Book Reviews

Astronautics

U. Walter

Wiley-VCH Verlag, Weinheim. 2008. Distributed by John Wiley and Sons, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, UK. 484pp. Illustrated. £65. ISBN 978-3-527-40685-2.

Ulrich Walter, former German astronaut and now professor at the Technical University of Munich, is obviously no stranger to Astronautics. True to the book's name, he has written a book about 'star-sailing', or at least space travelling, from a dynamics perspective. Topics cover the entire life cycle of space missions from launch vehicle propulsion, ascent trajectories, staging, thermal and electric propulsion, orbital mechanics, orbital transitions, the three-body problem, rigid body dynamics, orbit determination and finally atmospheric re-entry.

Targeted at graduate students and industry, the book is well written, containing many useful illustrations and describes many of the more complex aspects of spaceflight dynamics in an approachable manner. Notable in this regard are the chapters on orbit determination and atmospheric re-entry, subjects which most other texts shy away from. It also contains problems to be solved at the end of each chapter to aid the learning process.

The book's contents are, however, a little quirky at times. Notably absent are the solutions to the problems set at the end of each chapter. In addition, whilst the book includes some real peculiarities, such as relativistic rocket dynamics and mathematical considerations of whether life can exist in a universe with n-macroscopic dimensions, it fails to cover some inherently useful problems such as the basics of changing the inclination of an orbit.

That said, the book remains a very good introductory text to spaceflight dynamics and some may well enjoy its quirkiness. In the context of other recent texts which address this field, most notably by Curtis (Curtis, H. *Orbital Mechanics for Engineering Students*; Elsevier, 2005), it compares well though, for students new to the area, Curtis's book has a significant advantage in the shear number of example problems presented (and solved).

Dr Peter Roberts, MRAeS

Spacecraft Collision Probability

F.K. Chan.

Co-published by The Aerospace Press, 2350 East El Segundo Boulevard, El Segundo, CA, USA. 90245-4691, USA and American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, USA. 2008. 323pp. Illustrated. $54.95 (AIAA members), $79.95 (non-members). ISBN 978-1-884989-18-6.

Dr F K Chan has more than 40 years of experience in applied mathematics and the engineering sciences. He has expertise in spacecraft orbital and attitude dynamics, space debris collision analysis and pre-emptive manoeuvres, remote sensing, development of geographic information systems for global Earth applications, probabilistic antenna acquisition of moving objects and signal fading in the ionosphere.

The book is based on research conducted over the past 20 years and papers the author has presented at conferences. It presents an in-depth approach in order to provide the reader with a detailed understanding of spacecraft collision probability. A logical structure, clear explanation of concepts and a step-by-step development of mathematical arguments aid the reader's understanding. The use of figures, equations and tabulated and graphical data allows the reader to reproduce results. A large amount of information is presented in a concise manner.

The work is divided into 15 chapters. A brief overview of each chapter is given at the beginning of the book. Each chapter is subdivided into an introduction, numerical results, discussion, conclusion and summary and reference section. The content considers different aspects of spacecraft collisions including short-term encounters, long-term encounters, formation flying and close encounters with multiple satellites. A thorough case study is provided of the International Space Station and how it is best modelled to compute its collision probability.

The chapter on spacecraft encounters covers foundation concepts of the field. An explanation is provided for why different analysis methods are needed to analyse short-term and long-term encounters and difficulties in the methods are highlighted. The fourth chapter develops an analytical expression, the Chan model, for computing a wide range of spacecraft collision probabilities with clear limits for its applicability. Subsequent chapters develop equations for different encounters and consider how they can be applied to complex cross sections. Results of the Chan model are compared with the Patera and Alfano and demonstrate why the Chan model is more useful.

Chapter 7 discusses methods for designing an orbital manoeuvre (intrack thrusting and general thrusting) to mitigate potential collision threats. Both a simple and difficult manoeuvre are considered. Case studies are used to compare results of collision probabilities using the same model in order to demonstrate the inappropriate use of method for the short term encounter. The analytical expressions derived throughout the book are drawn upon and applied to formation flying and close encounters with multiple satellites. The book also demonstrates two methods for determining both the maximum probability of collision and instantaneous probability of collision.

The book is most useful to researchers, analysts and students in the field.

Jasween Dogra

Introduction to Structural Dynamics

B.K. Donaldson

Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU. 2006. 539pp. £70. ISBN 0-521-86574-3.

This book is a teaching text aimed at final year undergraduates or post-graduates. So there are many well-established textbooks in this field with the same aims, but this author claims two attractive features different from traditional approaches. Firstly the equations of dynamic systems are set up using Lagrange's equations and virtual work, which is certainly a simple and attractive alternative to deriving the equations of motion directly using Newtonian mechanics, particularly for multi-degree of freedom systems with generalised co-ordinates. Secondly, as a consequence, 'no organisational distinction is made between single and multiple degrees of freedom systems'. This does remove the mysteries of moving from single to many freedom systems modelled by commercial finite element codes for example. Student analysts will find this very attractive since most Universities now use commercial codes as a design and/or research tool.

The author does however spend a decent amount of time looking at simple systems to illustrate natural frequencies, response, resonance and the effects of damping. The move to multiple degrees of freedom is then prepared by a chapter on the finite element method, mostly using beam, tube and framework structures. The various methods for calculating natural frequencies and modes (Eigen-values and vectors) are discussed and the advantages of modal synthesis are shown for general dynamic loading. Random vibration is covered and also aeroelasticity using a simple two-dimensional aerofoil on two springs to reveal how energy is extracted from the moving air and resulting in divergence and flutter speeds.

The concluding chapter is on numerical integration using for example the familiar Runge Kutta. Some use of commercial codes is shown, for graduates likely to use them. There is sadly however one serious omission. No treatment of direct integration – especially for nonlinear non-periodic dynamics such as impact and metal forming – is given. Graduates should know the pros and cons of explicit and implicit codes for large systems. Admittedly the book is already over 500 pages long, but this is a serious omission.

Another strange strategy, often used, is to write down without proof an equation (such as the multiple degrees of freedom motion in matrix notation) and then refer the reader to a later 'end note' at the conclusion of the chapter where the general proof is developed. Is this a recognition that students in lectures just want the equations written down and will wait until exam revision for the derivation?

However the book does satisfy one essential criterion for a teaching text. There are countless examples worked through and also many set problems with answers in nine appendices at the book's end. These features alone should appeal to students and to lecturers.

Professor G.A.O. Davies, CEng, FRAeS

The History of the Theory of Structures: From Arch Analysis to Computational Mechanics

K-E. Kurrer

Ernst & Sohn Verlag, Rotherstrasse 21, D-10245 Berlin, Germany. 2008. Distributed by John Wiley and Sons, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, UK. 848pp. Illustrated. £90. ISBN 978-3-433-01838-5.

The common ground between the histories of bridge and building structures and the history of airframe structures is considerable – the striving for minimum weight structures, the development of the fundamental concepts of structural mechanics, techniques of computation and analysis, failure modes of structures and materials and so on. While this book is written mainly about bridge and building structures, the author has also provided an excellent history of the structural mechanics of airframes since their earliest days in the 1910s. This includes, specifically, developments in the analysis of redundant frameworks, three-dimensional frameworks and structures for resisting shear and torsion. Also mentioned are the contributions of Herbert Wagner, Hans Ebner, R.V. Southwell and others in developing the numerical methods that led to finite element analysis.

Eleven introductory essays will whet the appetite of anyone interested in the history of the theory of structures from the 16th century to the present day. The main chapters deal with the emergence of the fundamental disciplines of structural science – the theory of structures, strength of materials and applied mechanics, the development of methods of analysis and design for structural steelwork, spatial frameworks, reinforced concrete and the analytical methods suited to processing by computers, including the finite element method. There follows a discussion of 12 scientific controversies between rival academics. The final chapter reviews the recurring debates about the aesthetics of structures and different approaches to teaching the theory of structures and is followed by 175 short biographies of principal engineers and academics and a bibliography occupying over 50 pages.

The author provides a well-balanced, richly-woven narrative of mathematical analytical techniques, practical engineering and details of the people involved for nearly every aspect of the history of structural theory. The only omissions I noted are the development of scale model testing between the 1930s and 1960s for structures such as shells and gridshells whose behaviour was too complex for hand calculations and the development of prestressed cable and membrane structures. One aeronautical theme that could have been included is the development of airships and the techniques used for analysing the huge variety of structural frames used.

Kurrer's book (almost inevitably) presents the subject through German eyes and the contributions of a few French and British names (for example) are not given their full due – the work on tensile structures by René Sarger in France and the immense contributions to developing the idea of the computer program by Alan Turing and the Finite Element Method by Olek Zienkiewicz in Britain. Such under-representation, however, is more than outweighed by the wealth of information about the work of the great engineers and scientists from German speaking lands – August Föppl, Franz Joseph Gerstner, August Hertwig, Emil Mörsch, Johann Schwedler and Konrad Zuse who conceived 'calculating machines' controlled by a 'computer plan' fed with commands from a punched tape in 1936 – to name just a few.

Kurrer's achievement in compiling this book is colossal and it will, for a long time, stand well along side the other classics of the field – Timoshenko's *History of Strength of Materials* (New York: McGraw Hill Book Co, 1953) and Eduardo Benvenuto's *Introduction to the History of Structural Mechanics.*

Bill Addis, MCIOB and Companion Member IStructE

Modern Radar Systems – Second edition

H. Meikle

Artech House, 46 Gillingham Street, London, SW1V 1AH, UK. 2008. 701pp. Illustrated. £88. ISBN 1-59693-242-2.

There are a great number of books which aim to cover the subject of radar systems and quite a few of them that have been published in the Artech House radar series. This one gives a European perspective, with a distinctive style. The author, Hamish Meikle was educated in the UK and has worked as a consultant on various radar-related subjects in several countries in Western Europe.

This is the second edition of a book originally published in 2001 and is organized in 16 chapters and three appendices. Its style is at an appropriate level of mathematical detail and is such that it will appeal to practicing engineers and graduate-level students. A distinctive feature is that it uses the computing package Maple V as a means of presenting concepts graphically and it makes particular use of plots of signals and noise in real and imaginary form as a function of time. As such, it gives a useful insight not always present in other books and which may be helpful to some readers.

The book deliberately adopts simple, straightforward language, using military terms only where necessary and aims to avoid acronyms which abound in this subject and which can sometimes lead to confusion. It covers most of the topics that would be expected in a book on radar systems: new material in the second edition includes solid state devices, low-sidelobe and electronically-scanned antennas, sidelobe cancellers and adaptive arrays and antennas for airborne radar including synthetic aperture and airborne MTI, as well as phase-coded radar waveforms.

In summary, this is a useful addition to the radar literature. It provides a distinctive approach and will be worth consulting to provide additional insight into the subject.

Professor H.D. Griffiths, FREng, FIET, FIEEE