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Book Review

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# Bertin JM, Cummings RM, *aerodynamics for engineers*, 6th ed., 2022, Book review

## Abstract

This well-written, new and revised edition of Aerodynamics for Engineers comes both as a legacy of (the late) Professor John Bertin and a "gem" addressing mainly aeronautics and aerospace engineering students but also physics and applied mathematics students with an interest in compressible fluid flow and its various applications. Professor Russell Cummings has done a superb job to maintain the book's fame in the topic of aerodynamics. Several sections have been rewritten taking into account the more recent developments in the subject. For instance, many new examples have been added in order to enhance the reader's understanding and his capability of applying the theoretical concepts to "real life" situations (concerning mostly military aircraft applications), new sections are added to cover a series of topics that are significant to aerodynamics, such as applications of potential flow, converging/diverging nozzles, and characteristics of hypersonic flow, just to name but a few. Furthermore, references as well as figures and photographs have been updated, and answers to selected problems are included.

**Keywords:** aerodynamics, engineers, applied mathematics, compressible fluid flow

Volume 6 Issue 3 - 2022

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**Received:** August 01, 2022 | **Published:** August 11, 2022

## Book review

After the first chapter entitled "why study aerodynamics?" that clarifies the motive of studying the subject by pointing out the performance characteristics and the essential components of airplanes, developing a basic knowledge of fluid properties for perfect gases, and stressing the fluid behavior in the atmosphere, the book continues with the fundamentals of fluid mechanics always in the context of airplanes. Here, the main equations of fluid motion (continuity equation, Navier-Stokes equations) are presented in differential as well as integral form. Poiseuille and Couette flows are examined, and the Reynolds and Mach numbers are introduced as similarity parameters. Next, the concept of the boundary layer is introduced at the example of an airfoil. Finally, the first law of thermodynamics and the derivation of the energy equation in differential and integral form are studied, while Bernoulli's equation is examined in a proper example.

Chapter 3 deals with the dynamics of incompressible and inviscid fluid flow, while in Chapter 4 viscous boundary layers are treated. Wind tunnel examples are given, the notion of circulation and its significance for aerodynamics are introduced, the case of irrotational flow is examined, Kelvin's theorem is derived, and the concept of vorticity is explained. Next, the notions of stream function, streamline, and equipotential line are presented, while a nice example on corner flow is analyzed. The importance of Laplace's equation is stressed by some examples, while the notion of potential vortex and Helmholtz's vortex theorems are explicated. Lift and drag are analytically presented for various shapes and flows. Then, laminar and turbulent boundary layers (including thermal boundary layers), their equations, and their impact on aerodynamic flows are extensively explored, while emphasis is given on the control volume analysis.

The next three chapters are devoted to airfoils, wings, and their differences and impact on aerodynamics. The basic geometric parameters are investigated before proceeding to an extended study of incompressible flow around infinite span airfoils and finite span wings. In the latter case, delta wing aerodynamics and its difference from traditional wing aerodynamics is examined, while the lifting-line theory is followed by the computational approach of the panel numerical method and the vortex lattice numerical method, explicated by examples.

The book continues with compressible flows. Chapter 9 deals with subsonic and transonic flows. The governing equations are derived, the important Göthert "affine" transformation for a reduction of the linearized velocity potential equation to Laplace's equation is given, additional compressibility conditions for compressible experimental data are introduced, and the flow characteristics are explained. Transonic flow past unswept airfoils is studied, and the method of reduction of wave drag by design is presented, while swept wings at transonic speeds are examined. In the next, 10th chapter, two-dimensional supersonic flows around thin airfoils are considered. Starting with the linear theory (pressure waves are assumed to be sufficiently weak), the text continues with the 2nd order theory of Busemann for the pressure coefficient. Then, Ackeret's shock-expansion technique is introduced for the calculation of the flow field around an airfoil. Chapter 11 goes over to the study of supersonic flows over wings and airplane configurations. Here, after giving the governing equations and boundary conditions, the method of conical flow and the method of singularity-distribution are investigated, and several design considerations for supersonic aircrafts are presented. The chapter ends with sections on slender body theory, base drag, and aerodynamic interaction. Next, hypersonic flows are studied in Chapter 12. After describing the differences between hypersonic and supersonic flow, the Newtonian and the modified Newtonian flow models are described, the flow characteristics near a stagnation point of a hypersonic vehicle are determined, while lift, drag, and pitch moment are calculated for simple geometries at hypersonic speeds. The significance of aerodynamic heating and heating rate estimation on blunt bodies at hypersonic speeds is stressed, and the difficulties of determining the boundary layer transition from laminary to turbulent at hypersonic speeds are explained.

In Chapter 13, aerodynamic design considerations are given. For example, ideas on how to increase lift, or how to reduce drag, with an emphasis on specific tactical military aircraft, are discussed. The final, 14th chapter, contains a useful review of analytical/numerical aerodynamics tools (mainly CFD codes) while suggesting ways of synergy between such tools and semi-empirical, experimental data-

based methods coming from ground-based or flight testing. Two appendices and answers to selected problems close the book. In the first appendix, the equations of motion are expressed in conservative form, as it is frequently needed in CFD. The second appendix contains some helpful tables, where English as well as SI units are used.

As a final comment, one cannot but stress that the book of Bertin and Cummings is not only a "gift" that should be on the bookshelf of everyone interested in modern aerodynamics but also a joyful reading.

## Acknowledgements

None.

## Conflicts of interest

The Authors declares that there is no Conflict of interest.

**Citation:** Grammenos T. Bertin JM, Cummings RM, *aerodynamics for engineers,* 6th ed., 2022, Book review. *Aeron Aero Open Access J.* 2022;6(3):108–109. DOI: 10.15406/aaoaj.2022.06.00148