least action that the subject begins to acquire an interest for a modern scientist.

The fundamental approach of Maupertuis was still essentially teleological. "La Nature, dans la production de ses effets, agit toujours par les moyens les plus simples." It is also true that Proclus, the pagan neo-Platonist, said almost exactly the same thing nearly one and a half millennia earlier. Admittedly, Proclus had only the vaguest notion about how to work out the quantitative implications of the principle, but then Maupertuis hardly did better. On balancing the evidence one feels that Proclus was entitled to a mention in the historical introduction and perhaps he will get it in a subsequent edition.

The business part of the monograph starts in Chapter 5 with the equations of Lagrange and Hamilton. Hamilton's principle and related topics are further developed in Chapters 6 and 7. After elucidating the relation between the Lagrange equations and the Hamiltonian method, the authors make clear the important distinction between the principle of least action and what Hamilton called the law of varying action.

Other problems taken up in the book include the formulation of electrodynamics in Hamiltonian terms and the variational approach to quantum mechanics. There is a very interesting chapter on the principles of Feynman and Schwinger. These are so useful and important that one welcomes the careful exposition accorded them here.

There is an attempt in Chapter 13 to summarize the philosophical significance of variational principles. Whether or not one is to agree with the authors' views will depend chiefly on one's taste, since no facts can be disputed. But at least we must be grateful to them for using the question as a peg on which to hang a concise but thoughtful history of the theory of physical laws.

An Introduction to Astrodynamics. By Robert M. L. Baker, Jr., and Maud W. Makemson. 358 pp. Academic Press Inc., New York, 1960. $7.50. *Reviewed by T. Teichmann, General Atomic Division of General Dynamics Corporation.*

THE increasing number of artificial satellites in orbit and the imminence of manned exploration of space have created a great need for comprehensive expositions of astronautics, particularly regarding the trajectories of space vehicles and their determination. Numerous papers have, of course, been written on various aspects of these topics, but this work is the first to present a reasonably comprehensive account as a systematic application of celestial mechanics. The problems of interest are in one sense simpler than the main problems of celestial mechanics, since the motion of interest is in all cases that of an infinitesimal body; on the other hand, this motion is ipso facto more sensitive to minor perturbations, and may also be subjected to internally generated propulsive forces, designed to

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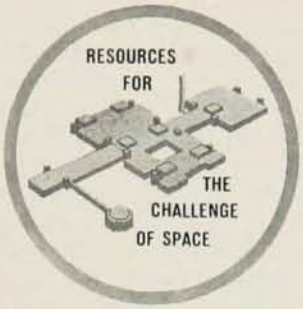

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minimize one or another parameter of the "mission" (i.e., the trajectory and the vehicle). As a result, new and interesting classes of problems present themselves, which justify a distinction from celestial mechanics.

After a discussion of basic astronomical notions, including Kepler's laws, and some fundamental properties of the solar system, particularly of the minor planets and comets, the major portion of the book is devoted to orbit determination, both from the analytical and observational points of view, including a thorough discussion of perturbative forces and their effects. The analytical and computational treatment is unusually complete, but would have made easier reading if the geometric aspects had been brought out more strongly. The book concludes with a description of interplanetary orbits, including a very illuminating treatment of the "re-entry corridor". The appendices include comprehensive glossaries of terms and symbols, a bibliography of 175 items, and two sets of interesting and relevant problems.

The approach of the authors seems strongly influenced by that of the observational astronomers. For many practical applications (including actual orbit determination and computation) this is probably most appropriate, since it enables the solution of something more than textbook problems. On the other hand, it does lead in a number of instances to apparent complications, at least from the notational point of view, which a reader trained in another discipline may find distasteful and not essential for understanding the basic facts.

This book fills an important gap in the astronautical literature, and can serve as a useful reference even in those areas where the introductory features may be heavy.

Planets, Stars, and Galaxies. An Introduction to Astronomy. By Stuart J. Inglis. 474 pp. John Wiley and Sons, Inc., New York, 1961. $6.75. *Reviewed by Otto Struve, National Radio Astronomy Observatory, Green Bank, West Virginia.*

IN a recent review in *The Observatory* (December, 1960) G. A. Wilkins deplores the almost simultaneous publication of three elementary textbooks on astronomy by three different publishers. Stuart Inglis' new book covers essentially the same material as do the three earlier texts, and it is not unreasonable to extend to it Mr. Wilkins' criticism.

At the same time it is also reasonable to recognize that the demand for descriptive books on astronomy is very great and is rapidly increasing, that new discoveries and theories come at a much faster rate than they did a decade or so ago, and that every teacher has developed his own style of presentation and tends to emphasize certain aspects of astronomy that may not be adequately covered by another author.

Inglis' book is a simple, straightforward, and enjoyable account of descriptive astronomy which should appeal not only to students of the liberal arts in a small college (for whom it was written), but also to a large number of amateurs and other laymen who have no prior knowledge of astronomy and mathematics.

After a brief introduction describing the scope of astronomy, the author treats first the basic tools and methods of astronomers, including optical and radio telescopes, simple spectrographs, and photometric devices. Next follows a chapter devoted to the structure of simple atoms, including a very brief account of the principal nuclear reactions in stellar interiors.

Nearly one-third of the book is devoted to the solar system, including a chapter on its age and origin. The rest of the book is concerned with the stars, including a brief account of spectral classification, HR diagrams, spectroscopic parallaxes, and the mass-luminosity relation. The problem of stellar evolution is discussed in a separate chapter, and this is followed by an account of different types of multiple stars. The closing chapters are concerned with interstellar diffuse gas and dust, the structure of the Milky Way, and the physical properties of extraneous galaxies. The book ends with seven pages of questions, several of star charts, and an index of subjects and a few names.

Each chapter concludes with a "basic vocabulary for subsequent reading" and a list of references "for further reading". The fact that most of the latter are for articles that have appeared in the *Scientific American* serves to highlight the excellent quality of this famous popular monthly magazine.

The dust cover of the book contains a large, folded map of the moon, with identifications of many prominent lunar formations. It is regrettable that the publishers have found enough space on the outside of the jacket for the usual, rather meaningless, advertising claims, such as the following: "The exposition is not broken up into unrelated sections and subsections; rather, it proceeds logically from paragraph to paragraph, and from chapter to chapter, so that the discussion of each new topic represents a coherent development of the preceding material." As a matter of fact, the chapters are broken up into sections—as they normally should be in a textbook (Chapter 11 has twelve sections). If it is so difficult for the blurb writers to describe their products in more interesting terms, would it not be better to omit altogether such sentences as the following: ". . . presenting astronomy for the space-age reader," and let the prospective buyer make up his own mind from the list of contents and the preface by the author? Yet this book contains several outstanding features that are not found in other textbooks: for example, the large, folded drawing of the Milky Way by Martin and Tatjana Kesküla (facing page 396), etc.

It is perhaps appropriate to close this review by expressing the hope that either the present publishers, or one of the others, would bring out a more advanced textbook, intermediate in level between the purely elementary books (of which Inglis' is a good example)