

## BOOK REVIEWS

**Fundamentals of mathematics (Volumes I-III)** edited by H. Behnke, F. Bachmann, K. Fladt and W. Süß. The MIT Press, 28, Carleton Street, Cambridge, Massachusetts 02142, USA, 1983, pp. Vol. I-549, Vol. II-685 and Vol. III-541, \$ 46 each.

This is a translation of 'Grundzüge der Mathematik' sponsored by the German section of the International Commission for Mathematical Instruction. Edited by well-known mathematicians such as Professors H. Behnke, F. Bachmann, K. Fladt and W. Süß, this beautiful collection of expository articles by more than 100 authors covers selected topics in a wide spectrum of mathematics—Foundations of mathematics, Algebra, Geometry and Analysis. It is addressed primarily to the instructor (as well as the student) at the gymnasium level with a view to provide an acquaintance with the modern viewpoint and references to current and classical literature; however, it is also a useful source of information for mathematicians in science and industry. In a book of this type, the treatment and the style are bound to vary from chapter to chapter; although some kind of uniformity has been maintained, one derives greater pleasure from reading some of the chapters. The authors have tried to bring the material up-to-date as far as possible; the bibliography in most of the chapters is excellent and one is pleased to find very thoughtful footnotes (e.g. pp. 164, 217, 330, 366 in Vol. I). It is however too much to expect a rigid uniformity in notation! (The field of rational numbers is denoted by  $P$  on page 378 and by  $\pi^{(0)}$  on page 411 of Volume I).

Part A of Volume I entitled 'Fundamentals of mathematics' deals exhaustively with the 'Foundations of mathematics'. With the help of thorough-going formalization of mathematics, metamathematical theories (e.g. classical logic) which are just as exact as 'precise' mathematics (which one is accustomed to) can be constructed and such theories are actually considered to be true constituents of modern mathematics. Mathematical proof depends on the fact that propositions possess a kind of structure, as revealed through a logical analysis of propositions in §2. The next two articles deal with the crucial concept of consequence which plays a pivotal role in the axiomatic method. Consequences are obtained, following a system of inference and proofs; calculi or algorithms refer to general methods for systematic handling of problems so as render automatic the process of solving. The next five interesting sections deal with set theory, Boolean algebra, theory of relations, Peano system for natural numbers and finally with a syntactic and a semantic antinomy in detail.

Starting with Peano's axioms for natural numbers, the elaborate construction of the real number system forms the theme of chapter I of Part B on 'Arithmetic and Algebra', which has a nice appendix on ordinal numbers. The next chapter (with some fascinating diagrams on several pages by way of illustration) gives an excellent and extensive survey of results in group theory. Vector spaces, linear transformations and the calculus of matrices are treated in chapter 3. A separate chapter is devoted to the study of polynomials and power-series. A rapid account of various results on commutative rings is

given in chapter 5 (which deals also with resultant of two polynomials). This is followed by a quick resumé of (elementary) number theory (including algebraic and additive number theory) in chapter 6. (Irrationality or Transcendence properties of numbers and the arithmetic nature of values of some standard functions as well as results in analytic number theory are reserved for chapter 13 of Volume III.) The next chapter presents the theory of algebraic field extensions including Galois theory, cyclotomic fields, solvability by radicals and constructibility by ruler and compass. Chapter 8 is concerned with real closed fields, the fundamental theorem of algebra, quaternions, Cayley numbers and a theorem of Frobenius on division algebras of finite rank over the reals. Lattice theory and basic concepts for a theory of (mathematical) structures are treated respectively in chapters 9 and 10. Zorn's lemma and the equivalent high chain principle are the topics covered by chapter 11, with a proof of Zorn's lemma (from the axioms of choice) and a few of its applications.

Volume II entitled 'Geometry' is divided into two parts, Foundations of geometry (Part A) and Analytic treatment of geometry (Part B) each of which is subdivided into eight chapters.

In part A, the first two chapters are devoted to a phenomenological discussion of geometry and a leisurely exposition of points, vectors and reflections. This is followed by four chapters on foundations of geometry on the same lines as Hilbert's book with the same title. There is a very detailed discussion of geometric constructions starting from some elementary constructions using straightedge, or straightedge and compass and ending with construction of curves of higher degree. The last chapter of this section deals with polygons and polyhedra which include a discussion of Euler's formula and cyclotomic polynomials. Gauss' theorem on construction of regular polygons is stated in a precise form but not proved (see also p. 372, Vol. 1).

Part B may be divided into three sections. The first section (chapters 9, 10 and 11) contains a good account of affine, Euclidean and projective geometry of conic sections leading to curves of higher degree in chapter 11 entitled Algebraic geometry. In the second section (chapters 12 and 13), we find a beautiful account of Klein's Erlanger program which highlights the relationship between geometry and transformation groups. The third section (chapters 14, 15 and 16) deals with differential geometry of curves and surfaces (chapter 14) followed by a chapter (15) on convex figures, both being mainly introductory in nature. The last chapter (16) 'Aspects of topology' gives an elegant heuristic introduction to the topological concepts of orientation, homology, homotopy, etc., ending with a discussion of Jordan curve theorem and separation axioms.

Volume III entitled 'Analysis' is quite comprehensive and deals with almost all aspects of analysis starting from the notion of a limit to analysis on manifolds. There are fourteen chapters in all, out of which roughly five are devoted to real analysis, three to complex analysis, two to differential equations, one to functional analysis, one each to difference equations and application of analysis to number theory and the final chapter on changing structure of modern mathematics.

Among the five chapters devoted to real analysis (chapters 1 to 4 and chapter 12),

chapters 1, 2 and 3 start from the concept of limit, convergence, continuous and differentiable functions and close with the notions of Riemann and Lebesgue integral and Schwartz' theory of distributions. This section ends with a nice and brief account of concept of probability, random variable and limit theorems. The Grassmann algebra of alternating differential forms, multiple integrals, change of variables and Stokes' formula form the contents of chapter 4 while results about Cantor sets and functions of Baire class are shifted to chapter 12.

The treatment of complex analysis begins from the definition of complex numbers (chapter 5) and after introducing holomorphic functions, an outline of Cauchy's theorem is presented. A good introduction to Riemann surfaces is given in chapter 6. Compactification of the complex plane  $\mathbb{C}$  is dealt with in chapter 7 under the title 'points at infinity', which also deals briefly with compactifications of  $\mathbb{C}^2$ .

In chapters 8 and 9 on ordinary and partial differential equations, different methods of integration, stability, wave equation, potential equation and heat equation are discussed. Besides these we also find a brief account of existence (Cauchy-Kovalevski) and uniqueness theorem, boundary value problems and equations of mixed type. In a span of 25 pages, these two chapters cover a good deal of material and give a very good introduction to the subject.

The chapter on Functional analysis (chapter 11) is divided into two parts, linear theory and non-linear theory. In the first part, we have a short account of Hilbert and Banach spaces, linear operators and spectral theory of bounded self-adjoint operators. The second part starts with an account of Fréchet differential, Banach fixed point theorem and their applications to non-linear operator equations. This chapter ends with a brief account of non-linear integral equations.

The remaining three chapters (10, 13 and 14) are welcome additions which are not usually found in books on analysis. In chapter 10, some simple difference equations which lead to Fibonacci numbers, Bernoulli polynomials and Euler summation formula are treated. After a good account of  $\Gamma$ -functions, some methods of solution of linear difference equations are given. A short account of applications of analysis to the distribution of primes and transcendence problems in number theory is given in chapter 13.

The final chapter (14) gives a bird's eyeview of the directions taken by different mathematical disciplines in the past (axiomatic method in geometry, set theory, algebra and analysis) and the interplay of one mathematical discipline in other areas and finally the Bourbaki construction of mathematics which has yielded rich dividends to the development of mathematics as a whole.

School of Mathematics  
Tata Institute of Fundamental Research  
Bombay 400 005.

S. RAGHAVAN and S. S. RANGACHARI

**Matrices in control theory** by S. Barnett. Robert E. Krieger Publishing Company, Box No. 9542, Melbourne, Florida, 1984, pp. 206, \$ 14.50.

This is a revised edition of the book of the same title published originally by Van Nostrand Reinhold Co in 1971. A significant change in the revised edition is the dropping of the subtitle, "with applications to linear programming", of the original edition. Thus, for instance, a section on Applications to linear programming in chapter 6 has been replaced by "Applications to linear feedback".

The contents of the book, which consists of seven chapters and appendices, can be roughly divided into the following parts. The first three chapters deal with key mathematical results needed for understanding the structure of linear systems and describe polynomial matrices, polynomials and rational matrices. The fourth chapter gives the main results on stability and also introduces new material on Metzler, Minkowski and Morishima matrices. The fifth chapter describes the basic properties of matrix Riccati equations which play a fundamental role in optimal control. The last two chapters are concerned with generalized inverses and unimodular matrices respectively. The appendices provide certain basic mathematical definitions and results which form the background for the areas treated in the chapters.

It is well-known that the book by Barnett is most useful for the mathematically-minded reader who needs to know the fundamental results of linear control theory, after having obtained the motivation for such a study elsewhere. The development is lucid and even where formal proofs are not given, an outline of arguments in the proof is presented. There is an extensive list of references at the end of each chapter and an indication of the nature of each contribution is given.

New material has been included in the revised edition and is easily distinguishable by the different style of type employed. The additions are mostly on the developments which have taken place after the publication of the original edition. The references have been considerably expanded and there is a new appendix, 'Further reading', giving more recent publications. The exercises at the end of each section have been updated. Even reading through the exercises enhances one's knowledge of the topic covered and also points out, in many cases, larger implications of certain basic ideas. The only item to be regretted is the omission of the very helpful 'Solutions to exercises' in the revised edition.

In summary, the revised edition should continue to be popular with control theorists as well as mathematicians who wish to know the basic results of linear control theory.

Department of Electrical Engineering  
Indian Institute of Science  
Bangalore 560 012.

M. A. L. THATHACHAR

*An introduction to science studies: The philosophical and social aspects of science and technology* by John Ziman. Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU, 1984. pp. 203. £12.95.

According to one estimate there are nearly half a million scientists in the world today and they constitute more than ninety per cent of the scientists that have ever lived on earth. But how many of these scientists ever ask themselves what distinguishes science from non-science, what are its goals, what influence science has on life, what are, or ought to be, the ethics of the scientific profession, what encourages the growth of science, what ultimate good (or harm) can science do and so forth? Cliche answers, of course, are at hand, but most of them do not stand up to careful scrutiny. At best the answers have to be severely qualified.

*Introduction to science studies* is an attempt to provide a broad perspective of the different dimensions of science: its epistemology, communication, its relation to technology, organization and governance, social and political implications, governmental control and patronage, ethics, etc., all of which come under the omnibus title of science studies.

Science studies, unlike scientific studies, are not yet strictly impersonal accounts of the situations they discuss and the view point of the author inevitably percolates into the arguments and conclusions. Although the author is generally careful to avoid bias and discusses alternative view-points, in less guarded moments, he allows himself to express the stock opinions. Otherwise, how can one understand a statement like the following (p. 115)? "Where these (*i.e.*, the science-based) techniques and modes of thought are lacking, as they still are amongst the general population of most developing countries, the instrumental function of science in society is greatly reduced. Thus, for example, complete ignorance of the bacterial causes of disease is one of the main obstacles to the widespread use of scientific methods of elementary hygiene in many countries. At this point, of course, we are not saying whether the influence of modern science and technology in the Third World is good or bad; we are merely noting that this influence is not to be measured solely in terms of the rice yields and expenditure on machine guns". Apparently the author ignores the historical and political circumstances in which technological and industrial development took place in the West and the present circumstances in which the Third World countries have to develop. Development is not a time-invariant process. Depleting resources, adverse trade balances, economic and political pressures, all make development of the Third World quite a different thing from that of the West. Be that as it may, why does the author have to doubt whether the influence of modern science and technology in the Third World is good or bad? Is he worried about the Third World countries going nuclear? Is the West a wholly neutral spectator in the Third World countries buying machine guns?

In a subject like science studies, it is, of course, easy to make an issue with the opinions of any writer. Despite above comment, the reviewer would like to recommend the book

to every one who has a serious concern for science for it makes him aware of the complex operation of science in modern life.

No. 68, II Cross  
Gangenhalli Layout  
Bangalore 560 032.

B. S. RAMAKRISHNA

**Welding of tubular structures** published by the Pergamon Press for the International Institute of Welding, 1984, pp. 574, US \$ 100.

This volume contains the collection of papers which were presented at the second international conference organized by the International Institute of Welding at Boston during July 1984. Welding of tubular structures has attained considerable importance in recent years. Contemporary problems faced in the welding of tubular structures have been analysed through the papers by eminent welding researchers of advanced countries.

The papers have been grouped under the headings of Applications, Fabrication and Design. The papers covering the aspect of applications seem to be confined to very special and narrow fields and may not be of much interest to the common fabrication welder. On the other hand, some of the papers covered under the next group of fabrication are more general in nature and provide useful practical details. Most of the papers under design concentrate on the fatigue behaviour of welded joints and on stress concentration in welds.

In all, this volume does provide useful information on design and execution of welds for tubular structures. There seems to be, however, no commonness among the different papers covered under each group. Manufacturers of welded tubular structures may find this volume handy and the information up-to-date.

Department of Mechanical Engineering  
Indian Institute of Science  
Bangalore 560 012.

S. SESHAN

**The physics of welding** edited by J. F. Lancaster. Pergamon Press, Oxford, 1984, pp. 297, US \$ 25.

A major portion of this book deals with the theoretical aspects involved with fluids at high temperatures, fluid dynamics and with metal transfer and mass flow. The above portions, dealt mathematically, are bound to be of extreme interest and use to fundamental researchers. Numerous references on these aspects have been cited and the treatment is extensive and deep. However, the discussions on electricity and magnetism seem to have only a remote connection to the main theme of the book.

The subsequent coverage of the general principles and characteristics of electric arc, vapour/plasma jets and the theories of cathode and anode mechanism is quite elaborate and of practical interest. Many aspects which are normally taken for granted by the welding metallurgist are clarified systematically; questions which have plagued the practical welder for years have now been answered.

The most interesting chapters are the ones on electric arc in welding and on high power density welding. Both these sections provide ample insight into principles of operation

and variables involved in modern welding processes. Inclusion of discussions on recent advances in laser welding, plasma welding and electron beam welding is noteworthy and timely.

This book should make interesting reading to those engaged in research on the fundamental aspects of welding and to a lesser extent to those who wish to explore novel and advanced welding techniques.

Mechanical Engineering Department  
Indian Institute of Science  
Bangalore 560 012.

S. SESHAN

**The case for Mars** (Science and Technology Series Vol. 57) edited by Penelope J. Boston. An American Astronautical Society Publication. Proc. Conf. 1981 University of Colorado, USA, 1984. \$ 25. Orders to Univelt, Inc., P. O. Box 28130, San Diego, California 92128, USA.

Mars, 'the Red Planet', has for long been the subject of much speculation. Sumerian, Egyptian and other ancient civilizations knew the planet well and attributed to its influence various events on earth. The eccentric behaviour of the orbit of Mars as compared to the other near-earth planets led to a detailed study of its orbit by Johannes Kepler. The results of these studies were the three Keplerian laws of planetary motion which even today constitute the basis for inter-planetary flight. The question of life on other planets especially Mars has also engaged the attention of scientists, artists and writers through the ages. These speculations have kept pace with improvements in the techniques of observation as well as with our new knowledge of the solar system and the universe. The names of Schiaparelli and Lowell and their dreams of life on Mars with its canals are important milestones in human speculation with regard to life outside the earth. The invasion of the earth by Martians in the famous H. G. Wells classic *The War of the Worlds* and Orson Welles' dramatic serialisation of this actually led many people to seriously believe that the Martians had actually landed.

Even with the advent of the space age, the possibility of life of some kind or the other on Mars was not excluded since most elements required for life — an atmosphere, water, reasonable temperature conditions in some locations — all existed on Mars resulting in the hope that there was indeed a serious case for life on Mars. The landing of the Viking spacecraft on the surface of Mars dispelled these notions to a great extent even though life elsewhere than on the landing sites still cannot be categorically ruled out. The next great adventure that humanity is going to embark on is clearly the exploration of the solar system. Colonies in space and on nearby planets are an essential element in this endeavour.

Given this background, a conference on 'A Case for Mars' is both timely and relevant. An understanding of the problems involved in making the colonisation of Mars feasible helps focus attention on a task which is not only sufficiently big and bold and imaginative but one which is also in the longer range possibly absolutely necessary. The survival of humanity in this age of 'Star Wars' and 'Mutually Assured Destruction' could possibly

depend on the colonisation of space and nearby habitable planets. The papers presented in this conference reveal that the challenge of colonisation of Mars is not that difficult to overcome and such colonisation can easily start in the next 15-20 years if there is a will and a political commitment to realise this.

The papers presented fall broadly into six groups. These are:

- the need to colonise Mars;
- what kind of mission scenarios are possible;
- what kind of spacecraft are required; this covers both take-off and landing requirements on earth and Mars;
- the kind of life support systems that are required;
- what kinds of surface activities are required and what kind of materials are available for colonisation;
- social and political aspects of the colonisation of Mars.

The three papers that deal with the question of why the colonisation of Mars is in the paper by Leonard David as:

- survival reasons (man may destroy the earth);
- an endeavour which is so big that it can unite the nations on earth and promote international peace;
- the use of the resources of Mars for human benefit;
- the desire to explore new areas and to gain new scientific knowledge for understanding the earth better.

Other reasons cited in other papers are that NASA would have a long term plan into which all other elements would fit. This would serve as a pace setter for development. The economic advantages that would accrue to the nation exploring and colonising the new frontier first is also emphasized as a major reason for the undertaking.

The section on Mission strategy outlines various possible mission scenarios. The paper on establishing the first human bases not on Mars but on Deimos and Phobos (the moons of Mars) to be followed by the exploration of Mars by manned and unmanned rover vehicles of Prof. Singer outlines in some detail how the exploration and colonisation can be carried out. A number of problem areas are identified. The case for more detailed reconnaissance and the location of suitable landing sites has also been made very strongly. The mapping of water locations would possibly be the most important criterion for location of the colonies which would go underground.

The section on spacecraft design deals with the details of how the colonisation can be realised and is very readable with ideas being presented simply and lucidly. The mission would have to be launched from earth orbit with the building of the Martian lander and transfer vehicle in earth orbit. The landing on Mars would similarly be accomplished by separation of the lander from a Martian orbit. A variety of techniques for minimising energy requirements are discussed. One major technical option emphasized is to use aerobraking and aerocapture for this purpose. Some details of various lifting/entry configurations are also presented. The use of a solar electric propulsion system, large



solar sails for the earth orbit to Mars orbit transit the aerocapture from Martian orbit seems to be the best technical choice. A paper on how the external tank of the shuttle (which is currently jettisoned into the sea) can be used as the building block of the transit vehicle is interesting since such an approach could be very cost effective. The impact of carrying the tank into orbit of a sufficient height to prevent decay has however not been touched upon. The idea is however interesting.

The five papers on life support are very detailed and comprehensive. The general impression that one gets is that the technology for supporting life exists, most of the medical problems are known and can be handled and that really there are no barriers to Martian journey and a prolonged stay on Mars.

The problems associated with the role of plants in a closed loop ecosystem including water balance and distribution, plant pathogenesis and the problems associated with long term plant survival in a closed loop ecosystem in the paper by Maquire are particularly interesting. The answer to the decalcification problem of bones and possible solution for it in long duration spaceflight has however not been touched upon in too great detail.

The section on surface activities and materials processing is possibly the most interesting section. This section seems to indicate that a human settlement on Mars is realisable and that most elements required for sustaining life and for transportation to and from the planet, can be manufactured on the planet itself. The use of argon found in relative abundance in the atmosphere of Mars in an electric propulsion system is an interesting concept.

The section on social and political aspects is not in the same class as the rest of the sections. Possibly it covers too wide a range of topics to be really effective. The legal aspects are also not really addressed in totality. The chapter on costs seems to project a figure which is about 1/2 of the cost of the Apollo program. This seems to be very optimistic projection. The possibility of a joint US-USSR international venture does not appear to have been taken seriously and is not discussed at all.

Appendix C entitled 'The future of Mars' is particularly readable since it presents a very interesting and plausible scenario of what can happen if we pursue the colonisation of Mars. Some parts of it combine the best elements of science fiction and very realistic and pragmatic possibilities.

Overall 'The case for Mars' is very readable and is a valuable addition to the subject of exploration of Mars. The workshop and its proceedings do make it appear that human colonisation of Mars is not a farfetched dream but a very realistic and practical proposition.

SRO Satellite Centre  
Vimanapura  
Bangalore 560 017.

K. KASTURIRANGAN

**Space: A developing role for Europe** (Proc. 18th European Space Symposium, London, 1983. Science and Technology Series, Volume 56) edited by L. J. Carter and Peter M. Bainum. Published by American Astronautical Society, 1984, \$ 35. Orders to Univelt, Inc., P. O. Box 28130, San Diego, California 92128, USA.

The history of the space programme and its evolution over the last two decades in Europe has mainly depended on the extent of cooperation and competition with the USA. The merging of the European Satellite Research Organisation (ESRO) and the European Launcher Development Organisation (ELDO) into the European Space Agency gave the combined European effort a status and a credibility that was lacking earlier.

The successful transition from development to commercialisation in communications, and in the marketing of the Ariane launcher have also provided substantial returns to European industry — the very purpose of setting up ESA. Cooperation with the US has not benefitted Europe very much — a sore point which the Europeans are bent upon changing. With the accomplishment of most of the tasks for the early eighties, ESA now has to re-assess its role and its stake in the future development of European space capabilities both for meeting European needs as well as for preserving Europe's share of the potential commercial market. The 18th European Space Symposium on 'Space — A developing role for Europe' tries to address the role of Europe and the goals it should set for itself in space in order to realise the full potential of European involvement in this market of the future.

The papers presented fall into three broad categories:

- the application missions in space sciences, space biology, space processing, remote sensing of the earth and telecommunications;
- the future scenario of launch vehicle development by Europe;
- the possibilities of European participation in the space station and other activities related to space platforms.

The section on the current and foreseen applications missions essentially focus on ESA's ongoing and immediate plans in these areas. These include details of the approved ERS-1 ocean remote sensing satellite, the microgravity and life sciences programme in Europe and the telecommunications programme including an overview of the LSAT system. Two articles deal with future developments in remote sensing and in communications in rather general terms, emphasising trends and prospects that are reasonably well-known. The results of the Infrared Astronomical Satellite (IRAS) presented in this section are interesting, especially the part that deals with the discovery of new comets. The possibility of a new astronomy mission in the ultraviolet, although presented at a very broad level still makes interesting reading.

The section on future launch vehicles is possibly the most interesting part of the book. All the three articles that make up this section make interesting reading. The article 'An aeroplane approach to launch vehicle design' by Ashford is particularly good with its very novel approach of a 'tourist' market for space and a 'space hotel'. The appendix to

this article provides a good summary of some of the technical problems associated with a single stage and two stage rocket/aeroplane launch into space. The Ariane-5 Hermes concept and the three favoured design options for realisation of the manned capability are dealt with in the article by Cretenet. The problems involved with introducing the manned winged hypersonic spacecraft HERMES on the Ariane-5 are also briefly touched upon.

The section on manned platforms and space stations dwells in some detail on the space station concept and the proposed European contribution to the US manned and unmanned space station. Concepts, approaches and participation is the theme. The focus on technical aspects and technology is rather limited.

As an overview of likely developments in Europe the material in the book provides an useful framework to watch and forecast what is likely to happen. Much of the material is qualitative in terms of outlining ongoing and projected activities. Nevertheless it is useful for managers/policy makers in all countries to get an understanding of the current and future developments in space from a European perspective.

ISRO Satellite Centre  
Vimanapura  
Bangalore 560 017.

K. KASTURIRANGAN