

Review of "An Introduction to the Mathematics and (the) Methods of Astrodynamics" by **Richard H. Battin**, *AIAA Education Series*, New York (United States), 1987 & 1999 (BEST SELLER! Winner of the Summerfield Book Award), as it appears on the Amazon website: <http://www.amazon.com> full text of the book: <https://arc.aiaa.org/doi/pdf/10.2514/4.861543> [Book Rating: ★★★★★]

The following comments refer to the 1987 edition. Some of these comments were communicated to Dr. Battin, who, very kindly, acknowledged them in his letter dated October 25, 1993, "Thank you for your letter and your interest in my book. I appreciate your list of corrections and suggestions."

The book by Richard H. Battin, Senior Lecturer in Aeronautics and Astronautics, Massachusetts Institute of Technology, United States, covers essential mathematical background needed to work with astrodynamical problems. Topics covered include hypergeometric functions, elliptic integrals, continued fractions, coordinate transformations as well as essentials of two-body-central-force motion.

The author's way of discussing these topics with historical introduction and personal narrative makes the book interesting to read. There are minimal typographical errors, probably, because the author, personally, typeset this book. However, there are a few omissions and oversights. For example, on page 172 captions are given for Fig. 4.15 and Fig. 4.16, whereas the actual figures are missing (*The author has rectified this omission in the 1999 edition*). In addition:

- a) On page 7 it is stated:

$$\Delta \mathbf{r} = \frac{s_g}{v_g} \mathbf{v}_g$$

where  $s_g = \int \mathbf{v}_g dt$ . In this equation, a scalar on the left-hand side is equated to a vector on the right-hand side. The equation should be modified as:

$$s_g = \left| \int \mathbf{v}_g dt \right|$$

- b) On pages 10-11 it is stated: "If you want to drive a vector to zero, it is sufficient to align the time rate of change of the vector with the vector itself." This is not true, in general, but only if time rate of change is negative.
- c) On page 13 the author tries to show that constant in the equation:

$$\frac{\nabla \times \mathbf{v}_c}{\rho} = \text{constant}$$

vanishes by the following argument. "The demonstration concludes with an argument that the fluid is converging on the target point  $\mathbf{r}_T$  so that the density in the vicinity of  $\mathbf{r}_T$  is becoming infinite. Hence, the constant is zero, implying that the curl is everywhere zero." There are 2 problems in this line of argument: (i) The statement "hence, the constant is zero" is true, only if the numerator is finite.  $B = \infty$  implies  $A/B = 0$ , only if  $A \neq \infty$ . Otherwise, one has to apply l'Hospital rule; (ii) Even if the constant is supposed to be zero, this does not imply that the curl is everywhere zero.  $A/B = 0$ , where  $B = \infty$  does not imply that  $A = 0$ . In fact, A could have any finite value.

- d) On page 109 equation of motion in a frame of reference moving with acceleration  $-\mathbf{a}_1$  is written as:

$$m_2(\mathbf{a}_2 - \mathbf{a}_1) = \frac{m_1 + m_2}{m_1} \left( \frac{Gm_1m_2}{r^2} \right) \left[ \begin{array}{c} \mathbf{r} \\ -\mathbf{r} \end{array} \right]$$

Since the frame is noninertial (accelerated), Newton's second law,  $\mathbf{F} = m\mathbf{a}$ , is not applicable in this frame.

- e) On page 223 it is stated: "When we compare Eqns. (5.57) and (5.58), it is clear that we **must** have:

$$\sin E \cong \sqrt{\frac{6(E - \sin E)}{\sin E}}$$

....." This is *not the only choice* for  $\sin E$ , which reduces (5.58) to (5.57) in the limit  $E \rightarrow 0$ . The word "must" is inappropriately used here.

I would recommend this book **very strongly** to any one involved in astrodynamical research.

*Review sent to Dr. Battin:* July 19, 1993  
*Dr. Battin replied:* October 25, 1993  
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*Note added on October 1, 2010:* This review is, now, part of the manuscript: The Multi-Stage-Q System and the Inverse-Q System for Possible Application in Satellite-Launch Vehicle (SLV), Proc. IBCAST 2005, pp 31, 32; full text: <http://www.ngds-ku.org/Papers/C66.pdf>

*Note added on October 1, 2015:* Professor Kamal became Senior-Most Professor of Mathematics on June 26, 2015 and Senior-Most Professor of University of Karachi on September 29, 2015. On the same day, he assumed charge of Dean, Faculty of Science and Faculty of Engineering as well as Chairman, Department of Applied Physics and Department of Computer Science, University of Karachi. On March 20, 2014, he gave Richard H. Battin Memorial Lecture entitled, "The Extended-Q System" (Battin passed away on February 8, 2014 after a distinguished career) during *the Second Conference on Mathematical Sciences*, organized by Department of Mathematics, University of Karachi during his second full-term of chairmanship (First Term, 2003-2006; Second Term, 2012-2015).

*Note added on March 25, 2016:* The constant in

$$\frac{\nabla \times \mathbf{v}_c}{\rho} = \text{constant}$$

should, actually, be a '**constant vector**' — Noor Fatima Siddiqui, Lecturer, Department of Mathematics, University of Karachi commented today.

*Web address of this document:* <http://www.ngds-ku.org/Papers/Battin.pdf>