PART ONE: FABRIC ESTIMATION FOR PATTERN CUTTING

2 A categorisation for designers and pattern cutters

Measuring fabric characteristics

The background

Designers should be aware that a major consideration in any design decision is the 'fitness for purpose'. In particular sectors of industry, other considerations may override the 'ideal' design decisions; for example, cost or availability of fabric. In sportswear, absorbency and perspiration control are principal property requirements. It is important that a designer discovers the type of relevant tests that are required for a product's viability (see Appendix Four). However, this book is concerned with those characteristics of a garment which affect its visual form.

The visual appearance of any garment is directly affected by the characteristics of the fabric in which it is made. Selecting the correct material for a design is a difficult problem for a designer when an artefact is made from materials that are solid, rigid and stable, but the problems are immense for garment designers working with the infinite variety of shapes and fabrics used in the textile industry. Mathematics, textile chemistry, physics, mechanics, structural engineering and other fields of science have been used in order to create theories that could be applied. Journals are prolific with papers showing graphs and calculations to support methods of analysis, and expensive equipment has been devised to measure the properties of fabrics. Many large textile and garment producers use these tests (see Appendix Four) especially when comparing similar fabrics for their advantages for a particular product range.

Some computer programs use these theories in their attempts to create realistic three dimensional (3D) models of fabric. The aim is to realise a virtual image of a garment during the pattern cutting process (see page 28). However, as discussed on page nine, the selection of a fabric by a designer usually comes at a much earlier stage in the creation of a range. Computer programs at this stage are more useful for decisions such as colour and pattern. Determining the suitability of a fabric for the *shape* of a design at the concept stage will still rely on human discrimination.

Fabric characteristics: a practical categorisation

There are enormous problems in defining and measuring some fabric characteristics, this does not mean that it should not be attempted. However, the methods of assessment described in the book are used solely for the purpose of pattern cutting, they are done to give a 'sense of visual and tactile order'. Flat pattern cutting is successful when a designer's intuitive knowledge of a fabric can generate a 3D mental image of the *fabric shape* that will be produced by the flat pattern. Industrial pattern cutting has to be done with speed and this human mental facility is faster than any computer system, it can be instantaneous. It has been noted that the reliance on calculators has reduced the ability in students in a variety of disciplines to 'estimate', the ability of visual estimation is one that clothing designers cannot afford to lose. The techniques in this book may help designers to strengthen their intuitive sense of integrating form and fabric. To illustrate this point the photographs opposite show that a very simple circular shape in basic fabrics (rayon jersey, light–medium-weight calico, heavy cotton twill) behaves quite differently when cut at different lengths and scales. Overlapping shapes at different angles in fabrics of complicated and uneven structures provide problems of infinite complexity that require refinements embedded within the process of cutting, it is not simply a procedure of prediction and modification. The photographs also demonstrate the false images that can be created by working in quarter or half-scale.

Five requirements: **WEIGHT, THICKNESS, SHEAR, DRAPE, STRETCH** for the initial selection of pattern cutting methods have been recognised in this book as crucial. This does not dismiss aesthetic qualities that impact on the senses; for example, colour, subtle textures and tactile experiences or fashion and cultural influences. But these, with the practical considerations of product type and 'fit for purpose', are different elements of the design process.

Weight, thickness, shear, drape, stretch

The relationship of these five characteristics to pattern shapes will be discussed in detail in the pattern cutting sections. Some simple examples may illustrate the changes to the types of garments worn today and how their cut will be principally determined by the fabric.

There is a limit to the amount of heavy cloth (WEIGHT) anyone wishes to carry on their body. Historically, heavy cloth was associated with warmth; but lighter cloths, wadded fabric (THICK), knitted pile (THICK AND HIGH STRETCH) or windproofed bonded fabrics (THIN AND LOW STRETCH), have replaced many heavy woollen cloths. Each of these latter fabrics are likely to require different stylistic and practical pattern cutting methods.

Fabrics that allow distortion of the warp and weft threads (SHEAR) usually have good draping qualities, but they will cause problems if they do not recover their shape, particularly as they come under body strains. But many new fabrics made from micro-fibres have HIGH SHEAR and also high recovery.

Fabrics with little drape or stretch have to have any body shape achieved through cut, whilst a small amount of elastane (HIGH STRETCH) in a fabric can give a garment some internal shape in wear.

These are simple illustrations, but many decisions are in 'grey areas' where defining the limits are not easy. The pattern cutting section will develop basic and more complex shapes and illustrate how fabrics with particular characteristics are likely to behave in those forms.

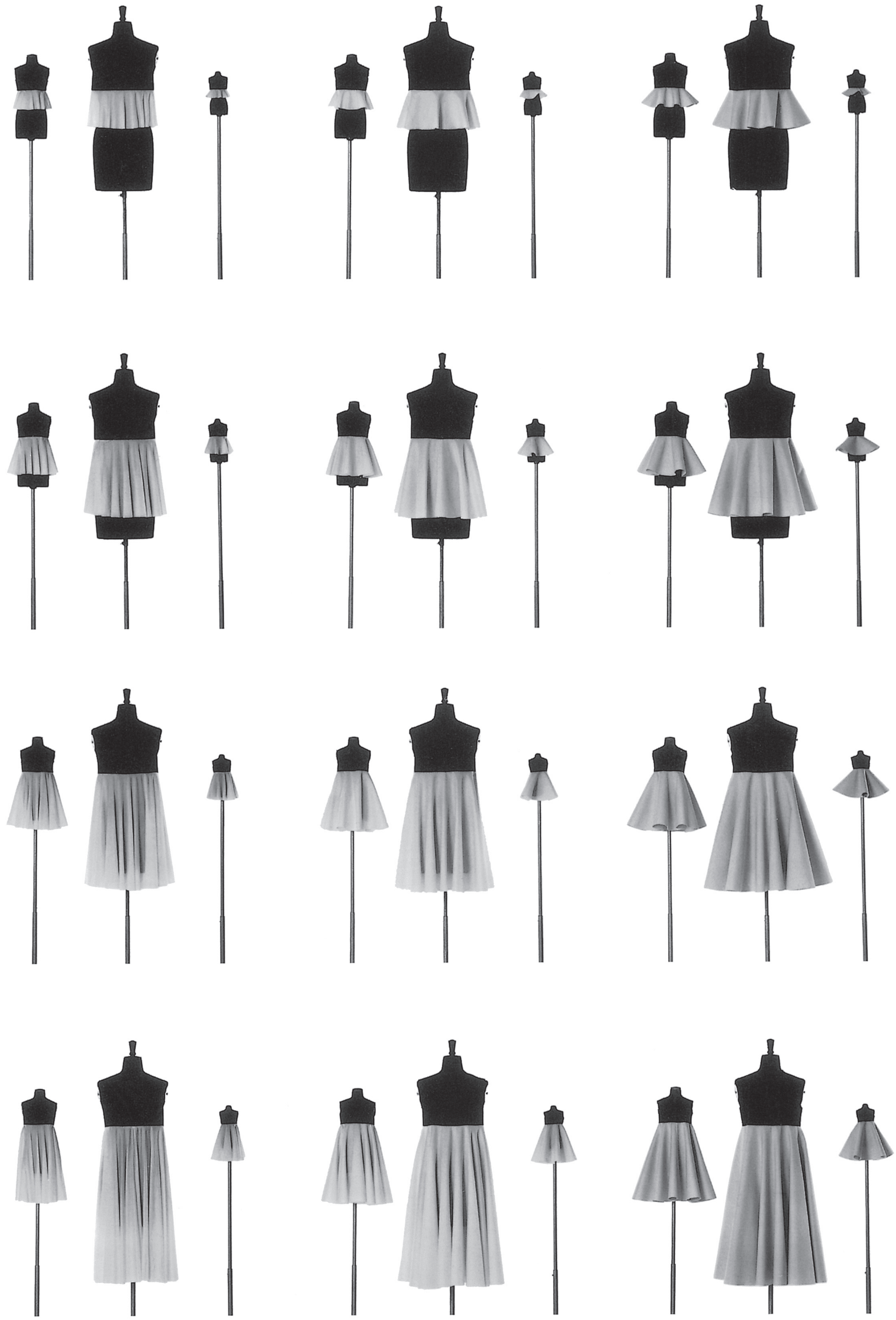


Figure 6 Three different fabrics cut in circular shapes of varying lengths and scales.

The fabric characteristic scale for pattern cutting

The term 'characteristic' is used because it is a descriptive term. In many textile books the words 'characteristic' and 'property' are used as if they can be interchanged. The latter should be used to relate to a fundamental chemical or biological property and in the context of broad design and garment shape decisions, the term characteristic is far more useful.

The pattern cutting method or block chosen for the development of a style should start with an analysis of the fabric. When the selection of fabrics was limited and style conventions influenced design, methods of cut were predictable. The increased availability of very different fabric ranges during the last decade needed a new approach. The five principal fabric characteristics which should be assessed before deciding the method of pattern cutting or the choice of pattern block are: **WEIGHT, THICKNESS, SHEAR, DRAPE, STRETCH.** They are assessed across a five point scale 1 2 3 4 5.

Opposite ends of each characteristic are as follows:

WEIGHT	Light-weight	1 . . . 5	Heavy-weight
THICKNESS (visual)	Thin	1 . . . 5	Thick
SHEAR	High-shear	1 . . . 5	Low-shear
DRAPE (visual)	High-drape	1 . . . 5	Low-drape
STRETCH	High-stretch	1 . . . 5	Low-stretch

Note that two are judged as a visual characteristic and therefore could be termed a 'visual measurement'. These terms are explained in the next section.

It is not argued that this method should replace or compete with other forms of technological measurement; instead, it is a different way of approaching the problems of translating 3D forms from 2D pattern templates.

Whilst it is recognised that other characteristics will play some part and would give subtle variations to the stark divisions offered, STRENGTH, SMOOTHNESS (friction), and COMPRESSION are secondary considerations. The weave structure (open or closed) should be examined. Open weave fabrics are often associated with shear, but many of the very closely woven micro-fibre fabrics can have shear characteristics.

The five-point fabric scale

The most accurate way of assessing fabrics is to use a full size circle of cloth, see page 21. However, the analysis in this book is made using only the fabric swatch piece (most fabric swatch pieces are on cards approx. A4 in size). This means that a square of 20 cm can be cut from the swatch. The sample swatch may be all that is available to a designer before purchasing a sample length.

Each fabric illustrated in the book will have a reference number attached for each characteristic. High numbers represent heavy, thick, low-shear, low-drape and low-stretch fabrics. Low numbers represent light, thin, high-shear, high-drape and high-stretch. Fabrics are quite likely to have a mixture of characteristics. The fabrics used in the illustrated garments are coded in the following way, for example:

Fabrics used in the illustration

		We	**Th**	**Sh**	**Dr**	**St**
1	Cotton voile	1	1	1	3	4

This means that the sample fabric is light-weight, thin, high-shear, medium-drape and medium–low stretch.

The measurements recorded in this book were taken using simple but specially devised equipment (see Appendix Three). However, even simpler methods of achieving a similar result are shown on the following pages. Any student could take fabric measurements by these methods. If students begin to assess fabrics in this manner, in quite a short time they should be able to intuitively code a fabric for comparison quite quickly. This helps the process of visualising a fabric's capability to produce certain shapes, and therefore compare and select fabrics.

Because the fabrics were so diverse (the scale would have been distorted if any statistical procedure had been imposed) the divisions between the categories 1–5 have had to be taken across an even spread across the majority of the fabrics. Extremely thick fabrics were not allowed to distort the group.

It is possible for others to disagree with my divisions and devise their own. This is not a mathematical scheme to be imposed, but a method that could be used across the whole range of fabrics, or adapted for a particular fabric group. Within narrow fabric groupings, the use of a statistical method (centiles) could be practical, agreement of the category divisions could then be made.

Throughout the book, there are no rules that dictate which fabrics should be used for particular blocks or pattern shapes, but visual examples are given which demonstrate what is likely to happen when they are realised in fabrics with different characteristics.

Special note 1. The 20 cm sample piece of woven fabric should be cut accurately along the warp and weft threads, and along the wales of knitted fabrics. The fabric piece should be checked to determine that it is perfectly square before the tests are carried out.
Special note 2. The order of the fabric characteristics is set for appreciation for pattern cutting. However, if only one 20 cm square fabric sample is available, the least distortion to the fabric will occur if the tests are made in the following order: **drape, thickness, weight, shear, stretch**.
Special note 3. The scale is a comparison across all fabrics and is not a comparison within a particular fabric group (e.g. shirtings).

Weight

The weight of a fabric is important, large amounts of heavy fabric can be uncomfortable to wear, but weight in a fabric will help to make graceful vertical folds and will 'swing' dramatically. There has been a general movement to lighter weight cloths, but some manufacturers are finding some resistance where customers attach weight to fabric quality, especially in wool fabrics. Often it is the reverse. Lighter wool fabrics are often made from higher-grade fibres or yarns and can be more difficult to weave. Light fabrics with low-drape and low-shear (example: cotton organdy) often give sharp crisp outlines but often crumple in use. This feature has been enhanced by many of the crinkle finishes available. Light fabrics with high levels of drape and stretch (example: single jersey) give wonderful body fitting and drape lines. Compact, closely woven medium-weight fabrics with high-drape and medium–high shear are excellent for crossway cutting (example: crepes or some micro-fibre fabrics).

Weight information is usually recorded by the square metre and to the nearest gm, although some fabric ranges give 5 gm intervals. In most cases, the weight will be listed on the fabric swatch or is available from the manufacturer. European manufacturers generally list the weight per running metre. To convert grams per metre length to grams per metre square: divide the weight by the fabric width and multiply by 100. Some UK manufacturers may still show the weight in ounces. To convert oz weight to gm weight: multiply the oz weight by 33.91.

Some domestic scales (see the photograph below) will measure in 1 gm intervals, this would be adequate for the type of broad categorisation that students may wish to undertake for themselves when calculating from a 20 cm square of fabric. Very accurate scales are required for more rigorous tests (example: British Standards). These scales are usually available in university textile departments.

Method for student practice

If the weight is not listed on the fabric swatch, weigh a 20 cm square piece of fabric (Fig. 7), then multiply the weight by 25 to calculate weight per square metre.

The categories shown below were decided by judging that any fabric over 450 gm should be described as 'heavy', and then five divisions were created.

The weight characteristic scale (in grams)

1	2	3	4	5
Light	**Light–medium**	**Medium**	**Medium–heavy**	**Heavy**
0–79.9	80–179.9	180–299.9	300–449.9	450+

Equipment used for weighing the fabrics recorded in this book

The fabrics used and recorded in the book were weighed (20 cm square) on an accurate TANITA Cal-Q-Scale which calculated to 0.1 gm. See Appendix Three, page 212.

Figure 7 Measuring weight. A method suitable for student practice. A 20 cm square of fabric measured on a domestic scale that records in 1 gm intervals.

Thickness

Fabric thickness is so variable that each fabric has to be judged individually. Fabrics that appear thick can be highly compressible, other fabrics have uneven thickness that may be unevenly distributed. Very close fitting garments will require extra ease allowances unless the fabric has stretch and recovery qualities. Most thick garments are adapted from the easy fitting blocks. Particular pattern cutting techniques have to be used where there is gathered or pleated fullness to reduce the bulk. Thick fabrics with low-drape and low-shear characteristics can give exaggerated and stable geometric outlines. Extravagant but soft shapes can be achieved with fabrics that are thick and have high-drape qualities.

Fabric thickness is extremely difficult to measure. Technical laboratories measure it under pressure, it is recorded with a 'load' reference which flattens the fabric. This is useful for the making up of fabrics; but for pattern cutting a visual measurement which does not distort the fabric is more useful. When comparing fabrics that are very textured or are unevenly woven or knitted, a measurement can record the thinnest and thickest points and take an average measurement.

Method for student practice

Place the 20 cm square of fabric between two blocks (Fig. 8). Use a linen tester (a magnifying glass marked in millimetres and used in thread counting) to determine the thickness of the cloth. Linen testers are available from MORPLAN, a major supplier to the clothing trade.

The categories shown below were decided by judging that any fabric over 5 mm thick should be described as 'thick', and then five divisions were created. For illustrations of a wider range of fabrics see Appendix Three, page 212.

The thickness characteristic scale (in mm)

1	2	3	4	5
Thin	**Light–medium**	**Medium**	**Medium–thick**	**Thick**
0–0.4	0.5–0.9	1–2.4	2.5–4.9	5+

Equipment used for measuring the thickness of fabrics recorded in this book

The fabrics used in the book were hung vertically and scanned on an A4 SHARP flat-bed scanner. See Appendix Three, page 212.

Figure 8 Measuring thickness. A method suitable for student practice. A 20 cm square of fabric placed between blocks and measured with a magnifying glass marked in mm.

Shear

The amount the fabric shears (distorts in the warp and weft; see diagram) can be measured. Shear can be an advantage or disadvantage and the amount is important. The amount of recovery after strain is important. Closely woven fabrics with a high-shear characteristic (for example, micro-fibre silk-like fabrics or some crepe weave fabrics) are very stable when used in crossway cutting. Open-weave high-shear fabrics distort if under strain. Many complicated luxury fabrics, particularly fabrics in linen, silk and viscose have this characteristic. Fabrics will tailor more satisfactorily if there is some shear quality, it allows the tailor to shape the garment; however, too much shear becomes a problem.

Method for student practice

Create a card scale for measuring shear and stretch. Draw a horizontal line at the bottom of the card. Draw two lines at right angles to this line 16 cm apart. Mark the right vertical line and horizontal line in 0.5 cm intervals for 10 cm as shown opposite. Draw a third vertical line at the end of the scale.

Tape the 20 cm square of fabric onto the underside of two rulers using 2 cm of cloth on each ruler. Place the first ruler firmly at the left-hand start of the scale. Move the second ruler under tension in a vertical (shear) direction along the marked scale. The shear measurement is the amount that the fabric shears before ripples appear on the surface of the cloth. The amount can be measured on the vertical line of the scale. The amount of recovery can also be measured.

The categories shown below were decided by judging that any fabric with shear over 5 cm should be described as 'high shear', and then five divisions were created.

The shear characteristic scale (in cm)

1	2	3	4	5
High shear	**High–medium**	**Medium**	**Medium–low**	**Low-shear**
5+	4.9–3.5	3.4–2	1.9–0.5	0.4–0

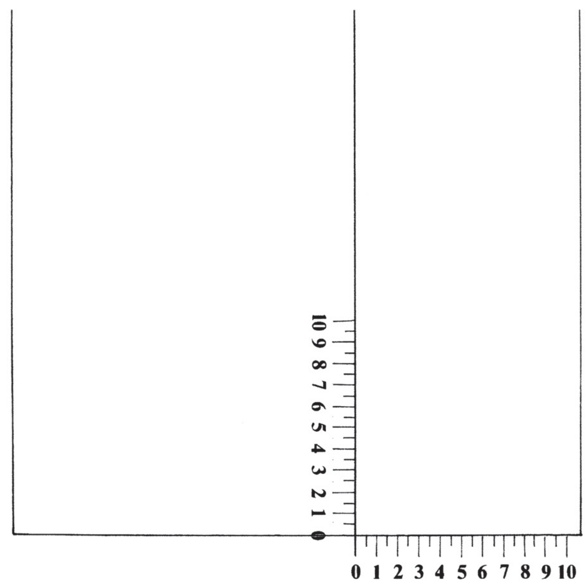
Percentages

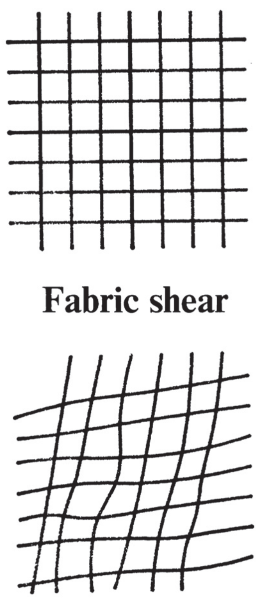
The percentage shear can be calculated by the following equation.

$$\frac{\text{amount sheared}}{\text{original length}} \times 100 \quad \text{e.g.} \quad \frac{2\,\text{cm}}{20\,\text{cm}} \times 100 = 10\%$$

Equipment used for measuring the fabric shear recorded in this book

A special piece of equipment was constructed that held the fabric under tension between two bars. A photograph of it in use is shown in Appendix Three, page 213.





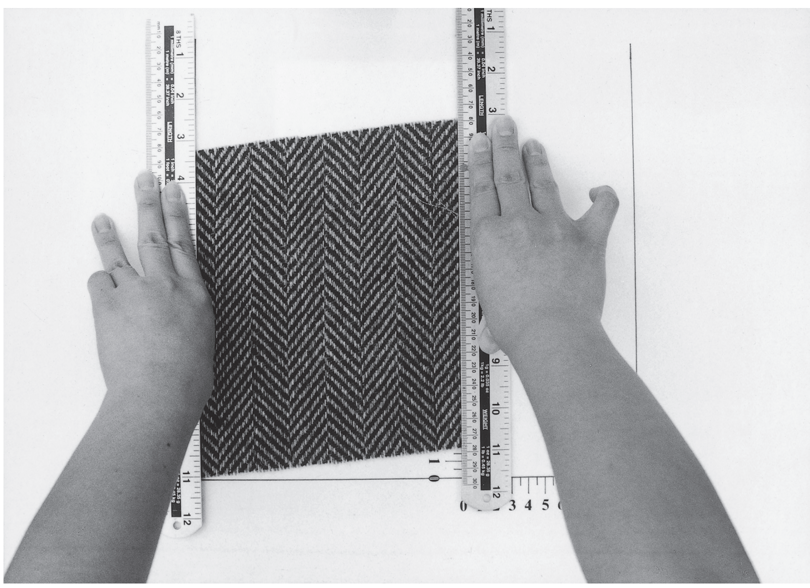


Figure 9 Measuring shear. A method suitable for student practice. The card scale and a 20 cm square of fabric taped to two rulers and the amount of shear measured on the scale.

Drape

Drape is the ability of a fabric to hang in soft folds and to fit around a figure, particularly in movement, without creating angular distorted creases and buckles. The strain is often across the fabric, thus good draping is needed across the fabric falling from flared shapes. The drape test done for these experiments concentrated on a crossway hanging test as this is a good guide to a fabric's potential to drape. Drape is a characteristic valued in many fabrics, it is only a part of that elusive quality 'hand'. 'Hand' is a combination of many qualities that will differ in different fabrics and this, I believe, is not measureable.

A simple assessment of the drape of a fabric, cut on the straight grain, can be made by holding a gathered sample piece vertically. The increased drop that would result from the weight of a larger piece of fabric would have to be taken into account. The difficulty of assessing how fabric may behave in circular cut is demonstrated on page 21. Asymmetrical shapes, crossway cutting and the effects of joining different curve shapes would add further complexity. The drapeometer test (BS 5058, see Appendix Four), which drapes a 30 cm circle of cloth over a circular disk, has little relationship to the hang of clothing. The new simple visual test, using a 20 cm sample piece, is only given as guide across the five categories.

Method for student practice

On a piece of thick white card mark a central point at the top. Mark a central line. Draw two lines at 45° each side of the line. Divide the area each side of the line into five sections. Mark them 1–5. Drive a nail or large drawing pin through the top point. Hang the corner of the 20 cm square of fabric onto the point at the top centre. The drape category can then be recorded.

The drape characteristic scale

1	2	3	4	5
High-drape	**High–medium**	**Medium**	**Medium–low**	**Low-drape**

A low-shear fabric will hang as a flat shape on the board; therefore, in pattern cutting terms, low-drape means virtually no drape. Note the difference in the two fabrics shown in Fig. 10.

Equipment used for measuring the fabric drape recorded in this book

The equipment described for student practice was used for the fabric codes recorded in this book.

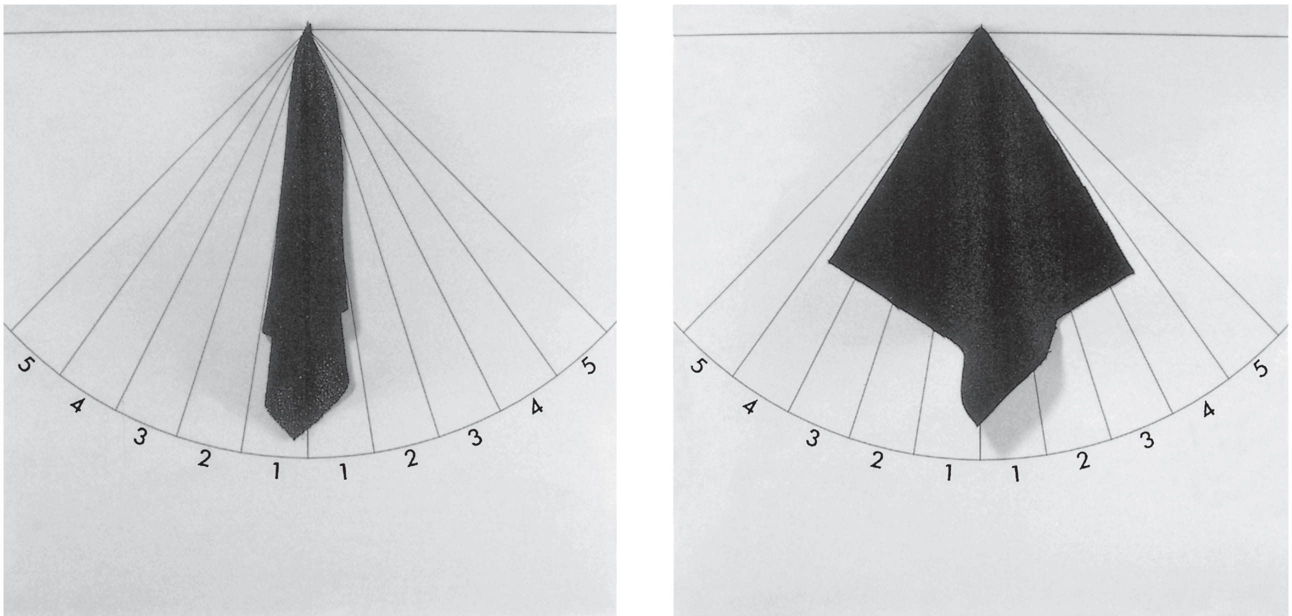


Figure 10 Measuring drape. A method of measuring drape suitable for student practice. The left fabric records 1 (high-drape). The right fabric records 4 (medium–low drape).

Stretch

Stretch characteristics in fabrics offer the opportunity to cut close to the body without complex body shaping. Quite simple shapes will fit closely to the body. Knitted fabrics may stretch but their recovery can be weak. The introduction of a small amount of elastane can make a remarkable difference to its stability. The introduction of elastane into woven and knitted fabrics has penetrated a large sector of the market, but there is still some resistance to the rather 'unnatural' hang of some of the garments. The amount a fabric will stretch can be measured; the instrument below will measure the maximum stretch horizontally, followed by the stretch vertically. However, these practical amounts are of little use if the fabric appears visually unpleasant at very high stretch or near the stretch limits of the fabric. The basic pattern cutting shape has to be based on a basic 'visual stretch' measurement. On body fitting garments or other garments, the designer has to decide the amount of stretch that is visually acceptable and then has to cut the garment pattern accordingly. This is the 'visual stretch' that is recorded in the work in this book.

Method for student practice

Use the card scale created for measuring shear and stretch (see the diagram on page 25). Tape the 20cm square of fabric onto the underside of two rulers using 2cm of cloth on each ruler. Place the first ruler firmly at the left-hand start of the scale. Move the second ruler under tension in a horizontal direction along the marked horizontal scale. The 'visual stretch' measurement in the weft direction is the amount that the fabric stretches before it begins to distort the fabric unpleasantly. The amount can measured on the horizontal line of the scale. The amount of recovery can also be measured.

The categories shown were decided by judging that any fabric which had a visual stretch of more than 5cm should be described as 'high-stretch', and then five divisions were created.

The stretch characteristic scale (in cm)

1	2	3	4	5
High-stretch	**High–medium**	**Medium**	**Medium–low**	**Low-stretch**
3.5+	3.4–2.5	2.4–1.5	1.4–0.5	0.4–0

Close body fitting garments
Four other measurements can be taken on the scale when cutting close body fitting garments in stretch fabrics.

(1) The horizontal visual 'action' stretch (visually acceptable stretch when the body is in action).
(2) The vertical (warp) stretch of bi-stretch fabrics.
(3) The decrease in measurement of the fabric vertically when the fabric is stretched horizontally.
(4) The amount of recovery after the fabric has been stretched.

Percentages
The percentage stretch can be calculated by the following equation.

$$\frac{\text{amount stretched}}{\text{original length}} \times 100 \quad \text{e.g.} \quad \frac{2\,\text{cm}}{16\,\text{cm}} \times 100 = 12.5\%$$

Equipment used for measuring the fabric stretch recorded in this book

A special piece of equipment was constructed that held the fabric under tension between two bars. A photograph of it in use is shown in Appendix Three, page 213.

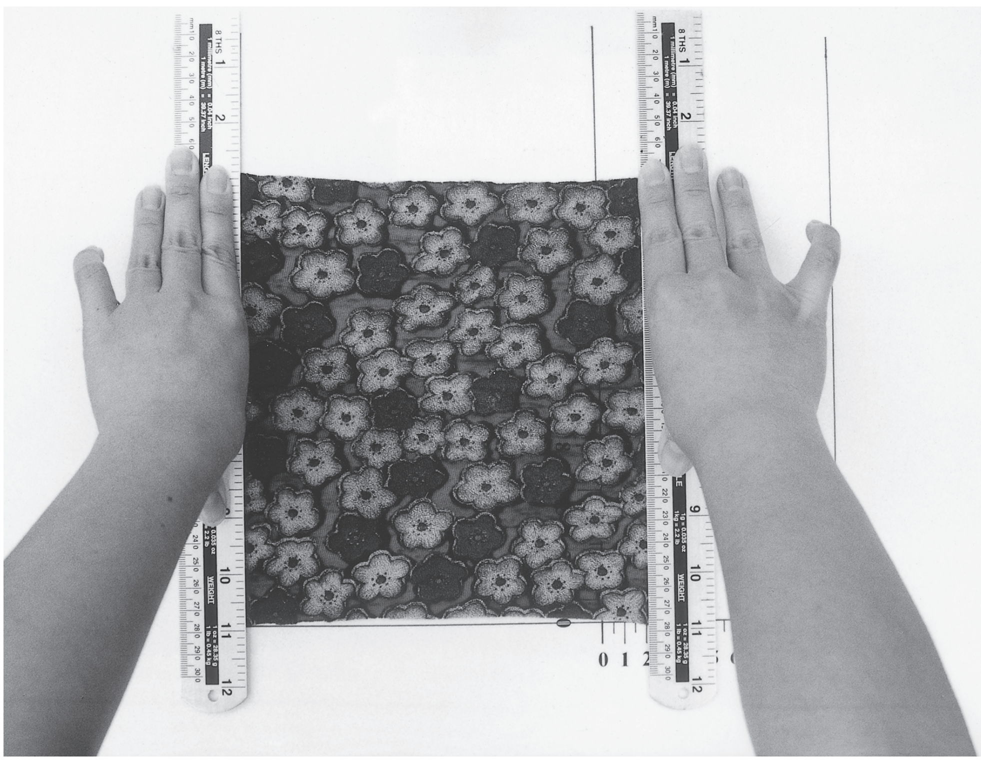
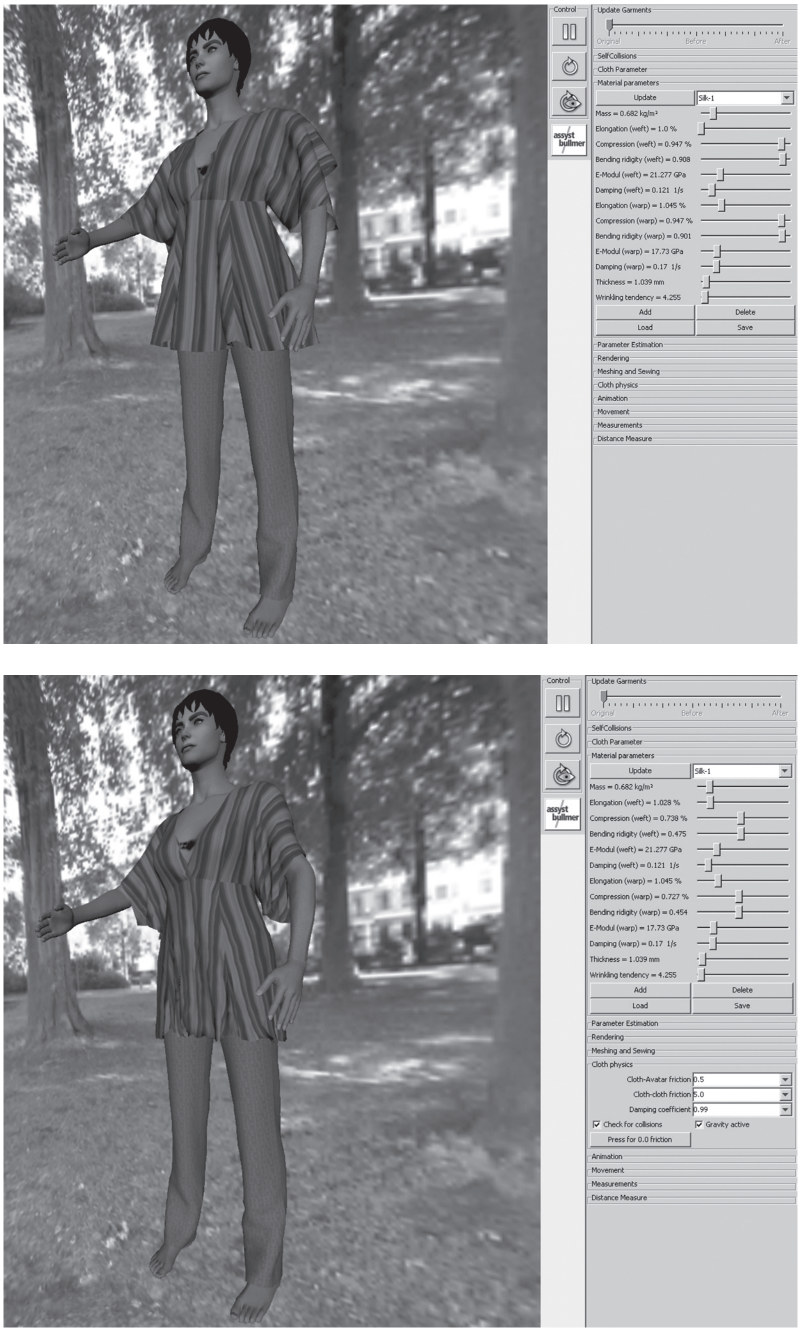


Figure 11 Measuring 'visual stretch'. A method suitable for student practice. A 20cm square of fabric taped to two rulers and the amount of 'visual stretch' measured on a card scale.

Fabric properties and 3D CAD images

A number of CAD software companies – for example Browzwear, assyst-bullmer, Optitex and Lectra – have developed software that creates the realisation of virtual garments in high resolution. Garment pattern pieces are joined together to create a 3D CAD image of a garment worn by a virtual model figure that will demonstrate how the garment will look when finished. The mannequin's skin, face and hair can be customised. The shape and size of the figure can be determined by the input of manual or body-scanned measurements. These virtual figures can revolve, change poses and perform many human movements.

In most companies many garment samples of designs are made up but then discarded. CAD suppliers claim that 3D CAD realisation could reduce this apparent waste of time and materials because decisions could be made at an early stage in the design cycle. A further purported advantage is that the fit and stress of the garment can be measured technically.



The companies have developed their programs in such a way as to emphasise different functions. Companies will select the software that responds to their priorities. For example, a design emphasis may focus on the manipulation of colour, shape and printed pattern in the development of a design range, whilst other companies may be more concerned with the fit, or the garment stress of body movements in sportswear, industrial wear or military activities.

However, the common denominator in all the programs is the realisation of how the fabric will determine the image of the garment. This requires the input of the measurements related to the mechanical properties of the fabric, and the majority of program developers are using The Kawabata Evaluation Systems for Fabrics (KES-F TEST). This is described in Appendix Four. It is usually large companies that invest in these CAD systems and they have access to fabric testing laboratories that conduct these tests.

An example of the fabric properties required can be seen in Figure 12: mass, elongation, compression, bending rigidity, E-modal, damping, thickness, wrinkling tendency.

The images show how the garment shape changes when different property values are input into the system. Some systems allow designers to use the sliders interactively to examine how a change of fabric will affect the design.

Students of CAD will find that an intuitive knowledge of fabric behaviour, so necessary for their manual pattern cutting, will also be invaluable in any technological future.

Figure 12 Notice how the shape of the garment is changed as the values for compression and bending rigidity are altered. Photographs reproduced with permission of assyst-bullmer.