Computer-aided Pattern Design and Product Development

Other titles of interest

Metric Pattern Cutting
Third Edition
Winifred Aldrich
0 632 03612 5

Pattern Cutting for Women's Tailored Jackets
Winifred Aldrich
0 632 05467 0

Metric Pattern Cutting for Menswear
Third Edition
Winifred Aldrich
0 632 04113 7

Metric Pattern Cutting for Children's Wear and Babywear
Third Edition
Winifred Aldrich
0 632 05265 1

Fabric, Form and Pattern Cutting
Winifred Aldrich
0 632 03917 5

Fashion Source Book
Kathryn McKelvey
0 632 03993 0

Fashion Design: Process, Innovation and Practice
Kathryn McKelvey and Janine Munslow
0 632 05599 5

Illustrating Fashion
Kathryn McKelvey and Janine Munslow
0 632 04024 6

Fashion Marketing
Edited by ME Easey
0 632 03459 9

Fashion Buying
Helen Goworek
0 632 05584 7

Master Patterns and Grading for Women's Outsizes
G Cooklin
0 632 03915 9

Introduction to Clothing Manufacture
G Cooklin
0 632 02661 8

Carr and Latham's Technology of Clothing Manufacture
Third Edition
David J Tyler
0 632 02896 3

Computer-aided Pattern Design and Product Development

Alison Beazley and Terry Bond

Blackwell
Publishing

Editorial Offices:
9600 Garsington Road, Oxford OX4 2DQ, UK
Tel: +44 (0)1865 776868
108 Cowley Road, Oxford OX4 1JF, UK
Tel: +44 (0)1865 791100
Blackwell Publishing Inc., 350 Main Street, Malden, MA 02148-5018, USA
Tel: +1 781 388 8250
Iowa State Press, a Blackwell Publishing Company, 2121 State Avenue, Ames, Iowa 50014-8300, USA
Tel: +1 515 292 0140
Blackwell Munksgaard, 1 Rosenørns Allé, P.O. Box 227, DK-1502 Copenhagen V, Denmark
Tel: +45 77 33 33 33
Blackwell Publishing Asia Pty Ltd, 550 Swanston Street, Carlton South, Victoria 3053, Australia
Tel: +61 (0)3 9347 0300
Blackwell Verlag, Kurfürstendamm 57, 10707 Berlin, Germany
Tel: +49 (0)30 32 79 060
Blackwell Publishing, 10 rue Casimir Delavigne, 75006 Paris, France
Tel: +33 1 53 10 33 10

First published 2003

A catalogue record for this title is available from the British Library

ISBN 1-4051-0283-7

Library of Congress
Cataloging-in-Publication Data
Beazley, Alison.
Computer-aided pattern design and product development/Alison Beazley and Terry Bond.
p. cm.
Includes bibliographical references and index.
ISBN 1-4051-0283-7 (softcover: alk. paper)
1. Dressmaking–Pattern design–Data processing.
2. Clothing and dress measurements–Data processing.
3. Computer-aided design. I. Bond, Terry, 1954–
II. Title.

TT520.B384 2003
646.4′072′0285–dc21

2002043912

Set in 9.25/11pt Times
by DP Photosetting, Aylesbury, Bucks
Printed and bound in Great Britain by
Ashford Colour Press, Gosport

For further information on
Blackwell Publishing, visit our website:
www.blackwellpublishing.com

Contents

Preface

The computer is a very useful tool that when used correctly can increase accuracy and productivity, and manage information. This removes the time consuming tasks of cutting card patterns and planning and drawing markers by hand, and the duplication of hand-written instructions. This computer technology has enabled the clothing design, pattern construction and product development to be integrated into a more continuous process.

Computer design systems enable designers to illustrate and visualise their designs both two and three dimensionally. The pattern technologist can construct and grade the patterns simultaneously. The sample garment can be viewed three dimensionally in simulated fabric. The cost of the garment can be calculated from a computer lay plan of the pattern pieces on the fabric for fabric utilisation. Having an easy access to a database assists the clothing technologist to calculate the cost of the garment for their specifications.

However, it is essential that the preparatory work is based on knowledge of the principles and techniques of pattern construction, grading and pattern lay planning and marker making. Initially the preparatory work may appear somewhat time consuming, but once the correct data has been put into the computer it can be operated with confidence.

The definition of design in the context of this book is not the creation of fashionable styles but the procedure of developing a style suitable for production that is influenced by the body dimensions, the fabric and the production methods. Originally computer programs were developed to grade garment patterns into a range of sizes for lay planning and marker making. Today there are major systems that have the further facility for designing patterns and altering patterns to the size and fit for an individual customer.

The pattern construction and design in this book is based on well-tried and proven methods used in the past by well-respected pattern makers. These methods have been adapted for today's computer systems but can also be drafted manually and then digitised into the computer. All the patterns constructed for this book were developed using a computer pattern design system and are for women's garments. They have all been tested by producing sample garments.

The intention of this book is:

- To introduce and explain the wide range of computer programs available to the clothing industry for pattern design and product development.
- To give guidance to those operating or planning to use computer programs for pattern designing, grading and lay planning by combining a theoretical understanding with the practical application.
- To give a reference source to students following courses in Pattern Design, Clothing Technology and Clothing Management.
- To give knowledge and understanding of the principles for developing garments to those conversant with operating computers but lacking experience in clothing product development.
- To assist those experienced in clothing technology with the transition from manual methods to operating computer systems.

The book is divided into six parts for ease of reference:

INTRODUCTION: Developments within computer-aided apparel systems.
The clothing industry has changed profoundly in recent years. Globalisation, speed of information and communication has stimulated competition. While manufacturers offer unlimited designs, the problem is how to bring products to the market quickly and achieve up-to-date information that is easily obtainable. CAD systems are now the essential tools required to integrate and achieve success taking the role of the 'configurator' between manufacture and retail. Utilising a full range of electronic tools, from the ubiquitous internet to the new powerful CAD systems can deliver clothing at relatively short cycles. Integration and communication utilising the internet become the new systems designed to achieve this.

PART 1: Pattern construction
The obtaining of body measurements and how they are formulated into size charts is explained. These size charts are requisite to all the pattern designing, grading and customisation that follow in Part 2, Part 3, Part 4 and Part 5. The various techniques of constructing and manipulating patterns manually and by computer are compared. The drafting of basic block patterns is described and their adaptation into

secondary blocks. This knowledge assists in the calculation of grading increments discussed in Part 2. These block patterns are the foundation for designing pattern for styles described in Part 3.

PART 2: Computer pattern grading
The principles of pattern grading to produce a range of sizes are explained. How they are applied to computerised grading is covered in detail. This is illustrated by the grading of the block patterns constructed in Part 1. The benefits of grading block patterns prior to computer pattern design is that the size increments are transferred on to the new style. This eliminates grading as a separate process. Alternatively, the digitising and grading of manually produced patterns is also explained.

PART 3: Pattern designing and grading
This covers the pattern construction or adaptation of a variety of designs for skirts, bodices, collars and sleeves. Suitable methods of grading are suggested. Details for completing the pattern with seams, hems and facings for production are also given.

PART 4: Pattern modification for garment size and fit
This section gives an introduction to the assessing of the figure shape and garment fit related to the stature, posture, body size and contour. The identification of fitting faults is explained and the appropriate pattern corrections. This information is in preparation for pattern alteration systems and made-to-measure.

PART 5: Computerised marker making systems
It has long been recognised that improvements at the front end of cutting can show substantial fabric savings. Fabric and trim account for about half the total costs of goods manufactured, and in a competitive situation, the first place that cost reduction can be achieved is in fabric utilisation. It is generally understood that 40% of the finished garment cost is fabric; it is also recognised that 90% of cutting room costs are fabric. Parameters relevant to lay planning and marker making will be identified.

PART 6: Product data management systems
Product data management (PDM) systems have been developed to improve the product and the process of the product development cycle. These systems provide an automated means to control and facilitate the flow of up-to-date information to authorised participants throughout the organisation.

PDM acts as a communication tool between design, retail and manufacture, containing details about patterns, garment construction, fabric and trims, packaging costs, quality and measurement specifications. It is the direct interface between CAD/CAM systems and management information systems.

APPENDICES
References and further reading are listed on p. 205. Appendix I gives a comprehensive index of technical terms and abbreviations related to the text. Appendix II shows reduced size basic block patterns for use as exercises in digitising, grading and pattern design. These are at 33.3% of the original and can be plotted full-scale.

Great improvements have been made to computer systems since the early 1990s. They are much more ‘user friendly’ today and are being continually updated. The content of this book is not specific to one specific system; the authors have used various systems for testing the illustrations. The reader should become conversant with the system they will be using, preferably by training from the supplier.

Acknowledgements

We wish to express our appreciation and thanks to the following people: Poppy Thomason, Penny Preddle and Anita McAdams for the time that they freely gave to reading the draft and constructive criticism of the text and diagrams. We wish to thank Aileen Jefferson and Julie Vernon for their practical contribution. We appreciate the following companies allowing the use of published photographs of their equipment and quote details of their products: Gerber Garment Technology, Wicks and Wilson, Telmat Informatique and the Textile/Clothing Technology Corporation. The preparation of this book could not have been undertaken if we had not had the support, use of computer facilities and permission to use some illustrations from Manchester Metropolitan University.

Abbreviations and symbols

bk	back
BP	bust point
CB	centre back
CF	centre front
fr	front
FS	face side of the fabric
GRL	grade reference line
NP	neck point
R	grade rule
SS	side seam
UP	underarm point
WS	wrong side of the fabric

Construction line

Construction line (secondary) and alteration line

Drill hole

Grade direction

Grain line

Notch

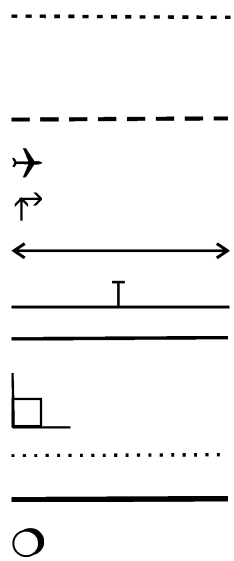
Pattern parameter

Square corner at 90°

Stitch line

Style line

Zero point for grading



Introduction

Developments within computer-aided apparel systems

Developments within computer-aided design for fashion, clothing and visualisation have been realised using 3D software. Offering the designer a virtual prototyping system has been an active research area for many years. Despite being applied in other commercial industries, the development of 3D imaging for use within the clothing industry has met many research challenges. However, by presenting recent developments within this virtual environment the 3D picture becomes much clearer.

In relation to pattern design the ability to move from 2D to 3D is perhaps the area of most interest. The creation of 2D patern shapes that can be wrapped around a virtual mannequin fits nicely within the 2D CAD pattern development application used within the industry, and development from this is the most likely way forward for the designer and pattern technologist.

3D software developed by Pad systems was one of the first commercial packages available to the clothing industry offering further integration between the pattern technologist and designer. This modular-based software allows 2D patterns to be modified and, following a sequence of assigning sew points, a 3D simulation on a virtual mannequin can be created. Fabric models within the module allow simulations of garment drape which can be linked to objective measurement data.

Gerber Technology now offers commercially their APDS-3D virtual garment draping system, which enables pattern technologists to view 2D garments assembled and draped on a virtual mannequin. Both the viewing and lighting angles of images are user defined; the horizontal and vertical cross sections of the mannequin can be viewed, offering the pattern technologist the ability to verify fit and ease allowance. Modifications in either 2D or 3D mode take immediate effect with results displayed. The system also allows integration of fabric images from the Artworks studio module, another of the family of software solutions offered by Gerber Technology. Current 3D software provides the pattern technologist and designer with a toolset to review the design and construction of their garments.

Lectra Systemes has expanded its organisation to embrace all areas of CAD/CAM. The developments of internet, intranet and virtual reality technologies are given high priority, the aim being to improve the products through brand building and to increase sales with leading technologies. These developments will allow Lectra to incorporate their pattern module solutions and offer commercially four key components: E-Design, E-Manufacturing, E-Sales and Lectra on-line. By maximising the potential of these technologies it may become possible to view an entire garment collection on a virtual reality catwalk.

CAD vendors with this developing technology bring a more structured and systematic approach to the pattern cutting and garment construction processes. At this stage of development, the 3D tools require improvement if they are to fulfil their promise and acceptability.

Developments within 3D body scanning systems capable of producing anthropometrics data offer a direct link to 3D design and pattern making. There are a small number of companies involved within body scanning: TC2, Tecmath, Telmat, Hammatsu and Wicks & Wilson. Telmat, the French company, have developed a 3D body scanning system, the Symcad Flash 3D system, which offers instant 3D automatic body measurements and open connectivity to CAD systems. In formation it can be directly linked to a made-to-measure CAD module either from a Symcad system or via the internet or an ISDN line. Developments within this area allow integration into the manufacture and retailing interface, offering individual service.

Among the software solutions offered by CAD vendors, resurgence in made-to-measure (MTM) allows manufacturers and retailers to develop into the rapidly growing area of mass customisation. With new technologies developed to simplify the customisation of a garment it is now possible to automate the garment development through to the point of manufacture. This gives the ability to manufacture single garments at mass production speeds and avoids the high cost usually associated with single garment production. MTM software is designed to integrate with existing CAD modules, allowing quick and easy entry of customer details, body measurements and customer orders. Information is linked to pattern-making software, marker planning, plotters and single-ply cutters.

Product data management software is a CAD tool which aims to reduce development time, increase quality and improve communications between manufacturer and clothing retailers. Its function is to organise information in the product development phase, to ensure technical specifications are followed to the last detail into the production phase of the garments. More specifically, product data management (PDM) systems contain information about patterns, garment construction, costs, quality and measurement specifications. New PDM systems are now Web enabled, allowing the major CAD vendors products to be internet, intranet and extranet enabled. The ability to transfer/share reliable information, ease of communication, is of the utmost importance.

3D visual merchandising is the new media promoted by major CAD vendors offering the ability to quickly simulate apparel collections in any virtual 3D retail environment. The ability to create and control the retail environment defining store layout, selected garments, style, colour, assortment and retail space offers the ultimate assortment planning 3D visual merchandising system for apparel brands and retailers. This is made possible by a powerful database encompassing a catalogue of 3D fixtures, dressed mannequins and custom objects importable from a 2D CAD media.

The success achieved by other industries in internet e-commerce has not so far extended into apparel, although the continued developments in visualisation technologies along with the ability to use 3D scanning data constantly improve the representation of garments on-line. In the near future from the comfort of home it will be possible to select a garment, use the data from the 3D body scan to try it on your own digital model, view around 360°, select the size that fits best or have the garment altered to your own specific measurements for a customised fit, then sit back and await the delivery of the selected garment.

Part 1
Pattern construction

The emphasis in Part 1 is on the preparatory work to be undertaken before the final patterns are constructed. This part covers:

- Taking body measurements manually
- Computerised measuring systems
- Size chart formulation
- Pattern construction techniques
- Block pattern construction
- Primary block construction
- Secondary block construction

The first requirement is obtaining body measurements that have to be formulated into the size charts for garments. These size chart measurements are then used for constructing block patterns that are adapted for the final garment patterns. The size charts and block patterns are also required for pattern grading explained in Part 2, pattern design and grading in Part 3 and computer 'made-to-measure' systems in Part 4.

Patterns represent the two-dimensional component parts of a garment. They are used as a guide for cutting the fabric, which when sewn together forms a three-dimensional garment. The creation of these patterns is the technique of pattern construction. In the past this was often termed pattern cutting, but with the advent of computers the cutting of individual patterns by hand is less essential. This is why in this book the term 'pattern cutting' is replaced by 'pattern construction'.

Pattern construction is part of the garment design process and product development. The pattern can also be considered as a foundation for garment production. The complexities of developing and grading a pattern are often underestimated. The designer or pattern technologist is creating a three-dimensional garment which is made in unstable two-dimensional fabric to be worn by a flexible body. The wearer has not only to feel physically comfortable in her garment but also psychologically confident and socially accepted.

To construct patterns by computer requires two skills: knowledge of pattern construction and how to operate the computer program. A skilled pattern technologist has also to be both mathematical and creative. Only guidance can be given for constructing patterns by computer as each computer system has different sets of commands and methods of operating.

BODY AND GARMENT MEASUREMENTS

Body measurements are a prerequisite to pattern construction. The size and fit of a garment depends upon their accuracy. At present we are in the transition between traditional manual measuring by tape measure and computerised scanning or photographic systems. Manual measuring requires a high degree of skill and is time-consuming. The techniques of computerised measuring have recently improved considerably and will supersede manual methods in the future. Whichever method is used the first consideration is to decide which measurements are required. Are they needed to develop size charts for garment production or for an individual. The age range of the group or individual being measured is important as this has great bearing upon the body proportion and size charts. Different types of garment also require a different set of measurements. Detailed below is the procedure for manual measuring. This is followed by an account of the development of three-dimensional body scanning and computerised measuring systems. Either methods can be used for measurement surveys of women to develop size charts or for altering standard patterns used in the computer 'made-to-measure' systems (see Part 4). A more detailed account of how to undertake a survey of body measurement will be found in an article by Beazley (1997).

Taking body measurements manually

PREPARATION

- The preparation is very important for accuracy. Good rapport must be developed between the measurer and the person being measured. The person being measured should feel at ease and be relaxed.
- They should remove thick outer garments and only wear the underclothes to be worn beneath the garments to be made.

- The person being measured should stand normally and evenly on both feet, with relaxed shoulders, arms hanging at either side and head erect.
- Locate nape of the neck (at top of seventh cervical) with masking tape or soft removable marker.

EQUIPMENT

Tape measure

A fibreglass tape measure is recommended. It should be clearly marked and have brass tips at both ends. Alternatively, a retractable metal tape measure can be used, as it is firmer for taking girth measurements.

Metre rule

A metal rule is recommended to measure the hip level parallel to the ground.

Tapes

Adjustable elastic tapes are useful to attach around major girth measurements to locate the measuring position (these must not indent the body). Alternatively, for the neck base measurement, a fine chain can be positioned.

Mirror

A full-length mirror positioned behind the person being measured is useful for checking girth measurements that need to be parallel to the ground.

Record sheet

A record sheet lists all the measurements required in the measuring sequence. Posture details are also useful (e.g. shoulders square or sloping; posture erect or stooping; height short, medium or tall).

MEASURING TECHNIQUE

- The measurer should stand slightly to one side when facing the person being measured.
- Hold the tape measure close to the body and taut, but not pulled tightly to indent. Do not add any extra to the measurements for ease allowance. These extra allowances can be added when constructing garment patterns.
- Be discreet about the measurements. Do not let the person being measured move to look down at the tape measure.

MEASURING METHOD FOR BODICE AND SLEEVE

(a) Bust girth: The person being measured stands facing the measurer. The measurement is taken horizontally around the fullest part of the bust and approximately parallel to the ground to incorporate the shoulder blades.

(b) Waist girth: The waist elastic should sit comfortably in the natural position of the waist (not parallel to the ground). The tape measure is held firmly, but not indenting, over the waist level elastic. This can be checked in the mirror for the correct position.

(c) Neck girth: The base of the neck should be measured in a suitable position for a close fitting collar. Starting from the nape position place a narrow cord or chain around the base of the neck. When this is straightened the distance is measured against a tape measure.

(d) Upper arm girth: Measure the thickest girth of the right upper arm, either at the armpit or biceps level.

(e) Elbow girth: Position the tape in the bend of the right elbow, and then have the arm bent across the front waist. The measurements have to be taken over the bone of the elbow.

(f) Wrist girth: While the arm is still bent measure the wrist around the widest part.

(g) Nape to waist: The top of the tape measure is positioned at the nape (seventh cervical) and placed vertically down the centre back to the lower edge of the waist level elastic tape.

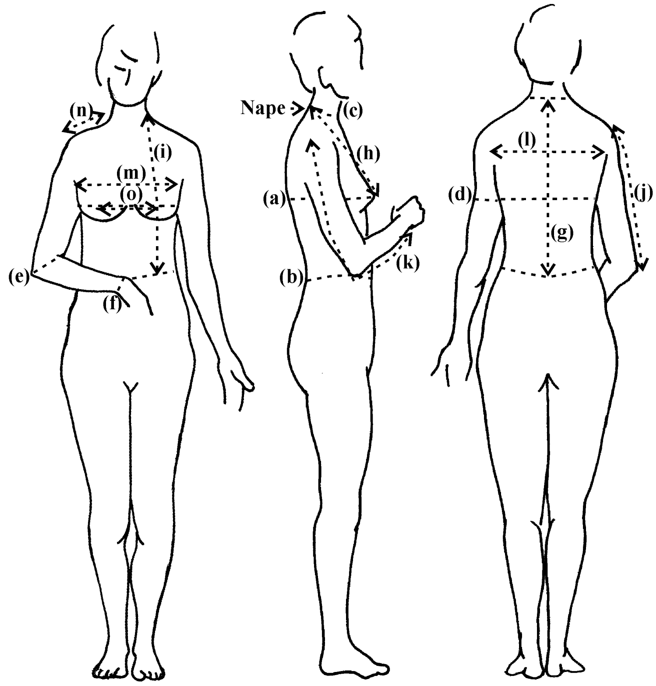
(h) Front length to bust: The tape measure is positioned from the nape over the right shoulder at neckline, then diagonally to the prominence of the right breast. (Half the back neck measurement of the garment is then subtracted from this measurement.)

(i) Front waist level: Measure as ‘h’ and continue the tape measure from the bust prominence vertically down to the lower edge of the waist level tape. (Half the back neck measurement of the garment is then subtracted from this measurement.)

(j) Elbow level: The person being measured stands with her right side to the measurer and right arm bent across her front waist. The tape measure is positioned from the nape over the end of the shoulder, diagonally to the point of the elbow. (The garment centre back neck to end of shoulder measurement is subtracted to give the final elbow level.)

MEASURING POSITIONS FOR BODICE AND SLEEVE

(a) Bust girth
(b) Waist girth
(c) Neck girth
(d) Upper arm girth
(e) Elbow girth
(f) Wrist girth
(g) Nape to waist
(h) Front length to bust
(i) Front waist level
(j) Elbow level
(k) Sleeve length
(l) Across back
(m) Across front
(n) Shoulder length
(o) Bust prominence width



(k) Sleeve length: Measure as 'j' and continue the tape measure to the end of the wrist bone at the 'little finger' side of the hand. (The garment centre back neck to end of shoulder measurement is subtracted to give the final sleeve length.)

(l) Across back: This width measurement is taken horizontally and gauged just above the skin folds where the arms connect to the torso.

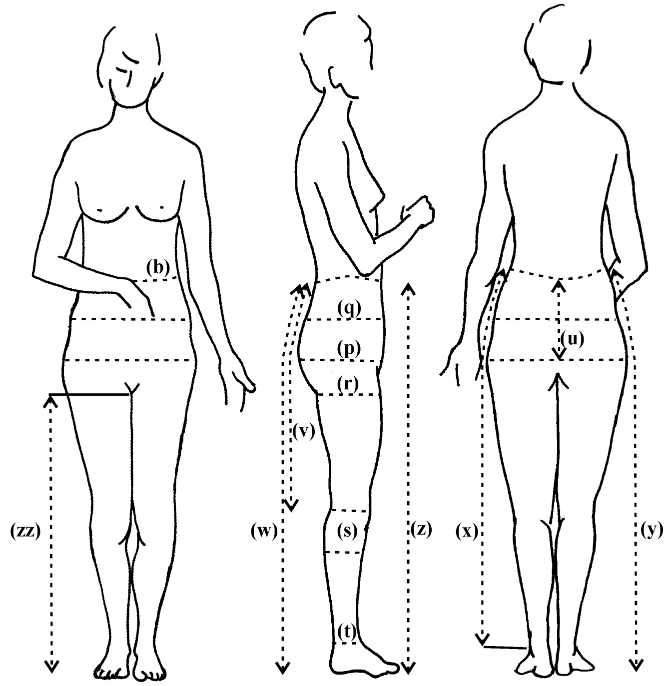
(m) Across front: This width measurement is taken horizontally between the centre front neck and bust level. The width is gauged at the skin folds where the arms connect to the torso.

(n) Shoulder length: The highest part of the shoulder is located and measured from the base of the neck to the bone at the end of the shoulder.

(o) Bust prominence width: Measurement horizontally between the most prominent part of the left and right breasts.

MEASURING POSITIONS FOR SKIRTS AND TROUSERS

(b) Waist girth
(p) Hip girth
(q) Upper hip girth
(r) Thigh girth
(s) Knee or calf girth
(t) Ankle girth
(u) Hip level
(v) Knee length
(w) Back length
(x) Ankle length
(y) Outside leg length
(z) Front length
(zz) Inside leg length



MEASURING METHOD FOR SKIRT AND TROUSERS

(b) Waist girth: See measuring method for bodice and sleeve.

(p) Hip girth: The tape measure is positioned horizontally around the fullest part of hips and buttocks and parallel to the ground (optionally an elastic tape can be positioned and levelled by using a metre rule). A note can be made of the measurement between the centre back waist and hip level (see (u)).

(q) Upper hip girth: Measurement midway between the waist and hip levels and parallel to the ground. The correct position can be checked in the mirror.

(r) Thigh girth: The person being measured stands with her legs slightly apart. The measurement is taken horizontally around the thickest part of the right upper thigh just below the crutch level.

(s) Knee or calf girth: Measurement horizontally around the thickest part of the right knee or calf, whichever is the largest.

(t) Ankle girth: Measurement around the thickest part of the right ankle.

(u) Hip level: Measure vertically from the centre back waist and the hip level.

(v) Knee length: Measure as (u) and continue down vertically to the crease at the back of the knee. (This measurement can be used as a guide for skirt lengths.)

(w) Back length: Measure as (u) and continue vertically down the back to the ground.

(x) Ankle length: Measure vertically from the side waist, over the side hipbone down to the lower edge of the anklebone.

(y) Outside leg length: Measure as (x) and continue the tape measure vertically down to the ground.

(z) Front length: Measure vertically from the centre front waist down to the ground.

(zz) Inside leg length: The person being measured can position the end of the tape measure between the legs at the crutch level. The measurer then places the tape down the inside of the leg to the ground.

Computerised body measuring systems

Various computerised body measuring systems have been developed since the early 1980s. These automatic systems operate by using scanning or photographic equipment linked to a computer. Developments since the early 2000s have realised great improvements and there are several systems now in commercial use. These systems record the body shape and posture two or three dimensionally, then calculate the body measurements. These systems can also be linked to a computer pattern alteration system or made-to-measure system (see Part 4). This enables the computer to find the nearest size pattern to the individual and alter the pattern according to the new measurements. These altered patterns can be transferred to an automatic marker making system and a single ply computer controlled cutter (see Part 5).

In Britain, Loughborough University pioneered the development of an anthropometrics shadow scanner (LASS). This produced a three-dimensional (3D) model of the human body. This method required a person, minus their outer wear, to stand stationary on a turntable as strips of light were projected vertically on to them while they were rotated 360°. A column of cameras recorded this within three minutes. This curve-fitting process treated the body as a series of 32 horizontal slices that corresponded to specific anatomical landmarks. The computer then processed this data that enabled a 3D image to be projected on the screen and the body measurements to be calculated (Fitting Research 1994 Apparel International).

An improved method of this system is now available commercially. This is the Wicks and Wilson's Triform scanner. The system is operated by the person to be scanned entering a booth wearing their underwear (Figure 1.1). They place their feet in a marked area, their hands holding a support rail which moves their arms away from their sides so that their torso is clearly revealed. They remain stationary while narrow and wide strips of white light are projected on to them and the camera captures one or more views of the illuminated object (Figure 1.2). 'By analysing the way in which the pattern of light is distorted by the shape of the object, the x, y and z coordinates can be calculated' (Wicks and Wilson 2000). This system only takes 12 seconds scanning time, as the person being scanned is not rotated as in the original LASS system.

The Triform body scanner processes the information within 2 minutes to produce a body shape image from which measurements can be extracted using the TriBody measuring system. This system requires the end points of the measurements to be placed manually on the scanned image so that the computer can read the distance between them. The system will also calculate the girth measurements around the body, e.g. waist, hips.

In France, Telmat Informatique developed the Systems of Measuring and Creating Anthropometric Data (SYMCAD). This was firstly using a 2D scanner, where a person enters a booth and removes their outerwear. Then a vision system records them standing facing forward and in profile. Two outline images are produced on a computer screen, which indicate their body shape and posture. This system was developed initially for use by the military to improve the allocation of correctly sized uniforms. It was used extensively in France and the UK.

Figure 1.1 3D Scanning booth (by permission of Wicks and Wilson Ltd)

The SYMCAD Turbo Flash/3D is similar in principle to the Wicks and Wilson's Triform scanner and has now superseded the 2D scanner. The 'SYMCAD Turbo Flash/3D takes more than 70 measurements and body figuration (or shape). Every measurement is automatically calculated at pre-defined points according to the ISO 8559 and 3635 standard' (Telmat Informatique 2000).

Another 3D scanning system developed in the USA on a different principle is the $[TC]^2$ (Textile/Clothing Technology Corporation 2000). The scanning system is designed using four stationary surface sensors. 'Each sensor consists of a projector and an area sensing camera, thus forming a vertical triangulation with the object or body' (Textile/Clothing Technology Corporation 2000). These capture an area segment of the surface. These segments are combined to form an integrated surface of the body. The actual scan raw data is further processed to show an image that has the positions of the extracted measurements superimposed within a matter of 53 seconds (Figure 1.3).

One of the major advantages of 3D body scanning is the speed, which has now been reduced to a matter of seconds, when compared with manual measuring with a tape measure. Some companies state that their system gives consistent results even if the person being scanned moves or breathes. Scanning also helps to waylay the apprehension of the person being measured, as it is not so intrusive compared with being measured manually. It is difficult to identify the prominences and hollows of the body when using a tape measure, whereas the 3D scanning system represents the exact body shape and posture. The scanned image is converted into a digital form required by a computer and is then displayed as a 3D image on the screen. This image can be rotated on the screen. From this image the computer will calculate the required body measurements. These 3D images and measurements can be stored in the computer's memory for future use. This measurement information can be transferred to a database from which the distribution of a specific population can be calculated and new size charts developed.

There are still certain difficulties in defining the true body shape when using 3D scanning. There is a problem with defining the person's actual height because of the amount of hair that rises above the scalp. At present the scanners cannot differentiate between the hair and the head. Another problem arises when scanning larger people as some of their flesh can form folds, for example under the chin or the underside of a woman's bust. Other areas that are difficult to scan are the armpits and the crutch. To overcome this the stance required while being scanned is with the legs slightly apart and the arms away from the sides. This is not really a normal posture. At present those being scanned are bare footed. Most people wear shoes when fully dressed and the height of the heel has an influence on their posture and length measurements. Consequently this can affect the balance or hang of their clothes.

It can be difficult to calculate from the scanned image some body measurements required for constructing or altering garment patterns. The scanner cannot accurately locate landmark positions on the skeleton that are used when measuring manually. For example, the seventh cervical at the nape of the neck or the bone at the end of the shoulder, which a measurer finds by feel.

Humans do not remain static in the present scanning positions. Allowing for the change in body size when moving is critical for the customer's comfort. There is considerable scope for further research into the changing body shape and measurements when, for instance, the arms and legs are lifted; also, the amount that knees and elbows increase in size when bent, and the hip size when seated.

The main current use of 3D body scanning systems is for surveys to give comprehensive information on the body shape of a specific population. This will aid the defining of the body size, shape and posture for developing size charts, and will improve the fit of clothing. There are two surveys being undertaken at the time of writing this book. In the USA there is the Civilian American and European Surface Anthropometry Resource (CAESAR) Project for which the Society of Automotive Engineers is gathering data of approximately 8400 men and women in the USA, Netherlands and Italy. In the UK a national survey organised by the Centre for 3D Electronic Commerce measured 8000 to 10 000 men and women during the autumn of 2001. This has been sponsored by a consortium of retailers and manufacturers and a grant from the Department of Trade and Industry (Centre for 3D Electronic Commerce 2000). One problem for body measurement surveys is obtaining a truly representative sample of population. This is because they rely on volunteers who are willing to be measured.

Another use of 3D scanned images is in the manufacture of workroom stands or mannequins. At present many of the stands are of an idealistic body shape. However, a more realistic contour can be produced from an average of scanned images or for one individual.

The generated body measurements for an individual's scanned image can be electronically compared with garment specifications. This can be useful for the computer pattern alteration or made-to-measure systems (see Part 4). In the future these customers could have a 'smart card' containing their measurements. This could assist them in obtaining the correct size from a retailer, a catalogue or the internet. A further possibility is for the customer to view the garment's appearance and fit on a simulation of a specific standard size or their own silhouette. Such facilities may in future be in general use in retail stores.

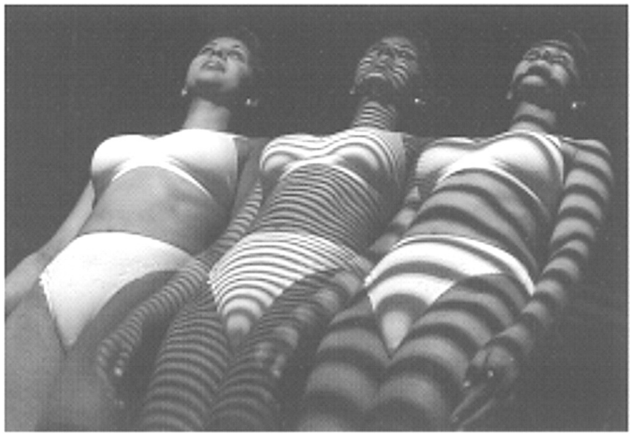


Figure 1.2 Camera images of narrow and wide strips of white light projection on to the body (by permission of Wicks and Wilson Ltd)

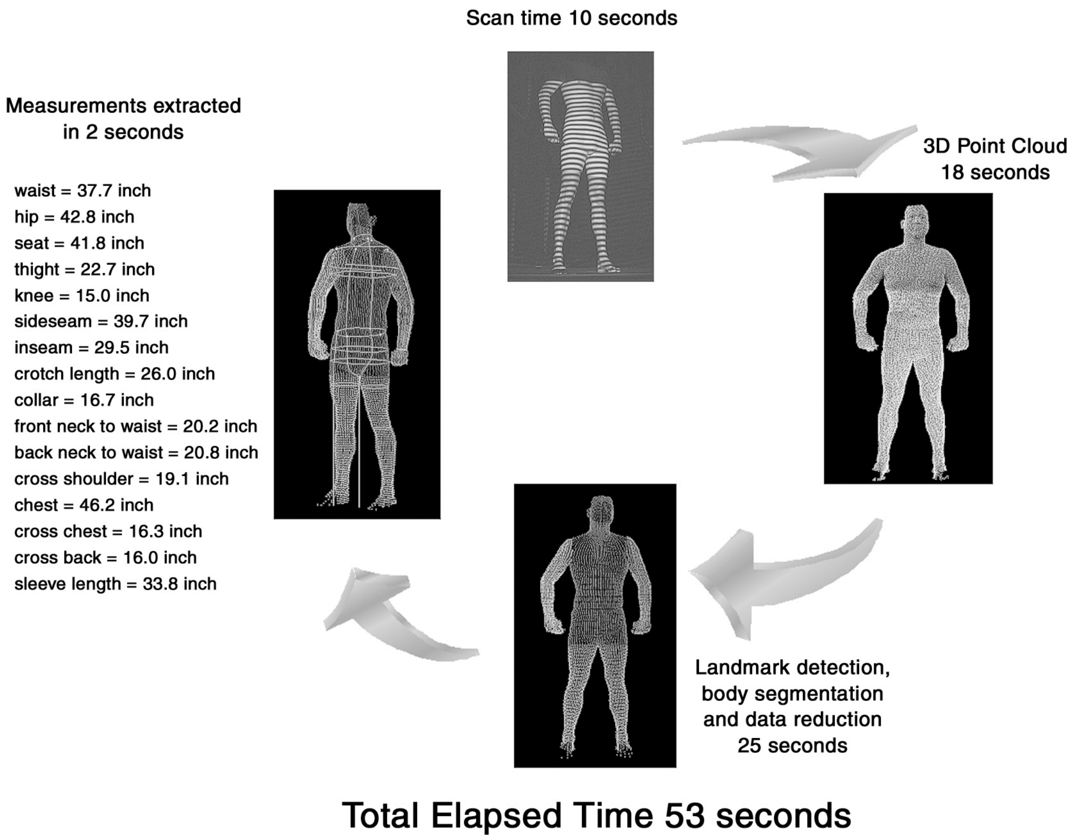


Figure 1.3 Scanning process and measurement extraction time (by permission of Textile/Clothing Technology Corporation)

SIZE CHART FORMULATION

A size chart is the dividing of average body or garment measurements artificially into categories to form a range of sizes. These average measurements are obtained from surveys of body measurements. Each size has to be given a code that is generally recognised by the public, such as 10, 12, 14, or labelled small, medium, large.

There are five stages in developing size charts for garments:

- Obtaining body measurements
- Statistically analysing the measurements
- Adding ease allowances
- Formulating the size charts
- Fitting trials to test the size charts

Firstly the body measurements have to be obtained generally through surveys taken manually or with the use of computerised equipment. (The details are described in the earlier section 'Body and garment measurements'). This is followed by the second stage of statistical analysis. Details of methods are described in an article by Beazley (1998). Often the statistical analysis of the body measurements runs to several decimal points of a centimetre, which are inconsistent and inconvenient to use for clothing manufacture. This may require the raw data to be rounded up or down to a whole centimetre or to one decimal point. Therefore the second stage is to round the measurement data to produce tables of body measurement (see Chart 1.1).

In the third stage a tolerance is added to the body measurements that is generally known as **ease allowance**. This is because garments have to be larger than the wearer to allow for movement and expansion. Three other factors which influence the ease allowance are:

- The function of the garment and whether it is worn over other garments, e.g. a coat requires extra width
- The style of the garment and whether it is close or loose fitting which depends upon the current fashion
- The type of fabric, whether it is stable or extensible, e.g. woven or knitted

Chart 1.1 illustrates the adding of ease allowances to the rounded body measurements to produce garment measurements for a straight skirt in woven fabric. Figure 1.4 illustrates the positions for the ease allowance to women's body measurements for a fitted bodice, semi-fitted sleeve and straight skirt for woven fabric. Initially the appropriate amount of ease allowance to be added in the correct position has to be estimated. The correct amount can only be confirmed after fitting trials of sample garments. More details concerning ease allowances can be found in an article by Beazley (1999).

The fourth stage is the formulation of size charts. These can be for either body measurements or garment measurements. It is difficult to manufacture a garment to an exact measurement due to dimensionally unstable fabric and sewing production. This requires a **production tolerance** to be calculated which is a measurement added to, or subtracted from, a garment measurement but still giving an acceptable size. When formulating size charts care has to be taken that the increment between the sizes is not the same as or less than the production tolerance.

The final, fifth, stage is testing the new size chart by constructing and grading patterns to the measurements, from which sample garments are cut and made. The sample garments are tested by fitting trials on groups of women of similar size. These trials confirm the correct sizes and also the amount and position of the ease allowances. If adjustments have to be made the charts and patterns are revised and re-tested.

Chart 1.1 Example of the three stages of formulating a size chart for a woman's skirt (measurements in centimetres)

SIZE		8	10	12	14	16
To fit	Waist	62.0	66.0	70.0	74.0	79.0
	Hip	88.0	92.0	96.0	100.0	105.0
Waist	Raw data	62.3	66.4	69.7	73.5	78.6
	Rounded	62.0	66.0	70.0	74.0	79.0
	Plus ease	66.0	70	74.0	78.0	84.0
Hip	Raw data	88.0	92.5	96.0	99.8	104.6
	Rounded	88.0	92	96.0	100.0	105.0
	Pluse ease	92.0	96.0	100.0	104.0	110.0

Women's size charts

The British Standards Specification for Size Designation of Women's Wear BS 3666 was last updated in 1982. These size designations are out of date when compared with retail sizing of today. Each successive generation has grown taller and wider in waist and hip girth. Very little corsetry is worn today compared with earlier generations (Beazley 1999). The most recent National Sizing Survey has not yet been published. For this survey it is planned to measure 10 000 women by a body scanning system. The following size charts are based on small-scale research undertaken by the Department of Clothing Design and Technology at Hollings Faculty, Manchester Metropolitan University between 1992 and 1998. The block patterns developed from these sizes have undergone numerous fitting trials. Therefore the sizes and patterns in this book represent the contemporary women's figure. However, any other satisfactory size chart can be used.

SIZE CHARTS FOR THE RANGE 8 TO 16

Charts 1.2 and 1.3 illustrate the development of the body measurement tables into garment size charts by adding the ease allowances for the base size 12. The amount added is the minimum suitable for woven fabric. It is advisable to have the base size as the central size from which the larger and smaller sizes are graded. This maintains accuracy in the pattern shape for each size.

The last column gives the grading increments for two size ranges. These size ranges are designated by the grade of key measurements to which all the other grades are proportional. The key measurement in Chart 1.2 is the bust girth with a grade of 4 cm or 5 cm (in parenthesis); in chart 1.3 it is the hip girth with a grade of 4 cm or 5 cm (in parenthesis). The key body measurement is often quoted at the top of size charts or on garment labels:

e.g. Size 12 to fit bust 88 cm
to fit hip 96 cm

Size charts with equal size intervals are restricted to four or five sizes as the body proportion changes shape beyond this number. Only five sizes are quoted in the charts from size 8 to 16 with the central size 12 as the base or sample size. Some extra measurements are included in Chart 1.2 for bodice and sleeve measurements only. These are not included in most size charts, but are useful for constructing patterns. Also included within Chart 1.2 (column headed 'Dress') are the suggested amounts for dart suppression relative to back/front shoulder and waist darts.

In the garment size charts, Chart 1.4 for dresses and Chart 1.5 for skirts and trousers have a 4 cm grade for the key measurements bust, waist and hips, whereas Charts 1.6 and 1.7 have a 5 cm grade. The base size 12 is the same size for both ranges but the other sizes vary slightly. For example, the garment bust grade:

	4 cm grade	*5 cm grade*
size 8	86 cm	84 cm
size 16	102 cm	104 cm

This gives a 2 cm difference on the largest and smallest sizes. All the other grading increments are proportional to whether the major girths of bust, waist and hips have a 4 cm or 5 cm grade.

SIZE CHARTS FOR THE RANGE 8 TO 20

The size charts which have been presented so far are for a limited range of four to five sizes with equal increments between the sizes. However, some styles need to cover a much larger range of sizes, as many as seven to ten sizes. These larger size ranges can be approached in two ways. Firstly, a very large size range can be split into two or three short ranges of differing proportions with separate central base size patterns. For example, a women's size range from

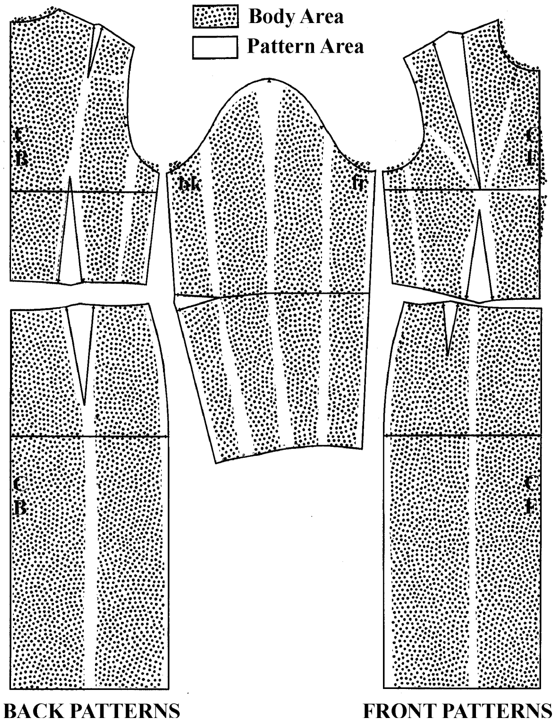


Figure 1.4 The positions for adding ease allowances to women's body measurements for a fitted bodice, semi-fit sleeve and straight skirt

Chart 1.2 Development of body measurements into garment measurement by adding ease allowances for size 12 women's bodice and sleeve (measurements in centimetres). Key measurement: bust 4 cm grade (5 cm grade in parenthesis). For average height 164 cm (5 ft 4½ in)

	Body	Ease	Dress	Grade
(a) Bust girth	88.0	6.0	94.0	4.0 (5.0)
(b) Waist girth	70.0	4.0	74.0	4.0 (5.0)
(c) Neck girth	38.0	2.0	40.0	1.0 (1.0)
(d) Upper arm girth	28.0	6.0	34.0	1.0 (1.6)
(e) Elbow girth	26.0	5.0	31.0	0.75 (1.0)
(f) Wrist girth	16.0	2.0	18.0	0.5 (0.5)
(g) Nape to waist	41.0	—	41.0	0.5 (0.5)
(h) Front neck point to bust	27.0	—	27.0	0.5 (0.5)
(i) Front neck point to waist	44.0	—	44.0	0.5 (0.5)
(j) Shoulder to elbow	35.0	—	35.0	0.5 (0.5)
(k) Shoulder to wrist	59.0	—	59.0	0.5 (0.5)
(l) Across back (at mid armhole)	35.0	2.0	37.0	1.0 (1.2)
(m) Across front (at mid armhole)	32.0	1.0	33.0	1.0 (1.2)
(n) Shoulder length	13.0	—	13.0	0.3 (0.4)
(o) Bust prominence width	19.0	—	19.0	0.4 (0.4)
EXTRA MEASUREMENTS				
Width of armhole	10.0	1.5	11.5	1.0 (1.3)
Back shoulder dart width at shoulder	—	—	1.5	— —
Front shoulder dart width at shoulder	—	—	4.5	0.5* (0.5*)
Waist darts width	4.0	—	4.0	— —
Depth of armhole	21.0	3.0	24	0.5 (0.5)
Armhole circumference	40.0	5.0	45.0	1.5 (1.8)
Sleeve head depth (approx. ⅓ armhole circumference	—	—	15.0	0.5 (0.5)

* Grade optional

NB For short women 156 cm (5 ft 1½ in), reduce bodice 3 cm between underarm and waist. Reduce the sleeve length 3 cm between the underarm and wrist.

For tall women 172 cm (5 ft 7½ in) increase bodice length 3 cm between underarm and waist. Increase the sleeve 3 cm between the underarm and wrist.

Chart 1.3 Development of body measurements into garment measurements by adding ease allowances for size 12 skirts and trousers. Key measurement: hip 4 cm grade (5 cm grade in parentheses). For average women, medium height 164 cm (5 ft 4½ in) (measurements in centimetres)

	Body	Ease	Garment	Grade
(b) Waist girth	70.0	4.0	74.0	4.0 (5.0)
(b) Waist band girth	70.0	2.0	72.0	4.0 (5.0)
(p) Hip girth	96.0	4.0	100.0	4.0 (5.0)
(q) Upper hip girth	90.0	4.0	94.0	4.0 (5.0)
(r) Thigh girth – straight leg – slim leg	57.0 57.0	10.0 8.0	67.0 65.0	2.6 (3.2) 2.6 (3.2)
(s) Knee or calf girth – straight leg – slim leg	37.0 37.0	15.0 9.0	52.0 46.0	2.0 (2.0) 2.0 (2.0)
(t) Ankle girth	25.0	9.0	34.0	1.0 (1.0)
(u) Centre back waist to hip	20.0	—	20.0	0.5*
(v) Centre back waist to knee	60.0	—	60.0	0.5*
(w) Centre back waist to ground	105.0	—	105.0	0.5*
(x) Side waist to ankle	100.0	—	100.0	0.5*
(y) Side waist to ground	106.0	—	106.0	0.5*
(z) Centre front waist to ground	105.0	—	105.0	0.5*
(zz) Inside leg (crutch to ankle)	72.0	−1.0	71.0	—
Crutch level (x − zz)	28.0	1.0	29.0	0.5 (0.5)

* Skirt and trouser length grade optional.
NB for short women 156 cm (5 ft 1½ in) reduce the skirt 3 cm and the trousers 6 cm.
For tall women 172 cm (5 ft 7½ in) increase the skirt 3 cm and the trousers 6 cm.

size 8 to 26 could be split into two of different proportions, sizes 8 to 16 with a base size of 12, and sizes 18 to 26 with a base size of 22. Alternatively, for a shorter size range of seven sizes the central base size can be graded with the increments varying between the sizes to change the patterns to the correct proportions.

The following size charts illustrate the change in body proportion from size 8 to 20 with a base size 12. The variations have been based on surveys of body measurements. The smaller sizes of 8 to 14 have fewer size differences than the sizes 16 to 20. Also, the bust, waist and hips do not have the same grading increments as the previous size charts. The pattern grading for larger sizes is more complex as the dart suppression can be changed in width. Chart 1.8 is an example of body measurements for sizes 8 to 20 for dresses, Chart 1.9 for skirts and trousers. The amount of ease allowance also varies between some sizes. This can be seen by comparing with the garment measurements of Chart 1.10 for dresses and Chart 1.11 for skirts and trousers. The ease allowance has been increased for the larger sizes. That is why there is a greater increase from size 14 to size 16. It has been advocated (Cooklin 1997) that the ease allowance should be calculated as a percentage of the major girth measurement. Although this is correct in theory, when the amounts were calculated they became complex requiring several decimal points. This has been simplified by rounding the amount of

Chart 1.4 Garment measurement size chart for women's dresses. Key measurements: bust and waist 4 cm grade (measurements in centimetres). Size range: 8–16, for average height 164 cm (5 ft $4\frac{1}{2}$ in)

SIZE		8	10	12	14	16
To fit bust	cm in approx.	80.0 32	84.0 $33\frac{1}{2}$	88.0 35	92.0 $36\frac{1}{2}$	96.0 38
To fit waist	cm in approx.	62.0 $24\frac{1}{2}$	66.0 26	70.0 $27\frac{1}{2}$	74.0 29	78.0 $30\frac{1}{2}$
To fit hips	cm in approx.	88.0 35	92.0 $36\frac{1}{2}$	96.0 38	100.0 $39\frac{1}{2}$	104.0 41
MEASUREMENTS						
(a) Bust girth		86.0	90.0	94.0	98.0	102.0
(b) Waist girth		66.0	70.0	74.0	78.0	82.0
(c) Neck girth		38.0	39.0	40.0	41.0	42.0
(d) Upper arm girth		32.0	33.0	34.0	35.0	36.0
(e) Elbow girth (fitted)		29.5	30.25	31.0	31.75	32.5
(f) Wrist girth (fitted)		17.0	17.5	18.0	18.5	19.0
(g) Nape to waist		40.0	40.5	41.0	41.5	42.0
(h) Front neck point to bust		26.0	26.5	27.0	27.5	28.0
(i) Front neck point to waist		43.0	43.5	44.0	44.5	45.0
(j) Shoulder to elbow		34.0	34.5	35.0	35.5	36.0
(k) Shoulder to wrist		58.0	58.5	59.0	59.5	60.0
(l) Across back (at mid armhole)		35.0	36.0	37.0	38.0	39.0
(m) Across front (at mid armhole)		31.0	32.0	33.0	34.0	35.0
(n) Shoulder length		12.4	12.7	13.0	13.3	13.6
(o) Bust prominence width		18.2	18.6	19.0	19.4	19.8
(p) Hip girth		92.0	96.0	100.0	104.0	108.0
(q) Upper hip girth		86.0	90.0	94.0	98.0	102.0
(w) Centre back waist to ground*		104.0	104.5	105.0	105.5	106.0
(u) Centre back waist to hip*		19.0	19.5	20.0	20.5	21.0
(v) Centre back waist to knee*		59.0	59.5	60.0	60.5	61.0
Depth of armhole (derived)		23.0	23.5	24.0	24.5	25.0

* Grading increment of 0.5 cm optimal.

NB For short women of 156 cm (5 ft $1\frac{1}{2}$ in) reduce the bodice length 3 cm between underarm and waist. Reduce the sleeve length 3 cm between the underarm and wrist. For tall women of 172 cm (5 ft $7\frac{1}{2}$ in) increase the bodice length 3 cm between the underarm and waist. Increase the sleeve length 3 cm between the underarm and wrist.