Importance The Adjoint Function. By Jeffery Lewins, Pergamon Press (1965). 172 pp. $10.00.

This unusual book is an exposition of the physical basis of variational and perturbation theory in transport and diffusion problems.

During the period just prior to World War II there was a considerable movement of scientists from the faculties of many European universities to American universities. There was a common feature about those men other than that they were fine scientists: They were great teachers. The memory of their typical lecture is of a blackboard with only a few fundamental equations but of an hour of fascinating insights into the physical basis of those equations. This monograph is in the tradition of that kind of a lecture.

The author offers the book "as a contribution to what Weinberg and Wigner have called a scholarly tradition in nuclear engineering" and later he says he "hopes the result, academic as it designedly is, will nonetheless be found useful as a reactor physicist's commentary on the variational principle." In this reviewer's opinion, he succeeds in both purposes and shows that "being in the scholarly tradition" and "being useful" are not mutually exclusive.

In the Introduction, the author puts variational theory in its historical perspective, pointing out that the variational principle stems from classical mechanics. Its starting point was the problem of the brachistrochrone. Related problems led to a certain metaphysical attitude to variational problems expressed as minimum or maximum principles. "It was felt that God ordered nature in the 'best possible way'." (Presumably up until He invented man who seems bent on disordering it). "Lagrange and Euler, however, removed some of the mysticism from the subject and showed that the essence of a variational integral was that it should be 'stationary' rather than that it should be a maximum or minimum." In classical mechanics, the integrals that are made stationary are called Lagrangians and the author carries the term over to reactor physics.

In Chap. 1 he develops the fundamental form of the variational principle for reactor physics. He introduces the physical picture of a series of detectors distributed throughout the system according to a distribution function $\Psi^+(\boldsymbol{x},t)$, all of which are joined together to provide a single meter reading $\bar{N}$ (the operational characteristic of the system). Then, in general,

$$\bar{N}(t) = \int \Psi^+(\boldsymbol{x},t) N(\boldsymbol{x},t)\, d\boldsymbol{x} \quad ,$$

where $N(\boldsymbol{x},t)$ is the neutron density and $\Psi^+(x,t)$ is the effect on the meter reading of a neutron with coordinates (x,t). A variational principle can be derived such that the condition that it be stationary to errors or variations in N provides an equation for Ψ^+ which is the equation adjoint to that for N.

The author points out that there are many Lagrangians, each of which is associated with a different operational characteristic of the system. He lists 13 in an Appendix.

In Chap. 2 he identifies the concept of "importance," a term introduced into reactor physics by Soodak, with the situation where the differential equation for N is linear. The importance is the Ψ^+ for the linear problem. He denotes it by $N^+(\boldsymbol{x},t)$ and gives it the further physical significance of being the expected or probable contribution of one neutron at $\boldsymbol{x}$ at time t to the meter reading at some final time t_f. "Thus a particle is 'important' to the (future) observable reading."

Also in Chap. 2, he gives a helpful discussion of various quantities like neutron population, effective source, reactivity, generation time, excess multiplication, lifetime, and multiplication constant; and gives formulas for them in terms of the Ψ^+ and N. These quantities and their different definitions by different authors have always been confusing concepts of reactor physics.

In Chap. 3 he derives the adjoint equations for specific models such as diffusion theory, Fermi-age theory, and transport theory.

Chapter 4 returns to the variational method itself and illustrates how the variation principle is used to calculate some desired operational characteristic of the system. The author relates various formulas useful in reactor physics to their original analogous formulas in classical mechanics and other fields. At the end of this chapter he touches briefly on the use of the variational method to reduce many-group models to few-group models. Henry has treated this interesting and useful problem extensively in a recent article in *Nuclear Science and Engineering.*

Chapter 5 is devoted to perturbation theory. This reviewer has found this subject to be particularly useful in computational support to reactor operation, namely at the MTR where we were introduced to the subject by A. M. Weinberg about 1952.

The final chapter is a brief discussion of nonlinear theory. The author points out that this is a fertile field for research and the "need is urgent if improvements in reactor performance throughout core life are to be secured at reasonable cost of computation."

The book has an excellent bibliography, listing 109 references.

It is customary to close with a remark about typographical errors. The book is remarkably free of them, but there is one interesting one on p. 72 which says that ν is the yield of neutrons from "fashion."

Whatever is fashionable is usually nu, but this book is likely to remain in fashion for a long time to come.

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About the Reviewer: J. Wallace Webster is a member of the staff of Oak Ridge National Laboratory with current interests in the cross sections and the calculational methods necessary to the satisfactory calculation of critical assemblies. Mr. Webster has long experience in nuclear energy dating back to the early aircraft propulsion project days, also in Oak Ridge, followed by a stint with Phillips in Idaho, with American Standard and, most recently, a three-year assignment with the IAEA. He did graduate work at Berkeley.