- Stretch resistance and shape retention
- Wickability
- Water repellency
- Durability and abrasion resistance
- Protection (from impact and/or exposure)
- Appearance (the glove must look good!)

The properties needed for a sports glove depends on the type of sport and equipment used. Once these are known, the best materials and designs can be selected.

MATERIALS

Materials commonly used in the manufacturing of sports gloves include:

- Leather
- Synthetic suede (Polysuede)
- Nylon
- Neoprene
- Synthetic leather
- Fleece
- Towel
- Spandex or Elastane (eg. Lycra)

Sometimes the properties of a material make it fit for a purpose. Sometimes the characteristics of a material, such as thickness, effect how well it can perform. Sometimes materials can be treated to improve them or give them an additional property.

DESIGN FEATURES

Some features improve the appearance of gloves. Some features improve their performance: they can help to give gloves the required properties. The types of features found in sports gloves include:

- Full-fingered
- Completely open-fingered (fingerless)
- Cut out sections, eg. Open palm
- Reinforced areas
- Elastic wristbands
- Pre-curved/bent (ergonomic) shape
- Open-fingered thumb and index
- Mesh sections/areas
- Padding (gel or foam)
- Internal liningSilicone/Rubber dots
- Velcro wrist closure

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{FACTSHEET} ROWING

Rowing is a popular sport and comes in many different forms.

Types of rowing include ...

- Traditional boats on a boating lake – enjoyed by many families during the summer
- Ocean racing – competitions on the sea and around the coast
- Rowing machines – not only for those visiting the gym, but fast becoming a sport in its own right
- Fine boats – the familiar racing boat, also known as Olympic class

Competitive rowing requires a great deal of strength, speed and stamina.

ROWING IN THE UK

The popularity of rowing in the UK, amongst people of all ages, is rapidly increasing.

Whilst the International Rowing Federation (FISA) sets the rules and regulations for all forms of rowing, British Rowing is the governing body for rowing in the UK. It is their responsibility to develop and promote the sport in Britain.

It is also the responsibility of British Rowing to select and train individuals and crews (teams of rowers) to represent Great Britain. Elite rowers have to work and train extremely hard to compete successfully at the highest level.

ROWING EVENTS

There are various types of competition rowing, including sweep and sculling.

For sweep rowing, the rower uses one oar held with both hands. So, all sweep boats must have an equal number of rowers – if they didn't, they wouldn't go in a straight line! Sweep boats have crews of two, four or eight. The eight carry a coxswain (cox) who shouts directions and steers the boat. The other crews are referred to simply as coxless pair or coxless four.

For sculling, the rower uses two oars, one in each hand. Sculling boats can be rowed individually (singles) or with crews of two (double scull) or four (quadruple or quad scull).

These different crew sizes and types of rowing are known as 'classes'. Heavyweight and lightweight events are held for each class. All classes race over a straight, flat water course of 2000 m.

{FACTSHEET} ROWING

ADAPTIVE ROWING

Adaptive means that the equipment is 'adapted' to the rower rather than the sport being 'adapted'.

There are four boat classes: Men's singles scull, Women's singles scull, Mixed gender doubles scull and Mixed gender coxed four. All classes race over a 1000 m course.

EQUIPMENT

While some equipment may still be made from wood, most boats and oars are now made from synthetic materials, such as Kevlar and carbon fibre.

Oars specifically designed for racing, have an aerodynamic profile. They are also hollow to reduce weight. They all have grips: moulded plastic, rubber or synthetic suede. Some even include an anti-bacterial agent to stop the growth of bacteria and fungus.

Adaptive rowing boats have special seats, depending on the rower's disability. Some boats (single scull) have buoyancy devices attached, which act as stabilisers.

USEFUL WEBSITES

FISA – www.worldrowing.com

British Rowing – www.britishrowing.org

www.olympic.org

www.crokeroars.com

www.row2k.com

{FACTSHEET} SAILING

Centuries ago, the ability to sail helped to shape the civilised world. Sailing was an important means of transport and enabled mankind to explore the earth, reaching uncharted destinations. Large ships also became fearsome vehicles of warfare. These days people sail for pleasure.

SAILING IN THE UK

In Great Britain, the Royal Yachting Association (RYA) is the governing body for all forms of boating. This includes dinghy and yacht racing, motor and sail cruising, RIBs and sports boats, powerboat racing, windsurfing, inland cruising and narrowboats.

The RYA helps all sailors, from beginners to professionals. It is the organisation responsible for nurturing the talent of our Olympians.

SAILING EVENTS

The number and type of sailing events has changed many times over the years, with different boats popular at different times. Have look at http://www.sailing.org/classesandequipment/index.php to see just how many classes there are. In the Olympic Games, for example, there are currently eight classes of boats ...

Laser	Men's single-handed dinghy
Laser Radial	Women's single-handed dinghy
Finn	Single-handed heavyweight dinghy – open
NeilPryde RS:X	Men and women's windsurfer
470	Men and women's double-handed dinghy
49er	High performance dinghy – open
Star	Men's two-person keelboat
Elliott 6m	Women's match racing

And three classes of Paralympic boats ...

2.4mR	One-person keelboat
SKUD-18	Double-handed keelboat – open
Sonar	Three-person keelboat – open

{FACTSHEET} SAILING

Paralympic equipment is modified depending on the sailors needs. Keelboats are used because they have better stability and more room for the athletes. Currently, the world's best disabled sailors regularly train and compete with able-bodied sailors in 'open' international regattas.

The International Sailing Federation (ISAF) is the official governing body for sailing. They manage the sailing events, train judges and other officials, and develop the rules and regulations for all sailing competitions.

Each race consists of nine separate runs, which each take around an hour to complete. The course will consist of upwind and downwind sections. Athletes gain points according to their position after each run, with one point for first, two for second and so on. The winner is the one with the lowest total of points at the end.

Competitors complete eleven races. They can discard the result of one of these races. The top ten boats in each class then take part in a final for which they receive double points which are added to their overall score. The aim, of course, is still to finish with the lowest possible total of points.

EQUIPMENT

The main components of a sailing boat are the hull, mast, sail(s), ropes, centreboard or keel, and tiller.

Competitors move their boat around the course by adjusting the position of the tiller which in turn moves the rudder from side to side. By taking in and letting out the ropes (which move the sails), the sailor 'catches' the wind in the sail and propels the boat forward. The centreboard is used to prevent the force of the wind blowing the boat sideways. Instead, this force is converted into forward propulsion. The centreboard can be lifted out of the water when sailing downwind, unless it has a fixed keel.

USEFUL WEBSITES

RYA – www.rya.org.uk

ISAF – www.sailing.org

www.olympic.org

{FACTSHEET} TECHNIQUES FOR JOINING MATERIALS

STITCHING WATERPROOF FABRICS

Waterproof fabrics can be breathable or non-breathable. When joining these materials, care needs to be taken to maintain the waterproof properties.

- If a fabric has a waterproof coat, the coated side should be inside.
- Do not make any holes outside the seams, for example when pinning fabrics together. Water can penetrate any hole you make.
- Use 100% polyester thread or nylon thread for heavier fabric. These are strong and will not shred or rot when exposed to water for long periods.
- Use a sharp microfibre needle and change it frequently. Microfibre needles are not wider at the eye.
- Make stitches long, with high tension.
- Seal the seams and stitching holes with a seam sealer. Some paint on, others iron on.
- Coated, waterproof, breathable fabrics should be lined to protect their delicate coating, without lining they will weigh less, but will not stay waterproof for as long.

STITCHES

When making high quality gloves, a sewing machine would normally be used. Tests need to be carried out before starting work because all fabrics will behave slightly differently. Different machines will also function differently. It is often about compromise.

- Shorter stitch lengths make the attachment of fabrics stronger. However, the more holes you create the more holes there are for water to penetrate.
- Stitches with higher tension are firmer. However, too much tension will cause the fabric to pull.
- Needles need to be sharp and large enough to easily penetrate the thickness of the fabric, but no larger, otherwise unnecessarily large holes will be created.

USEFUL STITCHES

Straight stitch (or **lockstitch**) is the most common type of stitch used on a sewing machine. Two threads are interlocked, one from the needle, the other from the bobbin. It is versatile with many uses.

Blindhem stitch can be used for almost invisible hems.

Zigzag stitch can be used on the edge of the fabric to prevent fraying. It is used on stretchable fabrics, including elastic, because it allows fabric to stretch without the stitches breaking.

Flatlock stitch can be used to create a more comfortable flat seam.

Further information can be found at http://www.sewing.org/html/guidelines.html

SEAM SEALER AND FABRIC GLUES

The chemistry involved in bonding two surfaces together is complicated. A glue that sticks to one thing will not necessarily stick to another. This is because the microscopic surfaces of materials are very different. Care needs to be taken in selecting appropriate glue for a particular fabric.

Fabric glues can be permanent (washable) or non-permanent (useful for holding fabric in place before sewing). Some fabric glues can be used to join two pieces of fabric instead of sewing. There are also glues that prevent fraying, or glues that stretch with stretchable fabric.

Bonding fabric is an adhesive material placed between two fabrics, which are then heated (by ironing) to bind the fabrics.

Sealing seams to make them waterproof can be done with glues or tape.

{FACTSHEET} UNDERSTANDING PROPERTIES

Different materials have different properties.
Different properties are suitable for different purposes.
Different gloves have different purposes.
The choice of materials for a glove depends on what it will be used for.
You need to decide what properties are needed and match them to materials.
We normally choose the material with the best combination of properties (at an acceptable price).
Some of the properties and terms, for gloves and materials, are explained here ...

ANTIMICROBIAL AGENT: Fabrics can be treated with an antimicrobial agent. This kills, or slows the growth of, micro-organisms that can cause bad odour and affect the properties of the fabric.

ABRASION RESISTANCE: Abrasion is the result of rubbing a fabric against another surface. Fabrics differ in the amount of rubbing they can withstand before they become worn or begin to tear.

ABSORBENCY: Absorbent fabrics are able to soak up moisture, such as water. Absorbency is not to be confused with wickability (see below).

BREAKING STRENGTH: See Tensile strength

BREATHABILITY: Some fabrics allow air to pass through easily. This is linked to ventilation (see below).

Breathability is often connected with waterproof (see below) fabrics. Fabrics which are both waterproof and breathable have pores which are too small to let raindrops in, but big enough to allow moisture, such as sweat, to evaporate out.

DEXTERITY: This is the ability to move and manipulate (twist, pull, pick up etc) objects. It is particularly related to the use of hands. Dexterity is linked closely to sensitivity.

DRYSOFT: Drysoft describes a material which is able to remain soft and supple even after repeated wetting (through rain, for example) and drying.

DURABILITY: This is how much use a fabric can withstand, before it shows signs of wear and tear. It is closely linked to abrasion resistance and tensile strength (see below).

ELASTICITY: Elasticity tells us how easily a fabric returns to its original size and shape after stretching. It is also called shape retention.

FLEXIBILITY AND SUPPLENESS: Fabrics which are flexible and supple are easy to bend and manipulate. This is linked to elasticity.

FINISH: Some properties, such as breathability, insulation and water resistance, can be achieved by treating the fabric, or 'applying a finish'.

GRIP: Grip depends on the amount of friction between a fabric and the surface it is touching. If a lot of grip is wanted, then designs and fabrics are used which give large amounts of friction.

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{FACTSHEET} UNDERSTANDING PROPERTIES

INSULATION: Insulating materials slow the transfer of heat, keeping things hot or cold. How well a fabric insulates is measured in 'togs'. Good insulators are given a high tog value.

LIGHTWEIGHT: Fabrics vary in weight. Lightweight fabrics are among the lightest.

PROTECTION: Good insulating materials protect from heat or cold. Fabrics and designs may also be used to protect from impact or things such as chemicals. Protection aims to prevent injury and reduce any discomfort or pain.

SENSITIVITY: This is how much a fabric limits the sense of touch. Sometimes it is necessary to use fabrics which don't reduce 'tactility' – the ability to 'feel'. Sensitivity is often linked to the thickness of a fabric.

SHRINKAGE: When fabric shrinks, it decreases in size. In other words, the length or width of the fabric gets smaller.

STRETCH RESISTANCE: Stretch resistance refers to how difficult it is to stretch fabric. A stretching force causes tension.

TENSILE STRENGTH: The tensile strength (or breaking strength) of a fabric tells us how much stretching force (tension) it can withstand, before tearing or breaking.

VENTILATION: Good ventilation requires a good air-flow. Breathable fabrics allow moisture to evaporate through them. Fabrics and designs can be used to improve ventilation and reduce perspiration (sweat).

WASHABILITY: Fabrics may need to be washed regularly. If so, it is important that washing doesn't cause any damage or affect the fabric's properties in any way.

WATERPROOF: A fabric which is completely water resistant and doesn't allow any water to pass through, over any length of time, is waterproof.

WATER REPELLENCY: Fabrics vary in their ability to resist wetting. This does not mean they are waterproof. Initially, water may appear to 'slip off' the fabric (it has been repelled), but in time, some may pass through.

WATER RESISTANCE: Some fabrics are unable to resist any water – it is absorbed and/or passes through the fabric immediately (without resistance). Other fabrics, whilst they may initially repel water, eventually allow it to pass through. The time taken, or the amount of water, required to penetrate the fabric depends on how resistant it is.

WICKABILITY: Wickability refers to how well fabric can absorb moisture, such as sweat, and move it away from the skin. It is different from absorbency as it is not only the ability to absorb sweat. Wickability allows the sweat to move away from the body through evaporation.

WINDPROOF: Windproof fabric prevents air from passing through.

{TEST PROCEDURE} ABRASION RESISTANCE

COMPARING THE ABRASION RESISTANCE OF FABRICS

When you rub a material, it gradually wears away. This process is called abrasion. It may change the appearance of the material. For example, the dull matt surface of stone or metal may become smooth and shiny. This also happens with fabrics, like at the knees of an old pair of jeans, eventually causing a hole.

Scientists and engineers test **abrasion resistance** of fabrics in ways such as:

- putting them in a rotating drum, lined with abrasive material (like sandpaper)
- rubbing them backwards and forwards over a flat abrasive surface.

Replicating the abrasion resistance method used in industry is extremely difficult without the appropriate equipment. The very simple procedure, below, can help you to test the abrasion resistance of various materials. However, you may want to try and think of a better way.

THE PROCEDURE

You can use this procedure to compare how well various fabrics stand up to the wear and tear of being rubbed against other objects.

To test your samples, you need to hold them flat while rubbing with sandpaper for a set number of strokes. Then check to see how much damage has been done.

EQUIPMENT

- smooth flat surface, on which samples are laid
- flat wooden block
- fine sandpaper
- sticky tape
- samples of fabrics, large enough to cover and overlap the smooth flat surface

Note: For a fair test you need to treat all your fabric samples in the same way. That means:

- using the same type of sandpaper
- rubbing each sample with the same number of back-and-forth strokes
- rubbing over the same distance
- pressing down with the same force.

You may wish to test the fabrics when **dry** and when **wet**.

METHOD

1. Draw up a results table like the one on the next page. Record the type of fabric sample in column 1.
2. Describe the fabric's appearance – for example, rough or smooth, shiny or dull, woven or knitted, close or open weave, coated with plastic or rubber.

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{TEST PROCEDURE} ABRASION RESISTANCE

3. Wrap the fabric around the flat surface. Carefully fold it underneath and tape it down to hold it firmly in position. You should now have a flat fabric surface to test.
4. Wrap the sandpaper around the wooden block. Tape it down at the back.
5. Move the 'sandpaper block' forwards and backwards over the fabric, counting the strokes. (One stroke = forward and back again.) Note: You may need to stop after every five strokes or so to 'defluff' the sandpaper.
6. Watch the fabric. If a thread breaks or a hole appears, stop rubbing and record how many strokes it took to break the fabric.
7. If no hole or broken thread appears after 200 strokes, record '>200'. Stop rubbing and record the appearance of the worn fabric – for example, whether it is now:
   - rougher or smoother than at the start
   - shinier or duller
   - changed in colour (because the surface has worn away)
   - any pattern is wearing away.
8. In the last column, note any other observations, such as whether the fabric:
   - stretched or tore as you rubbed it
   - produced dust
   - 'pilled' – that is, formed little balls of fibres rubbed off the surface.
9. Repeat the test for each sample fabric in turn.

If you test plastic- or rubber-coated fabrics, test both the coated side and the cloth side, using separate samples.

RESULTS

Fabric	Appearance at start	Number of strokes to break fabric	Appearance after 200 strokes	Other observations

Share your results with other groups, so you can compare a wider range of fabrics.

QUESTIONS

1. Why might results from different groups give comparisons that are not quite fair?
2. How could you adapt the procedure to make the comparisons more fair?

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{TEST PROCEDURE} ABRASION RESISTANCE

3. Which material appears to have the best abrasion resistance? How can you tell?

You may have tested fabrics made from the same material (such as cotton), but made in different ways – for example: thicker threads, closer weave, knitted instead of woven.

4. From your results, which seems to be more important for abrasion resistance – the type of material, or the way it is made into a fabric?
5. The gloves could be made waterproof by coating with plastic or rubber. Do your results suggest that the coating should be on the inside or the outside of the fabric? Explain why.

{TEST PROCEDURE} COLOUR FAST

FAST, BUT NOT RUNNING

It is very important that team colours stay true to their original. Garment manufacturers want their products to stay looking good for as long as possible – the colours in fabrics need to be 'fast' and they should not 'run'. How can you test how well a dye will stand up to wetting and washing?

THE PROCEDURE

There are two procedures here. Both will ask you to make a judgement. In industry, scientists may compare the colour, by eye, against a reference chart or may even use sophisticated methods with a spectrophotometer (which measures the wavelengths of the light absorbed by the sample).

EQUIPMENT

- fabric samples
- fabric scissors [CARE: SHARP]
- permanent marker pen

for Method: part 2

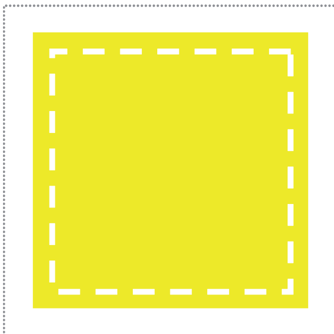
- white cotton fabric
- needle and thread

METHOD: PART 1

1. For each fabric, cut a reference strip and a test strip. You will not need to cut up multi-fibre strips, when you are testing your own dyes. Try to cut accurately along and across the weave of the fabric (the warp and weft).
   Number each reference strip 1, 2, 3 etc.
   Number each sample test strip 1A, 2A, etc.
2. Store the reference strips away from heat, sunlight and water.
3. Carry out the procedures: **wetting, washing and drying** on the sample test strips.
4. After drying, compare each sample with the relevant reference strip. Look at them both in bright daylight and under bright artificial light, such as a desk lamp.
5. Make a judgement about how well the fabric has retained its colour. Ask other team members for their opinion. Record these observations.

METHOD: PART 2

1. For each fabric, cut out a square of fabric. Ensure all the samples are the same size. Number each sample 1A, 2A, etc.
2. Cut out two pieces of white cotton fabric for each of the fabrics you are testing. These should be the same size as the samples.
3. Place each sample between two pieces of the white cotton fabric.
   Sew these together with long stitches. Write the number of the sample on the white cotton.



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{TEST PROCEDURE} COLOUR FAST

4. Carry out the procedures: 'wetting, washing and drying' on the samples. Remove the white cotton and dry alongside the sample.
5. When dry, make a judgement about how much dye has transferred to the white cotton. Look at it both in bright daylight and under bright artificial light, such as a desk lamp.
6. Ask other team members for their opinion. Record these observations.

USING YOUR RESULTS

For immersion in cold water or seawater, which fabric(s) gave the best results?

After washing, which fabric(s) gave the best results?

Which fabric(s) performed well in both tests?

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{TEST PROCEDURE} DYEING FABRICS

TWO TYPES OF DYE

Dyes can be spilt into two main types, **natural** and **synthetic**.

Most natural dyes are produced from fungi and plant materials. Synthetic dyes are manufactured and tend to be more versatile. However, they are often produced using hazardous chemicals, which are dangerous to work with and the production process can produce hazardous waste. Synthetic dyes are not environmentally friendly. The starting material is crude oil, so they do not come from a sustainable resource.

This procedure will guide you to experiment with different types of dye.

THE PROCEDURE

Use this procedure to find out how well different fabrics take up different types of dyes.

Test the quality of the dyes using the procedures: **wetting, washing and drying** and **colour fast**.

A risk assessment must be carried out before you start any practical work.

EQUIPMENT

- multi-fibre strips
- salt
- tripod
- heat-resistant mat
- sieve
- synthetic dyes
- water
- gauze
- thermometer
- balance
- natural dyestuff
- Bunsen burner
- beakers
- tweezers
- eye protection

METHOD

Draw a table like this ...

Dye			Observations					
name	colour	type	acetate	acrylic	cotton	nylon	polyester	wool

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{TEST PROCEDURE} DYEING FABRICS

PART 1: NATURAL DYESTUFFS

1. Label a large beaker and measure 250 cm^3 of water into it.
2. Add 30 g of one dyestuff and a tablespoon of salt.
3. Set up the heating apparatus: Bunsen burner, tripod, gauze and heat-resistant mat
4. Place the beaker on the gauze and bring the dyed, salted water to the boil.
5. Boil for 30–60 minutes.
6. Label a clean beaker and ask your teacher or technician to strain your dyestuff out of the water. DO NOT pick up the beaker of boiling water yourself.
7. Collect a set of multi-fibre strips. You have six fabrics, acetate, acrylic, cotton, nylon, polyester and wool. Identify which is which so you can recognise them after dyeing. Keep an unused labelled set, for reference.
8. Add your multi-fibre strips to your dye and simmer for 45–60 minutes.
9. Remove the strips with tweezers and lay them out to dry.

PART 2: SYNTHETIC DYES

1. This method will vary depending on the dye you use. You will need to follow the manufacturers guide, either on the packet, or given to you by your teacher.
2. Record your observations in the table.

USING YOUR RESULTS

Use your observations recorded in the table to make comparisons between the dyed fabrics. Try to find links between the types of fabric and types of dye. The better the dye has reacted, the deeper the colour will be.

QUESTIONS

1. Which fabrics take up which dye best?
2. In general, are natural or synthetic dyes taken up better by all fabrics?
3. What type of dyes are more colour fast?
4. What type of dyes wash out of fabrics more easily?
5. Why are natural dyes described as sustainable while synthetic dyes are not?
6. What happens when a fabric 'takes up' a dye? Why are some more colour fast or washable than others?

{TEST PROCEDURE} FABRIC FRICTION AND GRIP

GET A GRIP ON IT!

Athletes that use hand-held equipment need a good grip. In scientific language, they need high friction between their hands and the equipment.

Friction is the force that resists one object sliding over another.

THE PROCEDURE

To compare fabrics, measure the force needed to drag each one across the same surface. The larger the force needed, the higher the friction.

EQUIPMENT

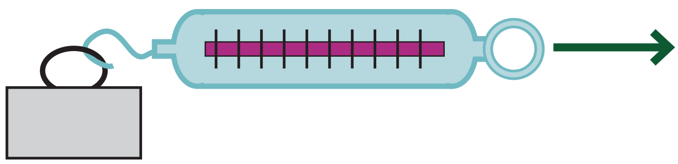
- smooth flat surface, such as a table or bench top
- 1 kg mass
- strong rubber band
- various Newton meters (or tension forcemeters)
- samples of fabrics

You may wish to test the fabrics when **dry** and when **wet**.

METHOD

1. Draw up a results table like the one on the next page.
2. Wrap the 1 kg mass in a fabric sample, holding it tightly in place near the top with a rubber band. Make sure the fabric is flat and smooth underneath the mass.
3. Record the type of fabric in the table.
4. Place the wrapped mass on a smooth flat surface, preferably varnished wood.
5. Hook a Newton meter onto the mass.
6. Pull the meter horizontally – gently at first, increasing the force until the mass **just** starts to move.

   Note: If the mass moves with only a little force, use a meter with a lower range. If it doesn't move before the meter reads maximum force, use a stronger meter.



7. In table column 1, record the force when the mass just starts to move.
8. Repeat step 6 twice more, recording the force in columns 2 and 3. Calculate the mean (average) of your three readings.
9. Repeat steps 2 to 8 with each fabric sample in turn.

If you are testing a rubber- or plastic-coated fabric, test both sides.

{TEST PROCEDURE} FABRIC FRICTION AND GRIP

RESULTS

Type of fabric	Force needed (N)			
	1	2	3	Mean

Share your results with other groups, so you can compare a wider range of fabrics.

QUESTIONS

1. Which fabric appears to give the best grip (highest friction) on the surface? How can you tell?
2. Which fabrics, if any, are particularly slippery (have low friction)?
3. What difference does it make to the results if the fabric is wet? Is this true for all the fabrics tested?
4. The gloves could be made waterproof by coating with plastic or rubber.
   A. Does this increase or decrease the friction? Or does it depend on whether the coating is plastic or rubber?
   B. Do your results suggest that the coating should be on the inside or the outside of the fabric? Explain why.

{TEST PROCEDURE} GLOVES FOR PROTECTION

PRESSURE POINTS, CONTACT POINTS AND FRICTION

People often wear sports gloves for protection. Yet, different sports can damage different areas of the hand. Glove designers need to know where these areas are – which bits of the glove need to provide the most protection? You could ask sportsmen and women where their hands get sore, or look at photos of hand injuries when gloves weren't worn. Or you could try one of these methods ...

THE PROCEDURE

Part 1 of this procedure helps you to work out which areas of the hand come into contact with equipment used in sport. **Part 2** helps you to work out which areas of the hand are subjected to the most friction. You could also use this part of the procedure to investigate the effects of other sports equipment, such as gym equipment.

EQUIPMENT

- plastic tube of appropriate diameter (or use something more suitable for your chosen sport, if necessary)
- washable, water-based paint
- digital camera (optional); you could use a mobile phone

METHOD: PART 1

1. Paint an area of the tube, just wider than your hand.
2. While the paint is still wet, lightly grip the painted part of the tube. Do not squeeze!
3. Take your hand away. Look at your hand to see where the paint has transferred onto your hand.
4. Record your results by asking someone to photograph your hand. Alternatively, make a sketch and/or detailed description of your observations.

METHOD: PART 2

5. Cover your hand with a thin coat of paint. Wait for the paint to dry.
6. Grip the (clean) tube and move it as though playing your chosen sport. You may need to ask someone to put resistance on the tube if appropriate (e.g. when canoeing, water pushes back on the paddle).
7. Check your hands every few seconds to see where the paint has rubbed off.
8. Record your results. You might also be able to feel where the equipment is rubbing – make a note of this.

USING YOUR RESULTS

Remember, we're all different! So, ask several different people to try this procedure. Compare the results and look for similarities.

You could try sketching a glove and indicate the areas that you think need protection.

QUESTIONS

1. What are the limitations of this procedure? How might it be improved?
2. Why is it important to carry out the procedure using several different people?
3. In what ways do your findings affect your glove design?

{TEST PROCEDURE} LIGHTWEIGHT FABRIC

EVERY SECOND COUNTS

Most sports clothing needs to be light – especially in a race situation, where every second counts – while retaining other important properties, such as strength or water resistance.

THE PROCEDURE

When comparing the weight of fabrics it's very difficult to work out which is the lightest when you have small, different-sized samples to compare.

This procedure shows you how to measure and compare the weight of fabrics. You can then calculate the weight of a glove made from each fabric.

EQUIPMENT

- pieces of fabric
- tailor's chalk
- fabric scissors [CARE: SHARP]
- piece of card
- ruler
- balance
- calculator

METHOD

Draw a table like this ...

Fabric	Weight of 5 cm x 5 cm sample (grams)	Weight of 200 cm^2 sample (grams)

1. Cut out a square of card, 5 cm x 5 cm. This is your template.
2. Lay the first piece of fabric on a flat surface. Make sure the fabric is as flat as possible, but do not forcibly pull the fabric to stretch it.
3. Gently lay the template on the fabric. Use a piece of tailor's chalk to draw round the template.
4. Use sharp scissors to cut out the square of fabric.
5. Tare your balance.
6. Place the fabric on the balance. Record its weight in column two of the table.
7. Using the same template, repeat steps 1–4 for the other pieces of fabric.

{TEST PROCEDURE} LIGHTWEIGHT FABRIC

USING YOUR RESULTS

The differences will seem very small, because you are only comparing small samples of fabric. Your glove will contain more fabric than you measured. So, you need to 'scale up' your results.

- What is the area, in cm^2, of the fabric sample you weighed?
- How much smaller is this than a 200 cm^2 sample?
- By what value should you multiply your results to work out the weight of a 200 cm^2 sample of fabric?
- Use this value to complete column three of the table.

Place your fabric samples in order of weight, from lightest to heaviest.

QUESTIONS

1. How would you calculate the area of fabric needed to make a glove?
2. Once you know how much fabric is needed for a glove, how will you use your results to calculate the weight of the fabric needed?
3. How significant do you think the weight differences are?
4. List three ways that you ensured this was a fair test.

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{TEST PROCEDURE} SHRINKING

IT FITS LIKE A GLOVE ..

Garments for top athletes must fit properly. If not, they will be uncomfortable. When fabrics become wet, they can shrink. If garments are made from fabrics that shrink, they change in size, and consequently the fit and comfort of the garment is affected.

THE PROCEDURE

Reference points, a set distance apart, are marked on the fabric. After wetting or washing, you check the measurements again. You can then calculate how much the fabric has shrunk – its shrinkage.

EQUIPMENT

- fabric scissors [CARE: SHARP]
- ruler and set square
- permanent marker pen, such as a ball-point
- assorted fabric

METHOD

1. For each fabric, cut a test square. Ideally they should be 30 cm x 30 cm. All the samples should be the same size. Try to cut accurately along and across the weave of the fabric (the warp and weft).

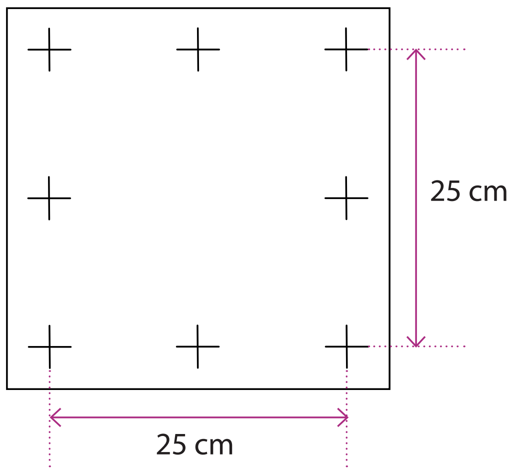
   Number each sample 1A, 2A, etc.

2. Spread out each sample on a flat surface. Hold it down flat without stretching. This will take several pairs of hands! On each sample piece, accurately mark out reference points as shown below.

   Make the marks 2.5 cm in from the edge of the fabric.

   There should be 25.0 cm between the furthest + marks both along and across the fabric.

   This will give three pairs of points, each 25.0 cm apart, along the fabric, and three pairs of points, each 25.0 cm apart, across the fabric. It should be square.



3. Carry out the procedures: **wetting, washing and drying**.
4. After each drying, carefully measure the distance between the + marks along and across the fabric. Record these in a table like the one on the next page.

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{TEST PROCEDURE} SHRINKING

Wetting and drying		**After wetting with cold water/salt water/warm water (circle which)**									
		Measurement along (cm)					**Measurement across (cm)**				
observation		1	2	3	mean	25.0 - mean	1	2	3	mean	25.0 - mean
sample 1A	*25.0*										
sample 2A	*25.0*										
sample 3A	*25.0*										
etc.	*25.0*										

USING YOUR RESULTS

- Are there any differences in shrinkage along and across each sample?
- For immersion in cold water or seawater, which fabric(s) gave the best results?
- After washing, which fabric(s) gave the best results?
- Which fabric(s) performed well in both tests?
- To present your results as percentages, use this calculation:

$$\frac{(25.0 - \text{mean})}{25.0} \times 100\%$$

{TEST PROCEDURE} TENSOMETER

STRETCH RESISTANCE, ELASTICITY AND TENSILE STRENGTH

When you pull a material, it may stretch and get longer. Some materials stretch more easily than others. When you let go, some materials return to their original length, others stay stretched.

Stretch resistance tells us how difficult it is to stretch the material. The higher the resistance, the more force is needed to make it stretch. The stretching force is called tension.

Elasticity tells us how easily the material returns to its original size after stretching. A rubber band is very elastic – it springs back quickly and easily when the tension is released.

Tensile strength tells us how much tension, or stretching force, the material can withstand without tearing or breaking. Scientists and engineers measure tensile strength using a tensometer. This machine stretches the sample with increasing force until it snaps. The tensometer records the force needed to break the sample. The procedure below is a simplified version of this test.

THE PROCEDURE

You can use this procedure to compare the tensile strength of fabrics, and give an indication of a material's stretch resistance and elasticity. To stretch your test sample, you will apply a load by hanging masses on the sample. You then increase the load – each time noting the amount it stretches and how close it is able to return to its original length – until the test sample breaks.

A risk assessment must be carried out before you start any practical work.

APPARATUS

- stand with 2 x clamps
- 2 x wooden blocks
- strong thread
- dowel with a pin or pointer attached to one end
- sticky tape
- 30 cm ruler
- 2 x 100 g mass hangers and masses
- box of crumpled paper
- samples of test materials, 40 cm x 1.0 cm, and of similar thickness

Note: Although a true comparison needs materials of similar thickness to be tested, you do not have to worry about this. You can test any material you wish. However, it is important to make a note of any of the reasons (such as thickness) why you think certain materials are stronger than others. This will help you when deciding on the types of material for your glove.

You may wish to test the fabrics when **dry** and when **wet**.

{TEST PROCEDURE} TENSOMETER

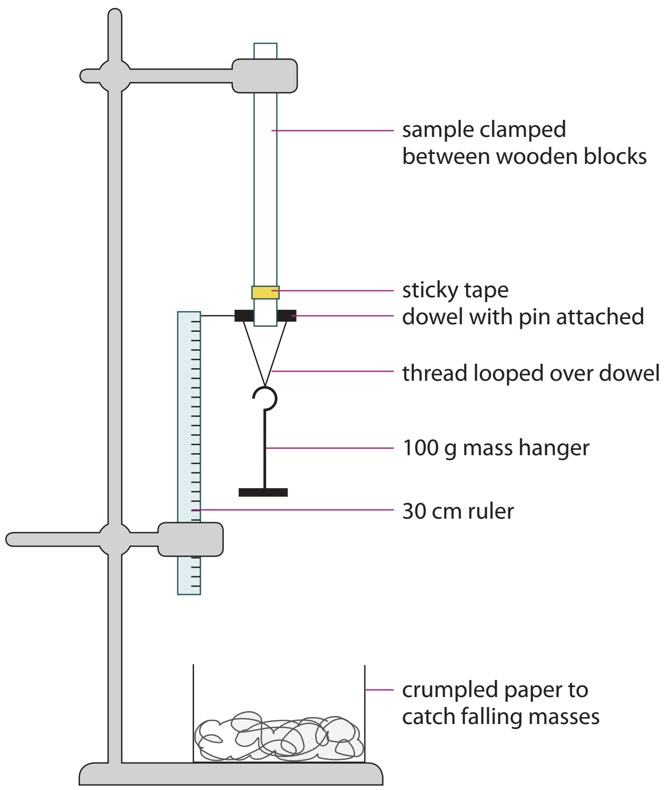
PROCEDURE

1. Draw up a results table like this for each material tested ...

Load added	Material:			
	Stretch resistance *tick load when material starts to stretch*	**Amount stretched (mm)**	**Elasticity (mm)** *difference in length from original length when load removed*	**Tensile strength** *tick load when material started to tear*
100 g				
200 g				
300 g				
400 g				
etc.				

2. Clamp one end of the sample between two wooden blocks, as shown in the diagram below.
3. Fold the other end around the dowel, and back on itself. Stick it down with tape, so there is 30 cm of sample between the clamp and the tape.
4. Fix the clamp in a stand and set up the rest of the apparatus as shown in the diagram.
5. Adjust the ruler so that the pin points to 0 cm.
6. Add a 100 g mass hanger and keep adding 100 g masses until the material starts to stretch (the pin moves). Record this load by ticking the appropriate box in the 'stretch resistance' column.
7. Record the new position of the pin in the 'Amount stretched' column.
8. Carefully remove the whole load and wait for the material to stop shrinking (the pin stops moving). Record the new position of the pin in the 'elasticity' column.
9. Add another 100 g mass, and repeat steps 7 and 8.

You may find that after a certain load has been added, the material does not shrink back close to its original length. This is because the heavy load has stretched the material permanently. It has lost its elasticity.



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{TEST PROCEDURE} TENSOMETER

10. Continue this process until the material begins to tear. Record the load required to tear the material by ticking the appropriate box in the 'tensile strength' column.

If 2000 g (= 2 kg) is not enough to tear the sample, repeat the test with a sample 0.5 cm wide instead.

11. To make sure your results are reliable, test at least three samples (of the same width) of each material.
12. Repeat the tests with other types of material.

USING YOUR RESULTS

You could plot a graph to show load against amount stretched.

STRETCH RESISTANCE QUESTIONS

1. Which material is most stretchy? How can you tell?
2. Which material is most stretch resistant?

ELASTICITY QUESTIONS

3. Which material has the highest elasticity (is most elastic)?
4. Which material has the lowest elasticity?

TENSILE STRENGTH QUESTIONS

5. Which material appears to have the highest tensile strength? How can you tell? Don't forget to bear in mind any differences in width and thickness of the samples.

OVERALL QUESTIONS

6. What connection, if any, can you find between stretch resistance, elasticity and tensile strength?

{TEST PROCEDURE} WATER REPELLENT FABRIC

REPELLENT, RESISTANT OR WATERPROOF?

Materials vary in how **resistant** they are to water. How resistant they are to becoming wet is known as **repellency**. Water resistance may also be measured by how much a material resists the penetration (passing through) of water. Materials that never let water through are **waterproof**.

(See the procedure **waterproof fabric** to test how waterproof fabrics are.)

THE PROCEDURE

Some materials initially resist or repel water before they start to absorb it.

To compare fabrics, weigh the mass of each *before* and *after* applying drops of water. The smaller the difference in mass, the better the water repellency.

Two or three people may be required to carry out this test.

EQUIPMENT

- small beaker of water
- Petri dish
- teat pipette
- balance
- various types of fabric

METHOD

1. Make sure each piece of fabric is the same size (area). Try not to use pieces less than 5 cm by 5 cm, although it will depend on how much of each fabric is available.
2. Draw a table like this ...

Type of fabric	Dry mass (g)	Mass after drops added (g)	Difference in mass (g)

3. Choose a piece of fabric. Record the type of fabric in the table.
4. Weigh the fabric. Record its mass in the table.
5. Hold the fabric over the Petri dish, pulling it taut (stretching it so that there are no wrinkles).
6. Fill the pipette with water from the beaker.
7. Holding the pipette 10 cm above the fabric, carefully squeeze 10 drops of water onto the centre of the fabric.
8. If any water seeps through the fabric and into the Petri dish, make a record of 'NOT REPELLENT AND NOT WATERPROOF' in the table, and skip to step 11.

   Note: This information will be useful if and when you choose fabrics to test for water resistance.

{TEST PROCEDURE} WATER REPELLENT FABRIC

9. Gently shake off any water still left on the surface of the fabric back into the beaker.
10. Immediately re-weigh the fabric on the balance and record the mass in the table.
11. Repeat steps 3–10 for each type of fabric available to you.

USING YOUR RESULTS

For each type of material, calculate and record in the table the difference in mass *before* the drops of water were added and *after* they were added.

List the fabrics in order of increasing difference in mass.

QUESTIONS

1. Do your results show a significant difference in the water repellency of fabrics? Which fabrics are the most water repellent?
2. If your chosen sport is a watersport, are the most water repellent fabrics suitable? What other properties might you need to consider?

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{TEST PROCEDURE} WATERPROOF FABRIC

REPELLENT, RESISTANT OR WATERPROOF?

Materials vary in how **resistant** they are to water. How resistant they are to becoming wet is known as **repellency**. Water resistance may also be measured by how much a material resists the penetration (passing through) of water. Materials that never let water through are **waterproof**.

(See the procedure **water repellent fabric** to test water repellency.)

THE PROCEDURE

Water repellent fabrics are not guaranteed to be fully water resistant. While they may initially resist water and, therefore, appear completely waterproof, eventually some water will seep through.

Spray or pour water over fabrics and observe the effects. Fabrics which are penetrated by water (allow it to seep through) are not waterproof. Those that prevent any water passing through are waterproof.

EQUIPMENT

- small beaker
- blotting paper
- sticky tape
- elastic band
- measuring jug, cylinder or beaker (at least 1 litre capacity)
- various types of fabric
- scissors (possibly)
- ruler

METHOD

Read through this method carefully before starting. **Take particular note of point 10**.

1. Draw up a table like this ...

Type of fabric	**Water in beaker** *tick or cross*	**Blotting paper observations**	*Your blotting paper measurement (see point 10)*

2. Choose a piece of fabric. Make sure it is big enough to cover the opening of the beaker and drape at least 2 cm over the edge, all the way round. Record the type of fabric in the table.
3. Cut a piece of dry blotting paper so that is slightly smaller than the beaker opening.
4. Using sticky tape, attach the blotting paper to the middle of the fabric sample.
5. Place the fabric over the beaker, making sure the blotting paper is on the inside. Secure to the beaker with the elastic band.

{TEST PROCEDURE} WATERPROOF FABRIC

6. Put the beaker into a sink.
7. Carefully pour water onto the fabric, from a height of 10 cm. You may choose to either….
   - Continue to pour water for a set period of time (e.g. 2 mins). This will require somebody to continually supply the pourer with jugs of water so that they don't have to stop and refill during the allotted time.
   - Pour over a set amount of water (e.g. 5 litres).
8. Observe whether or not any water has seeped into the beaker. Record in the table.
9. If no water is visible, carefully remove the fabric from the beaker, and look at the blotting paper.
10. If it is not clear that the blotting paper is wet, can you think of a better way to establish whether or not it has absorbed any water?
11. Repeat steps 2–10 for each type of fabric.

USING YOUR RESULTS

Looking at your results table, state which fabrics are waterproof and which are not waterproof.

Depending on your results, and the observations you record, you may be able to suggest an order of increasing water resistance, for those fabrics that were not waterproof. (This is not essential).

QUESTIONS

1. Is being waterproof enough to satisfy the requirements of your glove? If not, why not?
2. Could a waterproof material be used to make part of the glove? Which part could it be used for?

{TEST PROCEDURE} WETTING, WASHING AND DRYING

Garments may be subjected to a lot of wetting and drying. Unfortunately, some textiles react badly to this. Others spoil when they are washed, or dried with heat. The fabrics may ...

- shrink or distort
- lose stretchiness
- become hard
- lose 'body' (become soft or thin)
- change colour, e.g. the dye may run
- lose surface coatings such as waterproofing

... and so on.

QUESTIONS

1. For your own clothes, which fabrics have best survived the test of many washes?
2. What qualities did you use to judge them? There are three aspects – aesthetics (e.g. Does the jumper really look good as new?), function (e.g. Does the cagoule still keep you dry?) and comfort (e.g. Are the socks still soft?).

THE PROCEDURE

This procedure can be used to test the effects of wetting and drying on any of the properties of materials that you are interested in.

There are three types of wetting: cold water, salt (sea) water and hot water with detergent.

When washing the fabrics, wear eye protection and take care with hot water. A risk assessment must be carried out before you start work.

EQUIPMENT

- fabric scissors [CARE: SHARP]
- large trays
- paper towel
- beaker
- access to hotplate or waterbath
- tongs
- 'seawater'
- permanent marker pen
- large tiles
- eye protection
- measuring cylinder
- washing powder
- water

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{TEST PROCEDURE} WETTING, WASHING AND DRYING

METHOD: PREPARATION

1. For each fabric, cut a test square. Ideally they should be 30 cm x 30 cm. All the samples should be the same size. Try to cut accurately along and across the weave of the fabric (the warp and weft).
2. Number each sample 1A, 2A, etc. Keep a small piece of each fabric for reference and mark it with the relevant number, 1, 2, etc.
3. If you are going to measure shrinkage or colour fastness, refer to those procedures before you do anything more.

METHOD: RECORDING RESULTS

1. Draw up an observation record, like the one below. Use it to record your assessments of different properties.

You will need two copies: one for the cold (or salt) water test and one for the warm water test.

2. Decide which qualities to assess. This table gives a few suggestions.

Wetting with cold water/salt water/warm water (circle which)																	
		Suppleness (drape)				Colour				Stretch				Softness			
	Observer	1	2	3	mean	1	2	3	mean	1	2	3	mean	1	2	3	mean
Fabric																	
1	reference																
	sample A																
2	reference																
	sample A																
3	reference																
	sample A																
etc.																	

For some tests, you will get a numerical value, such as measuring stretch; for others, such as softness, you will have to make a judgement. If you are making a judgement, use a scale of 1 to 5.

3. Carry out one set of observations on the reference piece. Repeat the test or observations on each of sample 1A, 2A, 3A, etc., after it has been wetted in cold or salt water and allowed to dry. Repeat the test or observations again, after the samples have been washed and dried.

METHOD: COLD WATER

1. In a large tray, lay one sample of each fabric (1A, 2A, 3A etc.) flat. They can be weighted down with large flat tiles, if available.

   Cover with water at room temperature and leave for two hours.
2. Remove the samples from the tray and blot dry with paper towel. Allow to dry at room temperature.
3. Carry out assessments and record your observations.

{TEST PROCEDURE} WETTING, WASHING AND DRYING

METHOD: SEA WATER

1. Ensure that the seawater is at room temperature (15–20 °C).
2. Carry out the procedure as for cold water but use the prepared seawater instead of plain water.
3. After carrying out your assessments and measurements, thoroughly rinse out the seawater with tap water. Blot dry with paper towel.

METHOD: WARM WATER WASHING

Wear eye protection.

1. Place a large beaker on a hotplate. Pour 500 cm^3 of water into the beaker. Heat gently until the water reaches 40 °C.

   OR

   Place the beaker into a 40 °C waterbath. Add 500 cm^3 of water to the beaker and wait for it to reach the set temperature.
2. Add 5 cm^3 of washing powder. Stir until the powder has dissolved. Turn the heater down low, to keep the water at 40 °C.
3. Add the sample fabric. Allow to soak for 15 minutes. Then stir constantly for 5 minutes.
4. Turn off the heater. Use tongs to remove the fabric and place it in a sink.
5. Rinse 3 times in trays of clean cold water.
6. Lay flat to dry in a warm (not hot) place.
7. Carry out assessments and record your observations.

USING YOUR RESULTS

For immersion in cold water or seawater, which fabric(s) gave the best results?

After washing, which fabric(s) gave the best results?

Which fabric(s) performed well in all the tests?

{TEST PROCEDURE} WICKABILITY

KEEPING THE SWEAT AWAY

The physical effort, combined with the intense atmosphere of competition, causes athletes to sweat. This can harm the athletes' chances of success. Sweat may affect how well an athlete is able to handle equipment, it can cause discomfort, injury, or upset concentration.

Many sports clothing manufacturers use materials that are able to move moisture, such as sweat, away from the body. These 'wickable' materials not only absorb moisture, but allow it to evaporate quickly, keeping the athlete dry and comfortable.

This procedure will help you to test the wickability of various materials.

THE PROCEDURE

You can use this procedure to compare how well different fabrics absorb moisture and how quickly the fabrics dry out. The quicker the absorbency and evaporation, the better the wickability.

A risk assessment must be carried out before you start any practical work.

EQUIPMENT

- Petri dish
- clamp and clamp stand
- stop watch
- fabric scissors [CARE: SHARP]
- balance
- food dye
- various types of fabric
- permanent marker pen

METHOD

Read this procedure through carefully before starting.

1. Draw up a table like this ...

					Mass after ...			
Type of fabric	**Time taken to reach line (mins)**	**Distance travelled after 10 mins**	**'Dry' mass (g)**	**'Wet' mass (g)**	**15 mins drying (g)**	**30 mins drying (g)**	**45 mins drying (g)**	**60 mins drying (g)**

2. Cut your fabric into small strips of the same size.
3. Using the pen, mark a line 1 cm from the bottom of the fabric. Mark a second line 2 cm higher than this.
4. Weigh each fabric sample and record the mass in the table.
5. Pour at least 1 cm depth of water into the Petri dish.
6. Mix in a few drops of food dye.
7. Carefully clamp the top of a fabric sample so that it hangs vertically.

{TEST PROCEDURE} WICKABILITY

8. Place the Petri dish of coloured water under the fabric and carefully lower the fabric into the coloured water until the first line reaches the surface.
9. Start the stop watch.
10. When the coloured water reaches the second line, stop timing. Make a record of the time taken to reach the line, in the table.
11. If, after 10 minutes, the coloured water has not reached the second line, record the distance is has travelled.

Note: If the fabric has not absorbed any water, record it as 'NOT ABSORBENT'.

12. Immediately weigh your wet sample on the balance and record the new mass in the table.
13. Take new measurements of mass every 15 minutes and record in the table.
14. Stop after 1 hour or when the fabric has returned to its 'dry' mass.
15. Repeat steps 7 to 14 for each type of fabric. If you are able to set up apparatus to test more than one fabric sample at a time, you will save yourself a great deal of time!

USING YOUR RESULTS

You may wish to draw a graph showing the length of time taken for each fabric to absorb the coloured water up to the second mark.

A further graph could be drawn using the 'drying' data, plotting mass against time.

QUESTIONS

1. Which material is the most absorbent? How can you tell?
2. Which material dries the quickest? How can you tell?

You may have tested fabrics that have been made in different ways. For example, thicker threads, closer weave, knitted instead of woven.

3. What do you think has the greatest effect on absorbency and rate of evaporation – the type of material or the way it is made into a fabric?
4. Can you think of any other factors that could affect the rate of absorbency and/or evaporation?
5. What is the relationship, if any, between absorbency and rate of evaporation?

{TEACHER NOTES} INTRODUCTION

Students design a new glove for use in a sport of their choice. Students may find it helpful to talk with local people who partake in their chosen sport. The P.E. Department may be able to suggest suitable contacts.

Students should work in project teams of three to six people. Teams will need to manage their time effectively, perhaps sharing out different tasks. They must make sure they meet the challenge brief, but not take on more than can be realistically completed in the time you make available to them. Careful planning is required.

The Challenge Brief does not state precisely what work the project teams should carry out. Rather, it provides some points for teams to think about. The teams do not need to consider all of these; neither do the points cover all considerations.

A selection of tests, activities and factsheets are available for the students to use. **They do not have to use all of them**. They must decide what are the most important properties to include in the design of their glove. Students can then choose what activities and research to do accordingly. They may also think of their own experiments or research to carry out, as well as exploring the aesthetic aspects of design.

Flexibility and ownership are key. Teams should be encouraged to choose what they want to do, using the brief for guidance, but also incorporating their own thoughts and ideas. The Challenge is an opportunity for students to **explore, experiment and innovate**.

Note: Where possible, encourage students to look at the resources online. Only print sheets that are strictly necessary.

MATERIALS

To complete this challenge **it is not essential for students to test expensive fabrics**.

They do need to test a range of different fabrics, but are not expected to find the perfect choice for their gloves. For example, they may find a water resistant fabric but think it needs to be more durable. They could then use their research to suggest more suitable fabrics.

Common fabrics can be bought from markets or fabric shops (both on the high street or the internet). They could also be obtained by cutting samples from old clothes. Small quantities of technical fabric might be more difficult to find. You could try these suppliers:

- www.pennineoutdoor.co.uk
- www.profabrics.co.uk
- www.shelby.fi/catalog/default.php

Often, samples can be ordered before choosing which fabrics to buy. This is a useful way for students to feel many different fabrics before choosing a short list of fabrics to test.

HEALTH AND SAFETY

Although the tests and activities for this challenge do not pose any significant hazards, teachers must carry out a risk assessment for their particular circumstances and student group. Specific health and safety guidance for the tests and activities is given on the relevant teacher/technician notes.

{TEACHER NOTES} CURRICULUM LINKS (ENGLAND)

PROGRAMME OF STUDY FOR KEY STAGE 3

DESIGN AND TECHNOLOGY

KEY CONCEPTS

Designing and making

b. Applying knowledge of materials and production processes to design products and produce practical solutions that are relevant and fit for purpose.

Creativity

a. Making links between principles of good design, existing solutions and technological knowledge to develop innovative products and processes.

c. Exploring and experimenting with ideas, materials, technologies and techniques.

Critical evaluation

a. Analysing existing products and solutions to inform designing and making.

b. Evaluating the needs of users and the context in which products are used to inform designing and making.

KEY PROCESSES

a. Generate, develop, model and communicate ideas in a range of ways, using appropriate strategies.

b. Respond creatively to briefs, developing their own proposals and producing specifications for products.

c. Apply their knowledge and understanding of a range of materials, ingredients and technologies to design and make their products.

d. Use their understanding of others' designing to inform their own.

e. Plan and organise activities and then shape, form, mix, assemble and finish materials, components or ingredients.

f. Evaluate which hand and machine tools, equipment and computer-aided design/manufacture (CAD/CAM) facilities are the most appropriate to use.

h. Reflect critically when evaluating and modifying their ideas and proposals to improve products throughout their development and manufacture.

RANGE AND CONTENT

b. Users' needs and the problems arising from them.

c. The criteria used to judge the quality of products, including fitness for purpose, the extent to which they meet a clear need and whether resources have been used appropriately.

e. Aesthetic, technical, constructional and relevant wider issues that may influence designing, selection of materials, making and product development.

j. A broad range of techniques, including handcraft skills and CAD/CAM, and how to use them to ensure consistency and precision when making single and multiple products.

k. The behaviour of structural elements in a variety of materials.

l. How to use materials, smart materials, technology and aesthetic qualities to design and make products of worth.

SCIENCE

KEY CONCEPTS

Scientific thinking

b. Critically analysing and evaluating evidence from observations and experiments.

Applications and implications of science

a. Exploring how the creative application of scientific ideas can bring about technological developments and consequent changes in the way people think and behave.

KEY PROCESSES

Practical and enquiry skills

a. Use a range of scientific methods and techniques to develop and test ideas and explanations.

b. Assess risk and work safely in the laboratory, field and workplace.

c. Plan and carry out practical and investigative activities, both individually and in groups.

Critical understanding of evidence

a. Obtain, record and analyse data from a wide range of primary and secondary sources, including ICT sources, and use their findings to provide evidence for scientific explanations.

b. Evaluate scientific evidence and working methods.

Communication

a. Use appropriate methods, including ICT, to communicate scientific information and contribute to presentations and discussions about scientific issues.

RANGE AND CONTENT

Energy, electricity and forces

b. Forces are interactions between objects and can affect their shape and motion.

Chemical and material behaviour

KEY STAGE 3 AREAS OF LEARNING

TECHNOLOGY AND DESIGN

LEARN ABOUT

- Design
- Communication
- Manufacturing

LEARNING OUTCOMES

- Demonstrate practical skills in the safe use of a range of tools, machines and equipment.
- Research and manage information effectively to investigate design issues, using Mathematics and ICT where appropriate.
- Show deeper understanding by thinking critically and flexibly, solving problems and making informed decisions, using Mathematics and ICT where appropriate.
- Demonstrate creativity and initiative when developing ideas and following them through.
- Work effectively with others.
- Demonstrate self management by working systematically, persisting with tasks, evaluating and improving own performance.
- Communicate effectively in oral, visual (including graphic), written, mathematical and ICT formats showing clear awareness of audience and purpose.

SCIENCE

LEARN ABOUT

- Chemical and material behaviour
- Structures, properties, uses of materials
- Forces and energy
- Forces and energy transfer

LEARNING OUTCOMES

- Demonstrate a range of practical skills in undertaking experiments, including the safe use of scientific equipment and appropriate mathematical calculations.
- Use investigative skills to explore scientific issues, solve problems and make informed decisions.
- Research and manage information effectively, using Mathematics and ICT where appropriate.
- Show deeper scientific understanding by thinking critically and flexibly, solving problems and making informed decisions, using Mathematics and ICT where appropriate.
- Demonstrate creativity and initiative when developing ideas and following them through.
- Work effectively with others.
- Demonstrate self management by working systematically, persisting with tasks, evaluating and improving own performance.
- Communicate effectively in oral, visual, written, mathematical and ICT formats, showing clear awareness of audience and purpose.

{TEACHER NOTES} CURRICULUM LINKS (SCOTLAND)

CURRICULUM FOR EXCELLENCE

TECHNOLOGIES

Technological developments in society

- When exploring technologies in the world around me, I can use what I learn to help to design or improve my ideas or products. TCH 2-01a
- From my studies of technologies in the world around me, I can begin to understand the relationship between key scientific principles and technological developments. TCH 3-01a
- Food and textiles contexts for developing technological skills and knowledge
- I can use textile skills in practical and creative situations in my place of learning, at home or in the world of work. TCH 3-10c
- By using problem-solving strategies and showing creativity in a design challenge, I can plan, develop, make and evaluate food or textile items which meet needs at home or in the world of work. TCH 3-11a
- Craft, design, engineering and graphics contexts for developing technological skills and knowledge
- By using problem-solving strategies and showing creativity in a design challenge, I can plan, develop, organise and evaluate the production of items which meet needs at home or in the world of work. TCH 3-14a
- Having explored graphical techniques and their application, I can select, organise and represent information and ideas graphically. TCH 3-15a

SCIENCES

Forces, electricity and waves: Forces

- By contributing to investigations of energy loss due to friction, I can suggest ways of improving the efficiency of moving systems. SCN 3-07a

Materials: Properties and uses of substances

PROGRAMME OF STUDY FOR KEY STAGE 3

DESIGN AND TECHNOLOGY

- Use given design briefs, and where appropriate, develop their own to clarify their ideas for products.
- Identify and use appropriate sources of information to help generate and develop their ideas for products.
- Be creative and innovative in their thinking when generating ideas for their products.
- Identify and apply knowledge and understanding about technological, sustainability and health and safety issues to develop ideas for products that are achievable and practical.
- Develop a specification for their product.
- Explore, develop and communicate design ideas in a range of ways, including annotation, drawings and CAD.
- Evaluate, refine and modify their design ideas.
- Evaluate their final design ideas against their initial specification.
- Learn about the properties and characteristics of materials and apply this knowledge and understanding when designing and making products.
- Undertake materials testing, to determine suitability for intended use.
- Combine and process materials in order to create enhanced properties and desired aesthetic characteristics

SCIENCE

SKILLS

- Opportunities to carry out different types of enquiry (planning, developing, reflecting).

RANGE

- How things work

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{TEACHER NOTES} STARTER ACTIVITY

Use this activity to start thinking about the sports glove challenge. Although it is not imperative to have everything from the list below, the more variety you are able to use the more effective the activity.

YOU WILL NEED

A range of gloves, such as…

- Oven
- Washing up
- Gardening
- Cycling
- Fingerless
- Woollen
- Skiing
- Disposable (vinyl)
- Golf
- Mittens
- Baseball (catching)
- Leather
- Boxing
- Cricket

A variety of threads and cables, such as…

- Cotton
- Rope (eg. Skipping or climbing)
- Washing up liquid
- Wool
- Usb lead
- Other ropes or cables of different thicknesses
- String
- Scart lead

METHOD

Students should work in groups appropriate to the number of gloves available. Allow the students 5 minutes to investigate the ease of tying knots in the various threads and cables whilst wearing different gloves. Each group could be assigned certain gloves, or the gloves could be circulated so that every group gets a chance to try each of them. After 5 minutes, the students should feedback to the whole class. The students could also try tying the threads and cables without gloves but after coating their hands in a small amount of washing up liquid. They could further investigate the ease of manipulating the threads and cables after wetting their hands with water or with soapy water (made using the washing up liquid).

To bring an element of competition to the activity, the students could time each other to see how quickly they can tie a knot. Alternatively, they could race against each other, using the same type of thread and glove. This could be repeated for different combinations of thread and glove.

DISCUSSION

The aim of this activity is to initiate discussion about being fit for purpose. The students should realise fairly quickly that it is easier to tie knots wearing some gloves rather than others. Discussion should bring out the reasons for this. Rather than simple explanations such as "I couldn't move my hand as well in the cricket glove as I could in the disposable glove", search for the reasons why they could or couldn't move their hand very well. It may be thought that fingerless gloves would allow greater dexterity, but does the padding on fingerless cycling gloves impede movement? This will start the students thinking about the different properties of gloves.

Similarly, the students should discuss the thickness of the threads and cables. It is important for them to realise that there is a two-way interaction. In other words, the ease with which a knot can be tied, wearing a particular glove, is not solely dependent on the design of the glove but also on the object (in this case the thread or cable) that needs to be manipulated.

Furthermore, they will start to consider the effects of wet and slippy hands. This introduces the factor of different conditions and raises the notion of friction.

{TEACHER NOTES} ABRASION RESISTANCE

This student procedure is a simplified version of the Martindale abrasion test for fabrics, in which samples are subjected to linear mechanical abrasion. The orientation of the linear motion is gradually rotated, so samples are abraded in all directions. Abrasion is assessed by visual inspection and by loss of mass.

Students rub their samples by hand in a single orientation with a sandpaper block, until a thread breaks, a hole appears, or they reach 200 strokes, whichever occurs first. They assess the abrasion visually.

If desired, they could also assess mass loss. However, this requires weighing to 0.001 g, and careful cleaning of the sample to remove abraded dust and fabric pills. Also, since samples are taped down to hold them in position, the tape may leave adhesive on the fabric and/or extract fibres from the edge of the fabric when removed for reweighing. This would cause significant errors in the small mass loss.

EQUIPMENT

- smooth flat surface, such as a large glazed tile or sheet of hardboard, at least 15 cm square
- flat wooden block, approx. 10 x 7 x 2 cm
- fine sandpaper, approx 10 x 15 cm – preferably, a new sheet for each sample
- sticky tape
- samples of fabrics, large enough to cover and overlap the smooth flat surface

Note: The sizes given are suggestions only. They can be altered accordingly depending on the size and type of apparatus available to you.

TEST SAMPLES

Students should be encouraged to select suitable test materials for themselves, having been told the minimum size, which depends on the flat surface around which they are to be wrapped.

The range should cover various materials, such as cotton, linen, wool, leather and synthetics, and also different types of fabric (woven, knitted, non-woven, plastic/rubber coated) made from the same type of fibre. Comparisons could also be made between fabrics of the same material, but with fibres of different thickness, coarseness of weave or type of weave.

HEALTH AND SAFETY

A risk assessment is required before any practical work, but the specified procedure involves no significant hazards.

METHOD

Students abrade the materials attached to a smooth, firm, flat surface, such as hardboard or a ceramic tile. Simply taping the sample to the bench is likely to result in abrading the bench surface if a hole is worn in the fabric. A heat mat may be too rough, resulting in premature abrasion over highpoints in the surface.

For consistency between samples, students should not press down on the fabric.

Students compare abrasion resistance by noting how many strokes are required to break threads or wear a hole in the fabric. If this has not occurred within 200 strokes, they assess damage by visual inspection.

{TEACHER NOTES} ABRASION RESISTANCE

POSSIBLE EXTENSIONS

Students could investigate the effect of altering:

- the distance the sandpaper is moved over the fabric surface
- the number of strokes
- the grade of sandpaper
- the force, by using a 1 kg mass attached to the 'sandpaper block' to provide a steady pressure. The effects of increasing the mass can be investigated.
- the type of motion, for instance
  - side-to-side as well as back-and-forth
  - circular motion

Given access to suitable equipment, students might devise a powered abrasion tester – either with reciprocating linear motion, or multi-directional (as with an orbital sander). The sander could be supported, but not clamped, so that the weight of the sander provides the downward force. The students would measure time, rather than count strokes. Clearly this would require a thorough and rigorous risk assessment…

The activity is unlikely to be covered in the model (generic) risk assessments used in school science. Therefore, a special risk assessment would be needed. Member-schools should contact CLEAPSS.

{TEACHER NOTES} COLOUR FAST

This procedure is used in conjunction with the procedures: wetting, washing and drying.

EQUIPMENT

- fabric samples
- fabric scissors
- permanent marker pen
- access to desk lamp (Ensure it has been PAT-tested)

for Method: part 2

- white cotton fabric
- needle and thread

HEALTH AND SAFETY

Students should take care when using scissors. They should ensure that they do not mark their clothes with permanent ink.

METHOD

Ideally, the fabrics should be cut parallel with selvedges, to avoid odd reflectances from any texture.

If students are trialling their own dyes, using multifibre strips, then Method 1 should be used.

These methods are qualitative and students may need help in devising a suitable rating system.

If at all possible, the comparisons should be made in bright daylight, outdoors, and then under bright artificial light.

{TEACHER NOTES} DYEING FABRICS

This procedure compares the effectiveness of synthetic and natural dyes at colouring different types of fabric.

EQUIPMENT

- multi-fibre strips (see below)
- natural dyestuff (see below)
- water
- tripod
- beakers, 500 cm^3
- thermometer
- sieve
- eye protection
- synthetic dyes (see below)
- salt
- Bunsen burner
- gauze
- heat-resistant mat
- tweezers
- balance
- heatproof gloves (for teacher/technician only)

FABRIC AND DYES

Multi-fibre strips: These can be bought from the Society of Dyers and Colourists, PO Box 244, Perkin House, 82 Grattan Road, Bradford BD1 2JU. Tel: 01274 725138. Fax 01274 392888. Web: www.sdc.org.uk.

Synthetic dyes: Take care when choosing which ones to buy because the active dyestuff is not normally named. Try to purchase different classes in different colours, for example, Acid Blue, Disperse Yellow and Direct Red. Dyes can be bought from laboratory suppliers such as Aldrich or Philip Harris.

Dye specialists Town End (www.dyes.co.uk) or ELS (www.eurolabsupplies.co.uk) also supply many different dyes.

Natural dyestuff: For example, tea, coffee, blackberries, onion skins, and rhubarb roots can be used directly. Avocado skins or daffodil heads can be used but need to be soaked overnight before boiling.

HEALTH AND SAFETY

A risk assessment is required before any practical work.

Students should take care when using a Bunsen burner.

To avoid students burning themselves it is advisable that a member of staff sieves the dyestuff from the boiling dye (using heatproof gloves). Alternatively, the sample could be left to cool first.

METHOD

Students dye six different fabrics (acetate, acrylic, cotton, nylon, polyester and wool) using synthetic and natural dyes. They will investigate the effectiveness of the different types of dye on the different fabrics.

Students should discover that the take up of a particular dye depends on the fabric used. The correct fabric needs to be matched with the correct dye. This is because the dyeing process involves chemical reactions between the dye and fabric. For example, students should know that acids react with bases. Wool and nylon contain basic $–NH_2$ groups; for simplicity they can be described as bases. Therefore, they react well with acid dyes.

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{TEACHER NOTES} DYEING FABRICS

They can then test the colour fastness of their strips using the procedures: **colour fast** and **wetting, washing and drying**.

Students should find that dyes which are taken up more readily are also more colour fast. This is because they have bonded more strongly to the fabric fibres. Ensure students realise in this context that the term 'fast' means fixed not speedy.

Students should realise that, although synthetic dyes tend to be more effective, there are concerns about their effect on the environment and our health.

Dyes made from plants will only be sustainable if farming methods are used efficiently.

Note: For simplicity it is best to refer to dyes as natural or synthetic. It is possible students could become confused about the relationship between, natural, synthetic, organic and in-organic dyes. The term organic can refer to the farming method used to produce a product. However, in reference to dyes it refers to the chemistry of the dye and of course organic dyes are synthetic, carbon derivatives of petroleum.

EXTENSION

As an extension to this activity, students could carry out some internet research into the health and environmental concerns surrounding synthetic dyes.

{TEACHER NOTES} GLOVES FOR PROTECTION

This two-part procedure helps students to work out which areas of the user's hand come into contact with equipment used in their chosen sport, and work out which areas of the hand are subjected to the most friction. Both parts can be adapted by using something other than a plastic tube, that is more appropriate for their chosen sport.

EQUIPMENT

- plastic tube, of appropriate diameter
- washable, water-based paint
- digital camera (optional)

HEALTH AND SAFETY

A risk assessment is required before any practical work, but the specified procedure involves no significant hazards. Students should use a washable paint, such as those suitable for young children. Warn students to avoid getting paint on their clothes. Protective clothing, such as an old shirt, may be useful. Paint may be difficult to remove from equipment used.

METHOD

Part 1: Students lightly grip a painted tube and observe where the paint is transferred onto their hand.

Part 2: Students paint their hand and, when dry, grip the tube and move it as though playing their chosen sport (they may find it appropriate to use a classmate to provide resistance, to better mimic a real situation).

Both parts should be carried out on a number of different people, so students can compare results and work out which are the most common areas that need protection.

{TEACHER NOTES} FABRIC FRICTION AND GRIP

Students may use this procedure to investigate the friction grip of a range of fabrics on a surface. They could test the same range of fabrics on different surfaces.

To compare surface friction, they measure the minimum force needed to pull a weighted fabric sample across the surface.

No detailed understanding of friction is required, beyond knowing that it is a force that resists the sliding motion of one surface over another. Students should appreciate that it is friction that allows the competitor's hands to get a good grip on the surface.

EQUIPMENT

- smooth flat surface, such as a bench or table top
- 1 kg mass
- strong rubber band
- various Newton meters (or tension forcemeters)
- samples of fabrics, large enough to wrap around the 1 kg mass

HEALTH AND SAFETY

A risk assessment is required before any practical work, though there are no significant hazards in this procedure, provided students take care not to drop the kilogram mass.

METHOD

Students may work individually or in pairs, taking turns to pull, and to watch the Newton meter pointer.

It is suggested that pre-testing is carried out to determine the range of Newton meters likely to be needed to obtain meaningful results with the particular fabrics available. If necessary, a larger or smaller mass may be used, but only results with the same mass are comparable.

Students should be encouraged to suggest the types of fabric worth testing, but some 'slippery' fabrics should be included by way of contrast. Fabrics of different thicknesses may be used.

The rubber band needs to be tight, to avoid friction pulling the fabric away from the mass.

EXTENSIONS

Students could extend their investigation by:

- testing whether friction is improved by using fabric with a ribbed or bobbled surface
- adapting the procedure to test the friction between a bare hand and the surface, to check whether gloves do actually improve the grip.

{TEACHER NOTES} LIGHTWEIGHT FABRICS

Students weigh samples of fabric and perform calculations to scale up their results.

EQUIPMENT

- pieces of fabric
- tailor's chalk
- fabric scissors [CARE: SHARP]
- piece of card
- ruler
- balance
- calculator

Samples can be ordered before choosing which fabrics to buy. This is a useful way for students to feel many different fabrics before choosing a short list of fabrics to test/use.

- Pennine outdoor provide technical fabrics for outdoor garments: www.pennineoutdoor.co.uk
- Point north: www.profabrics.co.uk
- Extreme materials and gear: www.shelby.fi/catalog/default.php

As an alternative, if available, you could use old items of clothing.

HEALTH AND SAFETY

A risk assessment is required before any practical work. Sharp scissors capable of cutting thick fabric will be required. You will need to supervise students during this part of the task.

METHOD

Students create a template to make same-sized fabric samples for comparison. They weigh each sample and record its weight. They then perform calculations to work out the weight of a larger (200 cm^2) swatch.

USING YOUR RESULTS – ANSWERS

- 5 cm x 5 cm = 25 cm^2 of fabric.
- 200 ÷ 25 = 8 (the 200 cm^2 sample is eight times bigger than the 25 cm^2 sample)
- So, students need to multiply their results by eight to find the weight of 200 cm^2 of fabric.

QUESTION ANSWERS

1. Students might copy a sewing pattern for a glove onto graph paper to work out how much fabric they need.
2. The differences in weight may or may not be significant to the sports person wearing the glove. Students should decide on a way of judging and possibly classifying the fabrics.
3. Some suggestions for ways they could ensure a fair test:
   - Always cutting along the inside of the chalk marks (not sometimes inside, sometimes outside).
   - Being careful to keep the fabric flat but not stretching it as they draw round the template.
   - Checking the fabric against the template after it has been cut.
   - Using sharp scissors to make clean cuts.
   - Carrying out the procedure three times for each fabric and recording the mean value.

EXTENSION

Students could attempt to design a method for measuring and comparing the thickness of different materials.

{TEACHER NOTES} SHRINKING

This procedure is used in conjunction with the procedure: **wetting, washing and drying**.

It will involve several students as the fabric samples need to be held flat whilst they are marked up and then measured after wetting and drying.

EQUIPMENT

- textile samples
- fabric scissors
- permanent marker pen e.g. ball-point
- ruler and set square

HEALTH AND SAFETY

Students should take care when using scissors. They should ensure that they do not mark their clothes with permanent ink.

If a student carries out the procedure on their own, they will need to take care with any weights or books that they use to keep the fabric taut.

METHOD

The pattern of + marks should be marked as accurately as possible, to form a square. It may help if the marks are made in tailor's chalk in the first instance.

If the fabric samples are smaller than 30 cm square, the distance between the + marks will have to be reduced and the calculations amended accordingly. The reference marks should be 2.5 cm from the edge, to allow for any fraying etc. that may occur during the wetting process.

The fabric should be held taut, but not stretched, when being marked/measured.

EXTENSIONS

As well as converting their results to percentages, students could also calculate how much the fabric has distorted, by measuring diagonally (35.4 cm for a 25.0 cm square).

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{TEACHER NOTES} TENSOMETER

This procedure is a simplified version of the standard tensometer test, in which a sample is clamped at both ends and subjected to increasing tension until it narrows and eventually breaks, or in the case of a fabric, tears.

Students increase the tension on a hanging sample by gradually loading it with 100 g masses until it begins to stretch (indicating **stretch resistance**) and continuing until it starts to tear (indicating **tensile strength**). While increasing the load, they measure the increasing length of the sample; that is, its **extension**. They also compare the **elasticity** of their samples, by removing the loads to see how well the material returns to its original length. Once they reach a high load, the material will probably not shrink back, since it has been loaded beyond its **elastic limit** and become permanently stretched.

Note that the procedure does not give actual measurements of tensile strength, which is defined as the maximum force per unit area that a thread or fabric can withstand until it breaks or pulls apart.

$$\text{tensile strength} = \frac{\text{force causing failure}}{\text{cross-sectional area of sample}} \ \text{N m}^{-2}$$

The students measure the load in grams, rather than as a force in newtons, and do not calculate the cross-sectional area of the sample, which would involve measuring the thickness of thin fabrics.

EQUIPMENT

- stand with 2 x clamps
- 2 x wooden blocks, a few cm square, to hold sample strip in jaws of the clamp
- dowel with a pin or pointer attached to one end
- strong thread, to hang 2 kg from dowel
- sticky tape
- 30 cm ruler
- 2 x 100 g mass hangers and masses
- box of crumpled paper, to catch falling masses if sample breaks
- samples of test materials, 40 cm x 1.0 cm, and of similar thickness

Students should be encouraged to select suitable test materials for themselves.

For meaningful comparisons, sample materials must be strips of equal length and uniform width. Usually the materials would also need to be of similar thickness. However, in this case it is okay to use different thicknesses, and possibly find that the thicker materials are stronger. Thickness may be a consideration for the materials the students choose for their glove.

In addition to fabrics, students could test various types of flexible plastic sheet, such as used for plastic/rubber gloves, and padding materials.

Depending on the materials being tested, the width of samples and loads applied may need adapting, to ensure that most samples do fail under load. Some investigative pre-testing is recommended.

HEALTH AND SAFETY

A risk assessment is required before any practical work, but the specified procedure involves no significant hazards, provided fingers and toes are kept clear of falling masses.

METHOD

Samples must be clamped tightly between the wooden blocks to prevent them being pulled out under load. Depending on surface texture, some materials might not be held together by sticky tape, so the loop around the dowel may need gluing or stitching instead.

{TEACHER NOTES} WATER REPELLENT/PROOF FABRICS

These procedures are a variation on standard textiles tests for water repellency (the spray test) and water resistance (the rain test).

Water repellent fabrics: Students drop water onto fabric samples, shake off any repelled water and then re-weigh the fabric. **Waterproof fabrics:** Students subject fabric samples to a large quantity of water (either by set amount or set time), and assess whether or not it has penetrated the fabric. Note: It is much simpler to establish whether or not a fabric is waterproof (completely water resistant) than assess how water resistant it is.

EQUIPMENT

WATER REPELLENT FABRICS

- small beaker of water
- Petri dish
- teat pipette
- balance (accurate to at least 0.1g)
- various types of fabric

WATERPROOF FABRICS

- small beaker
- blotting paper or kitchen towel
- sticky tape
- elastic band, to fit around the beaker
- measuring jug, cylinder or beaker (at least 1 litre capacity)
- various types of fabric
- scissors (possibly)
- ruler

Students should be encouraged to select suitable test materials for themselves. They should use their repellency results to inform their choice of materials for the waterproof test.

It doesn't matter if the fabric samples vary in size (so long as they are large enough to cover and drape over a small beaker for the waterproof test) because the area subjected to water will either resist water or not, and it is the difference between the 'dry' mass and 'post-water exposure' mass that is important.

HEALTH AND SAFETY

A risk assessment is required before any practical work, but the specified procedures involve no significant hazards. Students should take extra care if using scissors.

METHODS

Students weigh dry fabric samples, place ten drops of water on each, shake off resisted (repelled) water, and re-weigh. The most repellent fabrics will absorb less water, and consequently the difference in mass will be smaller.

When assessing whether or not a fabric is waterproof, fabric samples are subjected to a large quantity of water and observed to see if any water passes through into the beaker. If this is not apparent, the blotting paper must be checked. It may be obvious that the blotting paper is wet. If not, then the students would have needed to weigh the blotting paper before setting up the equipment, and then re-weigh it after testing. Any increase in mass would suggest that it has absorbed some water.

EXTENSION

Students could attempt to design an investigation to measure and/or compare the level of water resistance of different materials. For example, how much water is needed to penetrate the material?

{TEACHER NOTES} WETTING, WASHING AND DRYING

As well as testing textiles when they are new, students should find out what happens to some of their properties/characteristics after wetting and drying.

Because of the wetting and drying times involved, students may need to limit their investigation into just a few fabrics and a few characteristics.

Teachers will need to help their students plan their testing over several weeks, to allow for the wetting and drying times.

EQUIPMENT

- textile samples
- permanent marker pen
- large tiles
- eye protection
- measuring cylinder
- washing powder
- 'seawater' for Sea water testing
- scissors
- large trays
- paper towel
- 1000 cm^3 beaker
- access to hotplate or waterbath
- tongs
- water, preferably deionised for **Cold water** and **Warm water** testing

If real seawater is not available, prepare 1 dm^3 of seawater as follows:

1. Mix 250 cm^3 limewater [LOW HAZARD] with 750 cm^3 deionised water.
2. Bubble carbon dioxide through the mixture for about 20 minutes, until the cloudy precipitate disappears completely.
3. Filter.
4. Add as much solid hydrated calcium sulfate [LOW HAZARD] until no more will dissolve.
5. Add about 30 g of sodium chloride [LOW HAZARD].
6. Stir until all the solid has dissolved.

For **Cold water** testing, if tap water is used, a small amount of wetting agent may be needed in hard water areas.

For **Cold water** or **Sea water** testing, the quantity of water will depend on the size of the tray. For the **Warm water** washing, the size of beaker and quantity of water will depend on the size of the samples being tested. If the samples are small, several can be washed together. It should not be a tight fit and the beaker should not be more than three-quarters full, to allow for safe stirring.

HEALTH AND SAFETY

Students must take care with hot water. A hotplate is preferable to a Bunsen and tripod for heating these larger quantities of water. It should be PAT-tested. Eye protection should be worn. Students should ensure they don't mark their clothes with permanent ink.

A risk assessment must be carried out before any practical work is carried out.

{TEACHER NOTES} WETTING, WASHING AND DRYING

METHOD

These wetting, washing and drying procedures can easily be carried out by one competent student, or a pair, allowing other team members to continue with other tests or aspects of the Challenge.

The observation tables can be used as an overarching device where all team members can contribute to its completion, inserting their before-and-after findings. Where a property or characteristic is being assessed qualitatively, students may need some help in assigning a scoring system. Encourage them to canvas the opinion of two or three team members.

When students are planning to assess shrinkage or colour-fastness, the fabric requires additional preparation. Refer to those Test Procedures.

EXTENSIONS

If time is available, students could subject their samples to multiple cycles of warm water washing and drying, to more closely replicate conditions in use.

Students could also try drying samples at 60 °C and/or washing at 60 °C.

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{TEACHER NOTES} WICKABILITY

This procedure involves submersing fabric in coloured water and measuring the speed of absorption, followed by the rate of evaporation.

EQUIPMENT

- Petri dish, large enough to hold at least 1 cm of water
- balance (accurate to at least 0.1 g)
- clamp and clamp stand
- food dye
- stop watch
- various types of fabric
- fabric scissors
- permanent marker pen

TEST SAMPLES

Students should be encouraged to select suitable test materials for themselves. It is useful if different fabrics are coloured differently for easy identification. Lighter colours make it easier to observe water/dye uptake.

It doesn't matter if the fabric samples vary in length because it is only the distance between the two lines that is important. However, the fabric must be of equal width as this could affect the rate of absorption, and possibly evaporation.

HEALTH AND SAFETY

A risk assessment is required before any practical work, but the specified procedure involves no significant hazards.

Students should take extra care if using scissors. They should also be careful not to mark their clothes with food dye or permanent ink.

METHOD

Students place fabric samples in coloured water and (i) measure the time it takes for the water to be absorbed and reach a specified point; (ii) measure the time it takes for the wet fabric to dry.

The quicker the coloured water reaches the specified point, the more absorbent the material. The greater the rate of evaporation, the quicker the fabric dries. Materials that are able to absorb and dry quickly are wickable; they have high wickability.

EXTENSIONS

Students could ...

- look at how the construction of the fabric affects its wickability. They could compare two different polyesters such as Coolmax® and a cheap general purpose polyester fabric.
- compare fabric thickness. For example, students could use the same fabric but different thicknesses and look at how it affects both the rate of absorption and evaporation.

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{ROLE MODELS} DR. ROSE L. SPEAR

NAME: DR. ROSE L. SPEAR

ORGANISATION: UNIVERISTY OF CAMBRIDGE, ENGINEERING FOR LIFE SCIENCES, DEPARTMENT OF ENGINEERING

JOB TITLE: RESEARCH ASSOCIATE

1. WHAT DO YOU DO?

As a researcher at the University of Cambridge, I work in a laboratory, investigating new materials for hip implants.

2. DESCRIBE YOUR TYPICAL WORK DAY

My typical day can include: reading papers and reports on the latest developments in my field; planning and conducting experiments and reporting on the results of our experiments through reports, papers and presentations.

3. WHAT HOURS DO YOU WORK?

My hours vary considerably depending on our experimental schedule and the availability of the instruments needed for my experiments.

4. WHICH SUBJECTS DID YOU ENJOY MOST AT SCHOOL?

My favourite subjects were chemistry and biology. I also enjoyed philosophy, literature and music.

5. WHAT QUALIFICATIONS DO YOU HAVE?

I have a BSc (Hons) in Chemistry and a PhD in Materials Science.

6. TO WHAT DEGREE WERE STEM SUBJECTS IMPORTANT IN GETTING YOUR JOB?

Without my science qualifications, I would not be able to do my job. To run my experiments and interpret the results requires a high level of understanding of chemistry, biology, mathematics and physics.

7. WHAT WERE THE MAIN FACTORS THAT ATTRACTED YOU TO YOUR CURRENT JOB?

I love understanding how and why things work. I also love exploring our natural world and creating new materials and ideas. My job offers me the opportunity to learn something new every day and to advance what we understand.

8. HOW DID YOU GO ABOUT ENTERING INTO THIS CAREER/ GETTING EXPERIENCE?

I originally wanted to pursue medicine but then had the opportunity to work with someone on a research project, developing materials for bone implants, in my last two years at university. This made me decide to go into research with a medical slant. I was very attentive to my studies when I was in school and was then lucky enough to work for several years with excellent scientists who trained me in the scientific method and techniques for conducting experiments to test our questions about natural and synthetic materials.

{ROLE MODELS} DR. ROSE L. SPEAR

9. DO YOU HAVE ANY ADVICE FOR SOMEBODY LOOKING INTO THE SAME CAREER?

My advice would be to work as effectively as possible on the things you enjoy and consider important and interesting – people who are the most happy are those who have identified what they are good at and what they enjoy. If you work to develop your skills, then you will be able to advance toward a satisfying career. It is important to keep an open and active mind.

10. WHAT ARE THE BEST/ WORST THINGS ABOUT YOUR JOB? WHAT DO YOU FIND MOST REWARDING ABOUT IT?

The most rewarding part is when we make a breakthrough after working for a long time without progress. The worst part is there can be a lot of administration and politics but it is important to have accurate records in order to convince others of the value of your work.

11. WHAT ARE THE CHALLENGES OF YOUR JOB?

Making sure we organise the experimental schedule effectively and ensuring that our interpretation of our results is accurate before we communicate them to others. It is also challenging to keep working on the larger picture despite several failed experiments.

12. WHAT HAS BEEN THE HIGHLIGHT OF YOUR CAREER SO FAR? WHAT HAS BEEN THE MOST EXCITING/ INTERESTING PROJECT YOU HAVE WORKED ON?

We were able to work with surgeons at Addenbrooke's hospital in Cambridge to design a new type of implant surface. This has led our projects into several new directions.

13. HOW DO YOU HOPE TO PROGRESS IN YOUR FIELD OVER THE COMING YEARS?

I want to continue contributing to medical materials research and this could take me in a number of directions in the future but most likely as a project leader in an industrial or academic lab.

14. WHAT PASSIONS AND INTERESTS DO YOU PURSUE IN YOUR PERSONAL TIME?

I love science outreach and lead several outreach efforts as Chair of the Cambridgeshire Branch of the British Science Association. Having a mentor or someone who inspires you can really change how you feel about a particular career. I'm also alumni editor for the Gates Cambridge Alumni Association.

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{ROLE MODELS} KHALID BOSTAN

NAME: KHALID BOSTAN

ORGANISATION: TURTLE WAX BV

JOB TITLE: INNOVATION AND PACKAGING MANAGER EMEA

1. WHAT DO YOU DO?

Develop new products and technologies for the car care market as agreed with the marketing teams across Europe.

2. DESCRIBE YOUR TYPICAL WORK DAY

Depending on the time of year and the stage of each project, the day can involve attending meetings to present findings on recent projects, signing off designs or time at the 'lab bench' developing new formulations.

3. WHAT HOURS DO YOU WORK?

Usually 8:30am to 5:00pm, although sometimes I do travel to our sites across Europe so this can vary. I can also work from home if needed.

4. WHICH SUBJECTS DID YOU ENJOY MOST AT SCHOOL?

I really enjoyed the Science subjects, as well as Art and PE. I was a little late in getting to enjoy English Literature – I think it was the way it was taught!

5. WHAT QUALIFICATIONS DO YOU HAVE?

I have A-levels in Physics, Chemistry and Biology, a HND in Physical Science, a BSc (Hons) in Combined Science (Chemistry and Materials Science), and an MSc in Polymer Technology. I also have qualifications in Health & Safety as well as other vocational qualifications in Environmental Practices.

6. TO WHAT DEGREE WERE STEM SUBJECTS IMPORTANT IN GETTING YOUR JOB?

STEM subjects were very important as they demonstrated to my company that they could rely on my skills and knowledge as well as my ability to continue to learn. In most cases it wasn't just the fact that I had a scientific background, it was the understanding of basic principles, experimental design, and how to interpret results.

7. WHAT WERE THE MAIN FACTORS THAT ATTRACTED YOU TO YOUR CURRENT JOB?

I have always loved the idea of being able to 'create' new products or develop concepts beyond the ordinary. Having a product that you have developed, helped manufacture and then sold all over the world is a great buzz. I also have the opportunity to work with some great people.

8. HOW DID YOU GO ABOUT ENTERING INTO THIS CAREER/ GETTING EXPERIENCE?

I was quite determined to get into a career in my chosen STEM subjects, and was lucky to get a role straight after my studies with a company who needed a chemist with a polymer background. I also did various lab jobs during my holidays while studying. I finally ended up at Turtle Wax some 16 years ago, in a research and development role, and progressed through the company, heading the Technical, Health & Safety department, and I've now moved into an Innovation role.

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{ROLE MODELS} KHALID BOSTAN

9. DO YOU HAVE ANY ADVICE FOR SOMEBODY LOOKING INTO THE SAME CAREER?

Don't be put off by the basic jobs, or roles which you are initially offered. These can be repetitive but they will give you a good stepping stone to your next role. Sometimes the experience of just working in a particular environment is all you need to differentiate you from other candidates. Learn as much as you can in every job role you do.

10. WHAT ARE THE BEST/ WORST THINGS ABOUT YOUR JOB? WHAT DO YOU FIND MOST REWARDING ABOUT IT?

There are days when things don't go my way or products aren't performing as you would expect but it is just a reminder that work is a process. There are a lot of deadlines and working with a mixed team of people can be testing at times. My job does allow me to work flexibly though and no two days are the same so I can never say the job is boring.

11. WHAT ARE THE CHALLENGES OF YOUR JOB?

The nature of the business and product ranges means that there a lots of deadlines to stick to ensure products get launched in time and at the right cost. Also, making what the marketing team have 'dreamt up' into reality can sometimes be real challenge.

12. WHAT HAS BEEN THE HIGHLIGHT OF YOUR CAREER SO FAR? WHAT HAS BEEN THE MOST EXCITING/ INTERESTING PROJECT YOU HAVE WORKED ON?

There are two products of which I am particularly proud; CHIPSTIKS and WAX IT WET, which have been sold all over the world. I have also been instrumental in developing new methods of manufacture to help save energy and water as well as reduce waste which led to an award for the design and concept.

13. HOW DO YOU HOPE TO PROGRESS IN YOUR FIELD OVER THE COMING YEARS?

It's a continually changing market so I hope to continue to make products which fulfil the needs of the business. I do also hope to be able to develop the technical team across Europe for the Turtle Wax business.

14. WHAT PASSIONS AND INTERESTS DO YOU PURSUE IN YOUR PERSONAL TIME?

I enjoy time with my young family and like to play Badminton as often as I can. I would also like to spend more time rambling, living near to the Peak District has its advantages.