
Book Reviews

Topology of Surfaces, Knots and Manifolds by Stephan C Carlson
Wiley 2001 ISBN 0-471-35544-5

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This is a book organized into five main chapters of “appealing....ideas and problems involving curves, surfaces and knots”, together with an introductory chapter in which ‘rubber sheet’ geometry is reviewed and the process of increasing the formality and precision of intuitive ideas is begun. This additional precision involves the compactness condition for the surfaces to be studied (surface includes its boundary), the definition of continuous deformation (bicontinuous bijection), and the Euclidean metric for R^n (for $n=1,2,3$ and sometimes 4). Also introduced in this chapter is the idea of plane diagrams of cylinder, torus, Mobius strip with their associated edge and vertex labelling. The diagrams are attractive and helpful, and should encourage students to draw their own or even construct some of the surfaces. Further reinforcement of the topological differences between these surfaces comes from the idea of playing tic-tac-toe (noughts and crosses to us) on the surface of a torus or Klein bottle.

In chapter 2 1- and 2- manifolds are defined and readers are invited to supply their own definition of 3- manifolds. Here the precision of the intuitive concepts of chapter one is sharpened by careful definitions of closed, bounded, neighborhood, basic neighborhood. This is where beginners begin to ask what all the fuss is about, so there are helpful discussions of several examples designed to illuminate the subtle consequences and restrictions inherent in such apparently straightforward definitions. Finally in this chapter are glimpses of what the 3-sphere “looks like”.

Chapter 3 leads to the classification theorem for all compact surfaces. On the way another theme of the whole book is introduced, that of a topological invariant, in this instance orientability. The method of proof follows closely that used in the Open University course in geometric topology. It works by a visually attractive technique of representing each face of a plane dissection of a surface by a word in an algebra, much like group elements being expressed as words in the generators. Various axioms for manipulating these words are introduced, each of which corresponds to a visualisable geometric operation on the surface – cutting, pasting and deforming in accordance with rules built on the discussion of the previous chapters, including most importantly the connected sum construction. The outcome of this strategy is that word w can be transformed to word w' by a finite sequence of application of the word axioms if and only if the compact surfaces they represent are topologically equivalent. The author does a very good job in persuading readers that each axiom really does correspond to an “allowable” operation. The power of the algebraic axioms is demonstrated by very efficiently proving the topological equivalence of various pairs of surfaces. For example it is difficult to visualise that the Klein bottle is homeomorphic to a connected sum of two projective planes, but the algebraic proof of this involves just five applications of the axioms.

The classification theorem is finally proved by an inductive argument on the length of the word describing

the surface. A brief summary of the two standard versions of induction is provided, though I would have thought that any reader requiring this would be struggling by this stage! Another minor disappointment is that students could be reminded of other similar examples of classification such as that of positive integers classified by their prime power decompositions which all will be aware of, and of Abelian groups by direct sums of cyclic groups, which some will have met. Opportunities to emphasise connections in mathematics should never be missed!

The chapter ends with a question – each compact surface is equivalent to one of a set of standard surfaces, but could it be equivalent to more than one? This neatly introduces the Euler characteristic as another surface invariant.

In chapter 4 this is pursued. The Euler characteristic of a surface is defined by a tiling of the surface, and a similar object is defined for a word representing the surface. That these objects are invariant under the allowable operations, and identical to each other is another triumph of the algebraic method.

Having introduced tilings on surfaces this is pursued in more detail, leading to complexes, map colouring, Heawood numbers and chromatic numbers.

Tilings lead naturally to graph theory which is the topic of chapter 5. All the usual topics of introductory graph theory receive a neat treatment: the distinction between a graph and a graph diagram, isomorphism of graphs, Eulerian and Hamiltonian properties, trees and their associated algorithms, bipartite graphs and planarity. Planarity leads to problems of embedding graphs on surfaces so there is a nice connection with earlier chapters via the genus of orientable compact surfaces.

The final chapter is advertised as knot theory (but includes links). Here the high standards in motivation, illustration and clarity are maintained, yet for me this was both the most inspirational and least satisfactory

chapter: inspirational because of the references to various modern applications, exciting recent research, more demonstration of the power of invariants (linking number, tricolourability), of intuitively appealing axioms (Reidemeister moves) and of algebraic versions of the geometric ideas; but unsatisfactory because virtually nothing is proved. This in itself is not fatal; my disappointment is based on the messages that readers get from the various chapters. In all the other chapters it is clear to the student reader at, say, second year U.K. undergraduate level, that he or she can make significant progress in the subject by using his or her present knowledge along the lines suggested by the text and by the exercises. But from chapter 6 I would have no idea whether I would need just a small nudge or three more years of intensive study in order to understand these

concepts. It also does not help the independent learner that the exercises, good as they are, have no solutions.

But these are my only quibbles. My overall feeling is that this is an attractive book which I would be happy to use, though not perhaps exactly for the purpose envisaged by the author. He has used it for a one semester first course on topology, so I would be happy to be proved wrong, but although not technically exacting the ideas involved are very different from those of calculus, linear and abstract algebra, probability, analysis etc. For this reason I would be inclined to spend the semester on a part of the book – say the first three chapters, simply because these new ideas would benefit from gradual exposure backed up by lots of discussion and practical work. Another ideal use of this material would be in a final year project.

Applied Stochastic Modelling by Byron J T Morgan
2000 Arnold, London. 227p plus apps ISBN 0-340-74041-8, Price £19.99

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This is a recent addition to the excellent and highly-affordable *Arnold Texts in Statistics* series. The material has grown out of a thirty-hour lecture course given by the author and it is aimed at final-year undergraduate and MSc students and also as a source of reference on modern statistical methods for research scientists and postgraduate students.

The book begins with a very apt quotation from Aristotle about learning by doing: this is a book about ‘doing’ stochastic modelling via an experiential treatment of the subject. The material is well-motivated by means of real data sets which have largely arisen out of the author’s long-standing research collaborations with mainly-biological scientists. Many of the late-twentieth-century developments in Statistics are covered and illustrated; the coverage is impressively wide-ranging and is brief and to-the-point, rather than deep, on each individual topic. The book is well-illustrated using the visualisation tools offered by MATLAB which is also used as a programming environment. Around fifty MATLAB programmes are described and used in the book and they (along with S-Plus equivalents) are available from the book’s website. One-hundred and seventy-five mainly-practical exercises are included and solutions and comments on a selection of them are provided. The author has taken the trouble to provide many interesting and helpful applied and theoretical references (fourteen pages in all) so that readers can deepen their knowledge and experience of any particular topic.

The first chapter contains ten interesting real data sets involving mainly discrete data, followed by a chapter which introduces some basic aspects of fitting models to data using the method of maximum likelihood. There is some extremely brief discussion about the purposes

of modelling. In chapter three, methods of function optimisation are discussed, including deterministic methods, such as steepest ascent, Newton-Raphson and the Simplex method, the stochastic method of simulated annealing and a hybrid approach.

Basic likelihood methods for inference and modelling are covered in chapter four. This is a brief survey of some standard asymptotic results, profile likelihood, profile-likelihood confidence regions, standard asymptotic tests and information criteria for model selection. The discussion is continued in the following chapter which contains material on some issues of parameterisation in a model, such as orthogonality and testing for parameter redundancy, together with the delta method, a nice exposition of the EM algorithm and discussion of non-regular problems and other non-Bayesian methods of model-fitting. The recent work on a symbolic-algebra-test of parameter redundancy and on the use of empirical transforms is particularly stimulating.

Various uses of simulation are described in chapter six, including the generation of random variables, Monte Carlo inference and the bootstrap. In the following chapter we meet Bayesian methods for the first time. A simple introduction to the Gibbs sampler is given along with the Metropolis-Hastings algorithm and there is discussion of their implementation. There is also

material on Bayesian goodness-of-fit, prior sensitivity and model averaging. The final chapter briefly mentions general families of models, including generalised linear models, generalised linear mixed models, generalised additive models and smoothing splines and has a few illustrations. Three appendices cover, respectively, a brief reference on probability, a helpful introduction to some aspects of MATLAB and, lastly, kernel-density estimation.

Overall, I really enjoyed this book and view it as a splendid achievement. While, personally, I would have liked to see more on the purposes of modelling and a clearer delineation, where relevant, between sample data and the wider population, I strongly recommend this book. It should serve as an ideal and illuminating introduction to stochastic modelling for the suggested target audience provided that the undergraduates involved are mathematically-confident and well-motivated.

**Introduction to Statistical Quality Control 4th Ed by Douglas C Montgomery
2001, John Wiley, New York. Hard-Bound, 796pp ISBN 0 471 31648 2**

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This is the fourth edition of what is one of the 'standard' textbooks on Statistical Process Control and Manufacturing Quality Control. The writer is an engineer by background and has an uncomplicated writing style that is both accurate and easy to follow. Thus the text is a good introductory one for use by both trained statisticians and non-statisticians alike. It would be particularly useful for the increasing number of 'Six-Sigma Black Belts' that are currently springing up in Industry. The book, as in earlier editions, relies heavily on diagrams, plots and highlighted key points, in particular equations, to get the major points over.

It includes many worked examples from a variety of commercial and manufacturing settings and is one of the best sources of this type of data currently on the market. There is a greater emphasis on the use of computer output than exists in other books covering similar material. As the author states this is the type of output that most people will be faced with these days and is an essential component of any teaching material. As a consequence the material is focused upon the techniques and associated computer output most often found in practice. The author has made extra material available on a web-site, much of it more advanced and meant for the use of teachers.

Following an introduction the book itself is split into five main sections, that could be used to form the basis of a set of teaching modules. The introduction covers the basic principles, terminology, history and ideas that underpin the rest of the book. Section one introduces basic statistical techniques and this leads into the section on Statistical Process Control and Process Capability, such as the use of control charts of various types. This section covers comprehensively the different methods that people may come across in the field. Section three covers the cumulative and weighted methods of monitoring processes, and includes modern

solutions to practical problems such as autocorrelation and small batch production. This section also introduces the newer Multivariate methods and Engineering Process Control, the term now reserved for feedback control as applied to continuous processes. Section four deals with designed experiments, from the factorial approach, and also introduces response surface methods. The final section deals with acceptance sampling, covering the main American military and civilian standards that one may come across. This section has been cut by almost half compared with earlier editions, reflecting the reduced reliance on lot sampling in industry generally.

The new edition has avoided the very few errors evident in earlier editions, and now appears to be the polished article. It reflects the changing philosophy of quality control from inspection to continuous improvement, and is a must both for teachers and users of these increasingly important techniques.

I recommend the text for all first degree applied statistics courses with an industrial element, all MSc courses based on Quality engineering or related fields and anyone developing or engaged in quality improvement programmes whether in industry or the service sector.