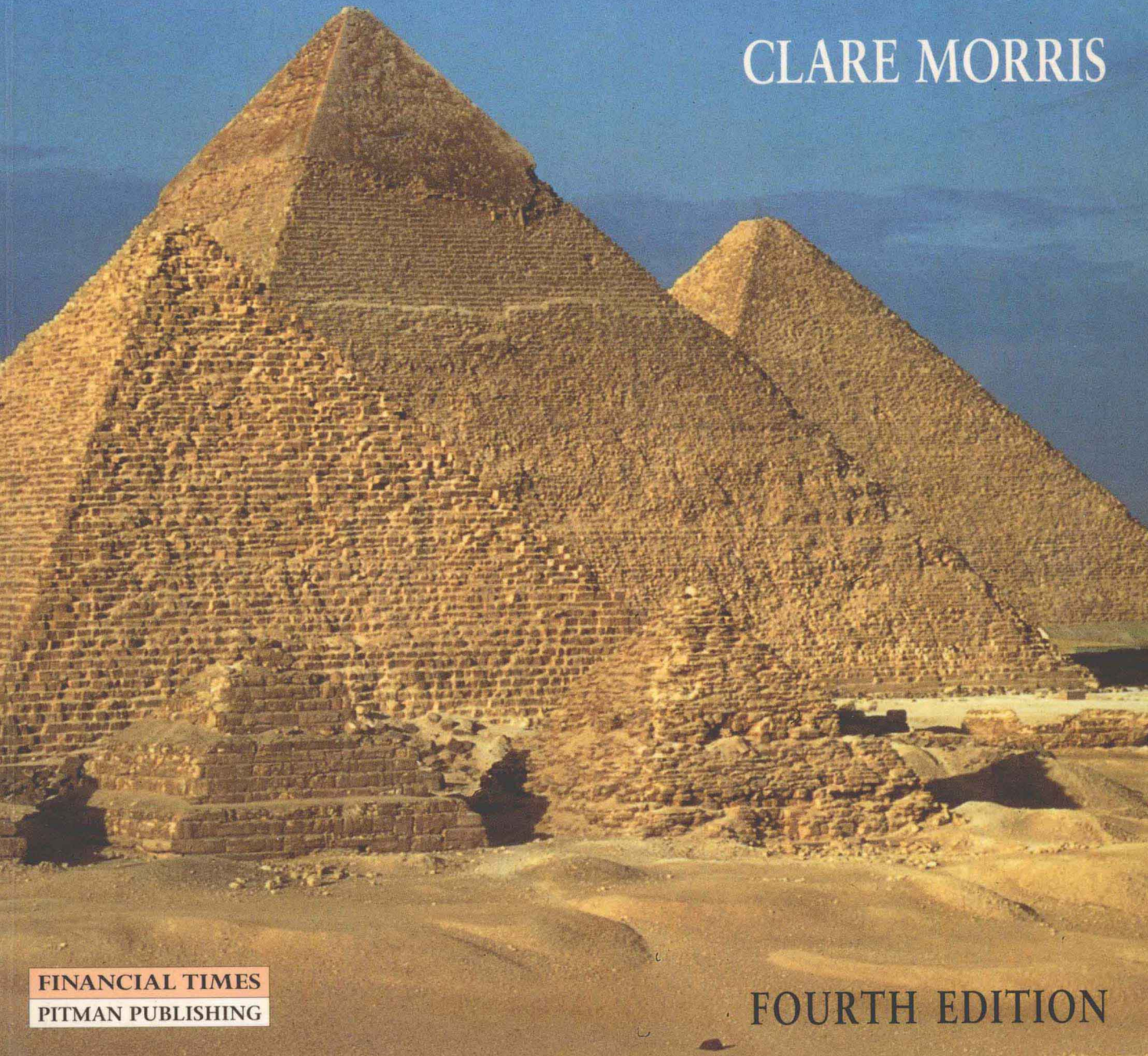


QUANTITATIVE APPROACHES IN BUSINESS STUDIES

CLARE MORRIS



FINANCIAL TIMES
PITMAN PUBLISHING

FOURTH EDITION

QUANTITATIVE APPROACHES IN BUSINESS STUDIES

Fourth edition

CLARE MORRIS

MA (Oxon), MSc, PhD (Bristol), C Stat
Warwick Business School, University of Warwick

FINANCIAL TIMES
PITMAN PUBLISHING

FINANCIAL TIMES
MANAGEMENT

LONDON · SAN FRANCISCO
KUALA LUMPUR · JOHANNESBURG

*Financial Times Management delivers the knowledge,
skills and understanding that enable students,
managers and organisations to achieve their ambitions,
whatever their needs, wherever they are.*

London Office:
128 Long Acre, London WC2E 9AN
Tel: +44 (0)171 447 2000
Fax: +44 (0)171 240 5771
Website: www.ftmanagement.com

A Division of Financial Times Professional Limited

First published in Great Britain in 1983
Second edition 1989
Third edition 1993
Fourth edition 1996

© Clare Morris 1989, 1993, 1996

The right of Clare Morris to be identified as Author
of this Work has been asserted by her in accordance
with the Copyright, Designs and Patents Act 1988.

ISBN 0 273 61697 8

British Library Cataloguing in Publication Data
A CIP catalogue record for this book can be obtained from the British Library

All rights reserved; no part of this publication may be reproduced, stored
in a retrieval system, or transmitted in any form or by any means, electronic,
mechanical, photocopying, recording, or otherwise without either the prior
written permission of the Publishers or a licence permitting restricted copying
in the United Kingdom issued by the Copyright Licensing Agency Ltd,
90 Tottenham Court Road, London W1P 0LP. This book may not be lent,
resold, hired out or otherwise disposed of by way of trade in any form
of binding or cover other than that in which it is published, without the
prior consent of the Publishers.

10 9 8 7 6 5 4

Typeset by Pantek Arts, Maidstone, Kent
Printed and bound in Great Britain

The Publishers' policy is to use paper manufactured from sustainable forests.

QUANTITATIVE APPROACHES IN BUSINESS STUDIES

FINANCIAL TIMES
MANAGEMENT

About our books

We work with leading authors to develop the strongest ideas in business and finance, bringing cutting-edge thinking and best practice to a global market.

Under the Financial Times Pitman Publishing imprint we craft high quality books which help readers to understand and apply their content, whether studying or at work.


To find out more please visit our website:
www.ftmanagement.com

PREFACE TO THE FOURTH EDITION

In a rapidly-changing educational environment, there is a need to revise texts with increasing frequency if they are to retain their currency, as witness to the fact that six years elapsed between the first and second editions of this book, four years between the second and third, but only three years between the third and this present edition. However, the major objective of that first edition remains unchanged; to recognise that most students studying quantitative methods as part of a business and management course are not mathematicians, never will be mathematicians, and have no wish to be mathematicians. At the same time, they undoubtedly have other skills – in problem-solving, communication, and business operations – which must be exploited by anyone attempting to interest them in a quantitative approach to business problems.

Accordingly, this book has a high proportion of words, and a correspondingly low proportion of numbers, mathematical symbolism, and jargon. Few proofs of results are given; instead, the effectiveness of the methods may be judged by whether they give sensible and useful solutions to practical problems. By adopting a problem-driven approach, I hope to convince students that quantitative methods, while not always easy to get to grips with, really do have something irreplaceable to offer as a tool of management.

The range of topics covered is probably larger than would be included in any single HND first-year degree course, or MBA programme, particularly as far as Part Four is concerned. The topics selected for any individual course will naturally reflect the interests of the lecturer and the specialist needs of the students involved. I have therefore tried to make the chapters of that Part as independent as possible of each other. Where there is a dependence on preceding material, the fact is indicated in the list of prerequisites at the start of the chapter. Further details about possible topic sequences will be found in the section. ‘How this book is organised’, on p. xii.

One major change which has taken place during the period since the publication of the third edition, and which is reflected in the current edition, is that EXCEL has become very widely used as the standard spreadsheet in industry; references to LOTUS 1-2-3 throughout the third edition have therefore been replaced by corresponding use of EXCEL, and the material on the associated disk has been changed to match. References to MINITAB now relate to version 10 for Windows. As in the third edition, material associated with the use of computer software is distinguished by the label  so that readers who wish to ignore it may conveniently do so.

The other most significant change is the introduction of an entire new chapter (Chapter 12) on Statistical Process Control. This has become probably *the* major way in which statistical methods impinge on management practice, not only in manufacturing but increasingly in the service sector. Feedback from lecturers who regularly adopt the book, and indeed from student users, also indicated that there was a definite demand for the inclusion of this material.

Inevitably in the course of a teaching career one's ideas as to how a particular topic should be approached will evolve, and on revisiting the chapter covering Correlation I found that I was no longer happy with the order and style in which the material was introduced. Accordingly this chapter has been completely rewritten to provide a stronger motivation for the Pearson correlation coefficient formula.

Other minor changes and updatings have been made throughout. Again in response to demand from readers, additional problems, both with and without worked solutions, have been included in most chapters. The opportunity has been taken to correct various errors and obscurities in the previous edition, and in this context I am grateful to numerous former members of the MBA programmes at Warwick Business School for making me aware of some of these problems. I also owe a particular debt of gratitude to Noel Petty, formerly of ICI Teesside, who read the entire third edition with a hawk-eyed attention to detail, not only revealing misprints which no-one else had spotted, but making numerous suggestions for modifications to the text which invariably resulted in improved clarity. I am grateful also to all other readers who have taken the trouble to inform me of errors and confusions they have come across; please continue to do so. Needless to say, any remaining errors are entirely my own responsibility.

Once again I am very greatly indebted to the many readers of the book, both students and colleagues, who have taken the trouble to inform me of errors and confusions they have encountered. Please continue to let me know of any which remain.

I am grateful to the Literary Executor of the late Sir Ronald A. Fisher, FRS, to Dr Frank Yates, FRS, and the Longman Group Ltd, London, for permission to reprint Tables IV and VII from their book *Statistical Tables for Biological, Agricultural and Medical Research* (6th edition, 1974). I would also like to thank Macmillan, London and Basingstoke, for permission to use part of Tables 1 and 2, and Tables 3 and 7, from *Statistical Tables* by J. Murdoch and J. A. Barnes; the Biometrika Trustees for permission to use material from Table 8 of *Biometrika Tables for Statisticians*, vol. I (3rd edition, 1966), and to the Controller of Her Majesty's Stationery Office for permission to reproduce Fig. 3.1 from the *Monthly Digest of Statistics*.

I would like to thank Minitab, Inc., 3081 Enterprise Drive, State College, PA 16081, USA (Telephone 814/238-3280, Telex 881612) for their co-operation in supplying material relating to their Statistical Software. Likewise I am indebted to Microsoft Corporation for permission to make reference to Microsoft Excel, and to use material generated by the use of this software. Both Minitab and Microsoft are registered trade names.

Finally, I am profoundly indebted to Simon Lake and Julianne Mulholland at Financial Times Management, for their support in the production of this edition, and most particularly for their patience and understanding when schedules began to slip!

Clare Morris
March 1996

An Instructor's Manual is available to lecturers adopting this textbook.

NOTE TO THE READER

Although I hope that you're going to find this book fairly readable, it would be silly to pretend that you can read it – or any other textbook on a numerical subject – in quite the same way as you would read, say, a detective story, or even a textbook in a more 'wordy' subject such as law or sociology. Since I naturally want you to benefit as much as possible from reading this book, and since it may be some time since you last studied a numerical subject, you may find the following points helpful.

At the start of each chapter you will find a list of the prerequisites for reading that chapter – the things which you need to understand in order to follow the material contained in the chapter. If you are doubtful about any of these, go back to the section in which the topic was covered (you'll find a reference given) and check your understanding of that topic. *Don't* just carry on into the chapter hoping for the best – that's the way to get confused and demoralised! To a large extent mathematics and statistics are cumulative subjects, in which one topic builds on another, so it's important to get each stage clear before going on to the next.

You will also find at the start of the chapters a list of the things which you should be able to do by the end of the chapter; when you've read the chapter, and gone through some of the exercises at the end – particularly the more straightforward problems – then waited a few days for the material to fall into place, you can use this list to check that you've grasped the main points of the chapter. You may also find that these lists are useful when you come to revise for examinations, in reminding you of the major areas within each topic.

Always have a pencil and paper to hand when you are reading the book, so that you can follow the workings of problems for yourself, or perhaps work out in more detail steps of a calculation which I have abbreviated. And don't worry too much if you feel you haven't grasped every single idea in a section immediately – most people find that numerical ideas may take two or three readings, plus some work on practical examples, before they make complete sense.

Finally, and most importantly, remember that all the skills which you bring to bear in other areas of your work – your ability to communicate effectively, your knowledge of business, your problem-solving skills, and above all your plain common sense can be used in the numerical context too. Is this a sensible result? Is it about the size of answer which I would have expected to get? Is it realistic in terms of the original problem we set out to solve? – these are the kinds of questions you should constantly be asking yourself as you work through the book, so that by the end numbers, and the ability to handle them effectively, will be just another of your everyday skills.

How this book is organised

Although most of the topics covered in this book appear in many courses on Quantitative Methods for business and management, you may find that your course does not include all of them. Or perhaps you are reading the book for interest only, and would like to be able to skip some material without getting lost.

For your guidance, here is an indication of how the book fits together, and of possible routes through it. You will find more detailed information about the pre-requisites for understanding each chapter at the start of the chapter. The order in which topics are covered is to some extent a matter of taste; I have tried to provide a logical structure by subdividing the book into four parts, but there are many other possible and equally logical orders which you could follow.

Chapter 1 is necessary only if you are not very confident of your basic mathematical skills; try the test at the start to find out if you have the level of ability needed for later work.

Chapter 2 is necessary for those of you who will be using either MINITAB or EXCEL software as an adjunct to your work with this book. Even if you will not be doing so, you may still wish to skim through this chapter to find out what the software has to offer.

Chapters 3–6 should be read sequentially, and cover the essentials for what is called Descriptive Statistics.

Chapter 7 on index numbers could be omitted without affecting later work.

Chapters 8–12 are also sequential; they cover probability and the problems of drawing conclusions from samples, and could be left out if you are only interested in the descriptive aspects of the subject. Chapter 12 on Quality Control could be omitted if you are not interested in this area of application.

Chapters 13 and 14 are chiefly devoted to correlation and regression, very important topics which are widely used in many business problems. They do not require you to have read Chapters 8–12.

Chapter 15 covers the topic of forecasting, again a very important area of interest for business applications. This chapter does not depend on previous work, and could be read much earlier in the sequence if you wish.

Chapters 16–20 are each devoted to a separate topic in Operational Research, and each is pretty well free-standing, except that Chapter 20 needs some of the material on distributions covered in Chapters 6 and 9.

CONTENTS

Preface ix

Note to the reader xi

PART ONE: NUMBERS – HOW WE HANDLE THEM 1

1 Tools of the trade: basic numeracy skills 3

Almost everybody's problem • Numbers and how we combine them • Operations with fractions • Decimals: a special kind of fraction • Significant figures and rounding • Percentages • Letters for numbers • Powers and roots • The use of brackets • Solving equations • Equations from problems • Some unfamiliar symbols • Simultaneous equations • Straight line graphs • Other types of graph • Making use of graphs • A business application • A word about calculators • Further reading

2 Computational aids: EXCEL and MINITAB 31

Introduction • Software for statistics • The datasets and worksheets • Further reading

PART TWO: NUMBERS – A MEANS OF COMMUNICATION 35

3 Obtaining the figures: sampling methods 37

The managing director's problem • Multifarious measurements • Whence information? • Collect-it-yourself • Where to find second-hand statistics • Points for further thought • A word of warning • Exercises • Further reading

4 Making sense of the figures: data interpretation 54

The factory manager's problem • Errors and explanations • What next? • Exercise

5 Presenting the figures: tables and diagrams 59

The management trainee's problem • The narrative approach • The dos and don'ts of effective tabulation • More complicated tables • Easily digested diagrams • Tabulating quantitative data • Diagrams from frequency tables • Some simple graphs • Tables and diagrams with MINITAB and EXCEL • How *not* to do it • Exercises • Further reading

6 Summarising the figures: measures of location and spread	96
The trade union leader's problem • What needs to be measured • Measuring location • Measuring spread • Summary measures with MINITAB and EXCEL • Which should we choose? • Exercises • Further reading	
7 Measuring changes: index numbers	122
The investor's problem • What is an index number? • Diversifying the diet • Weighting the index • Calculating the indices • Deciding which to use • The Retail Price Index • What's the use of the RPI? • Advising the investor • Some technical considerations • Other kinds of index • Exercises • Further reading	
PART THREE: NUMBERS – A BASIS FOR DEDUCTION	139
8 A firm foundation: elementary probability	141
The product development manager's problem • Reckoning the chances • Some easy examples • Putting probabilities together • Tackling problems • Giving probabilities a cash value • Decision tables • Decision trees • Drawbacks of the method • Exercises • Further reading	
9 Patterns of probability: some distributions	165
The quality manager's problem • The idea of a probability distribution • The binomial distribution • The Poisson distribution • The normal distribution • Some general points about the normal distribution • Some further points • Probabilities from the computer • Exercises	
10 Estimating from samples: inference	198
The dissatisfied customer's problem • A simple example • The sampling distribution of percentages • Applications of STEP • The sampling distribution of means • The problem revisited • Exercises • Further reading	
11 Checking a theory: hypothesis testing	219
The training manager's problem • Testing hypotheses about percentages • Further points about hypothesis testing • Testing hypotheses about means of large samples • An alternative way of carrying out hypothesis tests • Testing hypotheses about the means of small samples • Testing the difference between two sample means • Testing hypotheses about more than one proportion • Using the X^2 distribution • More about X^2 • Single-row tables • A cautionary note • A mixed batch of examples • Hypothesis testing with MINITAB and EXCEL • Conclusion • Exercises	
12 Making it better – statistics and quality improvement	255
The pizza manufacturer's problem • The importance of quality • Total quality management • How can statistics help? • Tracking down the problem • The effect of variability on processes • Can our machines meet the tolerances? • Controlling the mean of a capable process • controlling the range • Controlling other aspects of a process • Sampling inspection • Software for SPC • Exercises • Further reading	

13 Looking for connections: correlation	287
The sales manager's problem • What kind of relationship? • Using the scattergraph • Measuring the strength of a relationship: the correlation coefficient • Interpreting the correlation coefficient • The sales data revisited • What we have – and haven't – proved • The rank correlation • Correlation with MINITAB and EXCEL • Exercises	
PART FOUR: NUMBERS – A TOOL OF PLANNING	307
14 Spotting the relationship: line fitting	309
More problems for the sales manager! • What is a 'well-fitting line'? • Calculating the regression line • Regression with MINITAB and EXCEL • Forecasting the future: when can we do it? • Forecasting a steady percentage growth • More uses for semi-log graphs • Logarithmic graphs via EXCEL and MINITAB • How far have we got? • Exercises	
15 More about forecasting: time-series and exponential smoothing	338
The airline manager's problem • Forecasting from a short-term pattern • Extracting the trend • Analysing the seasonal variations • Getting a forecast • Other patterns of variation • Forecasting the pork pie sales figures • Forecasting in an unpredictable situation • Features of exponential smoothing • Software for forecasting • The story continues ... • Exercises	
16 Allowing for interest: financial mathematics	358
The management accountant's problem • The fundamentals of compound interest • Applications of the compound interest formula • The idea of present value • Applications of discounting • Calculating mortgage and hire purchase repayments • Some further points • Comparing investments • Computational note • Exercises • Further reading	
17 Planning an inventory policy: stock control	378
The small businessman's problem • The information needed • Simplifying the problem • Solving the simplified problem • Eliminating some assumptions • Making and using • Allowing stock-outs • The effect of errors in estimates • Further possibilities • Exercises	
18 Planning production levels: linear programming	395
The production manager's problem • Setting up the model • Graphing the model • Finding the best solution • Varying the constraints • Changes in the profits • A different type of problem • Problems where the solutions must be integers • Reservations and conclusions • Exercises • Further reading	

19 Planning a project: network analysis	413
The office supervisor's problem • Drawing up a precedence table • Constructing the network • Numbering the network • An alternative way of drawing the network • The shortest time for the job • Finding the floats • Making the best of it • Limitations of the method • Exercises	
20 Cutting down on queues: simulation	431
The computer manager's problem • Building up the picture • Imitating nature • Carrying out the simulation • What can we simulate? • Software for simulation • Exercises	
Appendices	443
1 Suggestions for further reading	445
2 Random sampling numbers	447
3 Cumulative binomial probabilities	449
4 Cumulative Poisson probabilities	451
5 Areas under the standard normal curve	453
6 Percentage points of the χ^2 distribution	455
7 The correlation coefficient	459
8 The t -distribution	461
9 Solutions to selected exercises	463
<i>Index</i>	473

NUMBERS – HOW WE HANDLE THEM

This Part covers the essential tools which you will need to use in order to get the most out of your reading of the rest of the book. Chapter 1 summarises the mathematical methods required, with material to help you revise and improve your understanding of these methods if necessary, and exercises to help you discover if you have done so satisfactorily. Chapter 2 introduces the optional diskette which accompanies this book, and the two software packages – MINITAB and EXCEL – with which the diskette may be used.

TOOLS OF THE TRADE: BASIC NUMERACY SKILLS

■ Chapter prerequisites

Before starting work on this chapter, try the short test of basic mathematical skills in this section; you will find the answers are given in Appendix 9 and, according to which questions you find difficult, you will be directed to the appropriate section of this chapter. This will save you time and prevent your having to read through a lot of things which in fact you can already cope with. If, however, you get more than half of the test questions wrong I would advise you to read the entire chapter.

■ Chapter objectives

By the end of your work on this chapter you should be able to:

- 1 carry out the four operations of basic arithmetic (addition, subtraction, multiplication and division) with positive and negative integers, fractions and decimals;
- 2 round off the results of your calculations to a given number of decimal places or significant figures;
- 3 perform calculations involving percentages;
- 4 handle expressions involving powers and roots of a variable;
- 5 remove brackets from algebraic expressions;
- 6 construct a linear equation or inequality from a verbal problem;
- 7 solve linear equations;
- 8 solve a pair of simultaneous equations;
- 9 plot the graphs of linear equations or inequalities;
- 10 make efficient use of your calculator.

TEST

- 1 $-3 + 4 =$ 2 $-5 \div 2 =$ 3 $\frac{3}{8} + \frac{4}{5} =$ 4 $\frac{7}{8} \times \frac{3}{5} =$
- 5 $2 \div \frac{1}{2} =$ 6 $0.05 \times 2.5 =$ 7 $8 \div 0.2 =$
- 8 Convert $\frac{5}{12}$ to a decimal.
- 9 Express 0.28 as a fraction.
- 10 What is 67.469 to 3 significant figures?
- 11 16% of 8 = 12 18 as a percentage of 64 =
- 13 The price of an item including the dealer's 20% mark-up is £36. What did it cost before the mark-up?
- 14 $x^2 \times x^4 =$ 15 $\sqrt{x^{16}} =$
- 16 $2(3a + b) - (a - 2b) =$
- 17 If it costs £6 to drive k miles then what is the cost of driving 4 miles?
- 18 Items priced at m pence per dozen are repacked in boxes of 100. What will the cost of such a box be, in pounds?
- 19 There are f female workers and m male workers in a factory. Write down an algebraic expression to show that the total work-force must be less than 150.
- 20 $3x - 5 = 10$; $x =$ 21 $\frac{4}{y} = \frac{7}{8}$; $y =$
- 22 $\begin{cases} 3p + 2q = 9 \\ 4p - 6q = 25 \end{cases}$ Find p and q .
- 23 Where does the graph of $s = 3t + 5$ cross the t -axis?
- 24 Which of these graphs, (a), (b) or (c), could be the graph of $y = x^2 + 3x - 4$?

