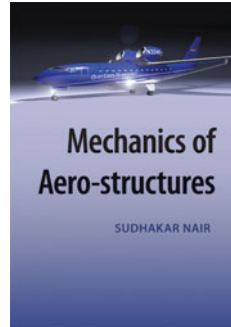


discussed in the text and also introduce realistic applications. Useful formulae are neatly summarised in 18 sections of appendix. This book will be particularly useful for those interested in compressible flows, as Section II and the latter part of Section V are heavily focused on those. This is a welcome addition to the audience of *The Aeronautical Journal*, as classic textbooks on theoretical fluid dynamics, such as that of G.K. Batchelor, often focus on incompressible flows only.

The author's remarkable achievement is that mathematical methods, especially advanced linear algebra and transformation theories are seamlessly introduced while discussion is focused on physics of fluid problems. Although there are many textbooks available that survey mathematical methods commonly used in science and engineering, fluid mechanics examples used in those books are often out of the context.

Therefore, this book is recommended not only to fluid mechanics scientists and engineers who want to establish firm theoretical foundation but also to applied mathematicians who wish to apply mathematical methods to fluid mechanics problems. Readers would need some proficiency in advanced engineering mathematics; therefore, it will be more suitable for graduate students and professionals.

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## Mechanics of Aero-Structures

**S. Nair**

*Cambridge University Press, The Edinburgh Building, Cambridge, CB2 8RU, UK. 2015. 182pp. Illustrated. £39.99. ISBN 978-1-107-07577-1.*

This book has been written with the intention of providing a concise text on the mechanics of aircraft structures for third- and fourth-year undergraduate students studying in aerospace and aeronautical engineering. The book is nicely presented and is well illustrated. It includes several worked examples to outline the application of the theoretical analyses procedures developed in the various chapters of the book and provides numerous exercises to be carried out by the student to enhance and facilitate the students' knowledge and understanding of how the structural systems work. The book provides an online resource that gives solutions to the student exercises. This is password protected for lecturers who will use the book to teach aero-structures. The reviewer believes that providing the

answers to the exercises in the book would have been more helpful to the students especially those who buy the book but are not following a course based on the book.

Chapter 1 gives a very brief introduction to the structural components that formulate an aircraft fuselage and wing and discusses the elements of the aerodynamic forces acting on a wing during flight. The loads acting on an aircraft in level flight are detailed as well as those in the case of symmetric manoeuvres including the pull-out from a dive and a banked turn, leading to the development of the normal acceleration load factors for these cases. Gust loading and the aircraft flight envelope are discussed as well as the essential considerations of the proof and ultimate load factors in the aircraft design process. The reviewer considers this chapter to be lightweight in its coverage of the structural layout and loading aspects of an aircraft. No details are given of the empennage structure or of the various auxiliary surface and control surface structures. The author refers to fuselage ring frames as bulkheads, whereas this term normally relates to transverse frames, which extend completely across the fuselage cross-section. No details are given of a typical fuselage bulkhead designed to deal with cabin pressurisation at altitude or of the landing gear aspects of an aircraft and its associated loading on the airframe structure.

Chapter 2 gives a detailed outline of the basic elements of elasticity through a three-dimensional description to a two-dimensional simplification leading to the appropriate plane stress and plane strain constitutive relations. In addition, the chapter discusses other material aspects including

composite materials, plasticity in metals and commonly used materials in aircraft construction.

Chapter 3 gives a detailed outline of the energy methods of approach in structural analysis. Work and complementary work and strain energy and complementary strain energy are explained first. The virtual force and virtual displacement methods are then developed leading to Castigliano's first and second theorems, which then culminate in the unit load and unit displacement methods of approach. A number of example problems are detailed in the chapter, showing the application of the methods for the determination of deflections, external reactions or the loads in the members of statically indeterminate structural systems.

Chapters 4 and 5 give a detailed account of the torsion, bending and shear analyses procedures pertaining to thin-walled open and closed section beam members. Chapter 4 deals specifically with the torsion of thin-walled members, and the reader is introduced to the phenomenon of warping of the cross-section whereby plane cross-sections before deformation do not remain plane during the torsional loading process. The influence of constrained warping on structural performance is discussed in this chapter, and its effects are clearly explained. The bending and shear behaviour of thin-walled members is essentially dealt with in Chapter 5, which introduces the mass-boom concept of construction in which the booms carry axial load and the thin plate connecting members between the booms carry the shear flow in the cross-section. There are numerous clearly worked and informative examples presented in these chapters as well as appropriate exercises for the students to

gain experience in the application of the developed analyses procedures.

Chapter 6 deals, essentially, with the stability aspects of axially loaded beams. The chapter presents the analysis procedures and associated solutions pertaining to the buckling of beams with different boundary conditions. The topics covered in the chapter include exact solutions of the appropriate differential equations of equilibrium and the energy method of analysis as well as the torsional-flexural buckling analysis procedures relating to singly-symmetric, thin-walled open section compression members.

Some discussion is given to the post-buckling deflections of beams using large deflection theory and to the dynamic stability of an aerofoil using a very simplistic two-spring analysis model for the attainment of the appropriate equations of motion. It is surprising that no mention is made in this chapter of the local buckling aspects of thin skin elements subjected to compression and/or in-plane shear loading, as this is a major consideration in the aircraft design process.

Chapter 7, the final chapter of the book, puts together a number of topics relevant to the strength characteristics of materials. Brittle failures are discussed in the context of the maximum principal stress and strain theories, and the Tresca and Von Mises theories are outlined in respect of ductile material failures. Some failure theories for fibre-epoxy composite materials are highlighted in this chapter, and the student is introduced to the basics of the fatigue and fracture mechanics of materials.

The title of the book *Mechanics of Aero-Structures* is an all-encompassing title that generates high expectations in its content before the book cover is opened. In this respect, the reviewer has been disappointed in the depth of coverage by the author. There is much that is missing from the book, which the reviewer feels should have been included. The analysis of fuselage frames and wing ribs with due consideration of their interaction with the covering thin skins, the influence of cut-outs and the importance of thin skin buckling are topical areas which have been neglected.

There are existing textbooks on aircraft structures for engineering students which already cover the material of this book and to a much greater depth. Although composite materials have been discussed in Chapters 2 and 7, there are no examples or exercises presented in the book relating to the behaviour of composite open and closed single- and multi-cell sections subjected to bending, shear and torsional loading. Bearing in mind the considerable and increasing use of composite materials in today's aircraft, and I mention here the Boeing 787 Dreamliner and the Airbus A350 XWB as examples, it would have been instructive to have included the behaviour of composite sections in Chapters 4 and 5 of the book and to have highlighted the influence of laminate lay-up configuration on structural performance. This would have been a valuable contribution to the book, as it is something, in the reviewers' opinion, that is an essential topical element that should be included in any student course text dealing with the analysis and design of aircraft structures in the present day.

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