cannot be completely discussed, since current theories of nuclear structure are entirely omitted, as mentioned above. For the same reason, the section on inelastic scattering cannot be considered to be adequate. Moreover, for a text which has as its main point of view the "use of nuclear reactions in order to understand nuclear structure," it is hard to see how reactions involving isobaric analog states can be omitted, since these have done more to accomplish this goal than perhaps any other reactions.

In summary, I believe that the book will not serve as a general textbook for a nuclear theory course, but can serve as a reference text for a course in nuclear reactions. The reader can find some topics in the treatment of nuclear matter and nuclear reactions which are not included in other texts. The survey of the application of nuclear reaction theories will be especially useful to experimentalists.

Professor Leonard S. Kisslinger has been at Case Western Reserve University since receiving his PhD (University of Indiana) in 1956, except for periods spent at the Bohr Institute in Copenhagen, at the Weizmann Institute, and at MIT. He has been a visiting physicist at Brookhaven, Oak Ridge, and Lawrence Radiation Laboratories, and a consultant to Los Alamos Scientific Laboratory. His fields of research include nuclear models and structure, particle physics, and the many-body problem.

SOURCE BOOK FOR PLASTICS TESTING

Title The Properties and Testing of Plastics Materials

Authors A. E. Lever and J. A. Rhys

Edition Third, 1969

Publisher John Wright & Sons, Bristol, England

Pages ix + 445

Price $22.75

Reviewer Albert Lightbody

As stated in the Preface, this book is a source or reference for those who test plastics. As such the book does not list the properties of plastics nor the details of the testing of plastics material. Instead, the new materials now on the market are listed with descriptions that give clues for possible utility.

The extensive use of the second edition and the changes that have occurred since it appeared in 1962 fully justify this third edition. The practical rather than theoretical features of plastics testing are emphasized. The point is consistently made that the performance of a plastic molding depends as much on the design and the molding conditions as on the materials used.

The >4000 references cited draw heavily from testing methods widely accepted in the United Kingdom and the United States. There are references from practically all standards agencies although the list is heavily weighted, as one might expect, by the American Society for Testing Materials Specifications, US Government Reports, and British Standards. A list of the standards organizations throughout the world is given.

The quality of the definition and description of each subject discussed in the text is excellent. These subjects are clearly and succinctly defined with the limitation of the tests clearly stated, and the text is well written.

Some space might have been devoted to the determination of the glass transition temperature of polymers and the importance of this property to the physical behavior of plastics. This subject is covered in many of the references cited but is not mentioned in the text. The authors may have considered this of more interest to the academician than to the engineer.

The comparative results of many of the properties of the materials are tabulated.

The high quality of this work should make this book valuable to all who are interested in the properties and uses of the many types of plastics materials. Its scope is broad enough to be of interest to all engineers, and especially those responsible for evaluating materials.

Albert Lightbody, Chief of the Chemistry Research Department of the US Naval Ordnance Laboratory (NOL), White Oak, Silver Spring, Md., has been interested in plastics research and engineering since 1943. A past director of the Society of Plastics Engineers and now the Secretary of the Plastics Institute of America, he was instrumental in developing a specimen, known throughout the industry as the NOL ring, for testing of filament-wound composites. His PhD (physical chemistry) was earned from the University of Nebraska in 1933.

ELIMINATING AN ASTERISK

Title Project Icarus

Editor Louis A. Kleiman

Publisher The MIT Press, 1969

Pages xiv + 115

Price $6.95

Reviewer Francis J. Jankowski

For several years MIT has been teaching Systems Engineering to graduate interdisciplinary classes. The success of this approach is evident in the enthusiasm of the students and faculty, in the adopting of this approach at other universities, and in the several successful solutions to large-scale problems attained by these classes.

Part of the pedagogical process has been the requiring of each class to prepare a final report and present it orally to a group of faculty, industry, and government people. This book is the final report of one class.

The problem presented to this class was a hypothetical one. Icarus is an asteroid having an elliptic orbit that intersects that of the earth. In June, 1968, it came within 4 000 000 miles of the earth—a near miss on the astronomical scale. This project postulated that Icarus and the earth, in the spring of 1967, were on collision courses, with but 70 weeks in which to design and effect a remedy. This book reports this design effort.

In this rapidly evolving field of Systems Engineering, such a text would be potentially valuable to engineering faculty, systems and project engineers, and engineers in a specialty related to the project reported.

However, this text is of limited value in all three areas, for reasons discussed below.

The book does present a believable solution to a hypothetical problem and accomplishes this within present technology. It is of value in the following ways:

1) As an engineering case study, for university classes in Project Engineering, Design Engineering, and Systems Engineering.

2) As a report on the results of a project engineering effort that can be studied for ideas useful to other projects. (To a large extent this need is satisfied by the distribution of the original report and summary articles in journals.)

3) As a book for non-scientists having a strong interest in technology, particularly high school students. To this audience this book gives a dramatic picture of the capabilities of today's technology.

Although advertised by the MIT Press as "semi-fiction," this book lacks the personal involvement, the drama of decision making, the excitement of initial uncertainty, and the anticipation of final success that are present in novels and science fiction.

As a student report this book is excellent. It is concise and amazingly complete in its coverage of a large project in 115 pp. It deals with such diverse topics as space trajectories, launch systems, space vehicle design, communications and control, interaction of the nuclear explosive with the asteroid, scheduling and resources required, probability of success, and the design, instrumentation, launching, and operation of a monitoring satellite. This is all done realistically and logically under the restraint of a fixed time schedule.

Many of the analyses are approximate, for the small class and its limited resources precluded more complete analyses. These cases are acknowledged, and their presence add to the interest and value of the report. One example is the analysis of the velocity profile of debris from a crater produced by the nuclear explosive, from which the velocity increment imparted to the asteroid is estimated. Another is the analysis of the plasma formed as a result of the absorption of x rays from the nuclear device, a topic not encountered in many publications.

Although only a student report, the book compares favorably to publications of experienced engineers except for obvious shortcomings that reflect more on the reporting than on the work. The subject coverage is uneven. For example, guidance and control are covered relatively thoroughly, while design of the nuclear device and the thermal control of the space craft are treated very lightly. Another type of uneveness involves numerous instances in which questions that occurred to this reader were answered several pages later.

A weakness, possibly a result of being concise, is the presentation of decisions with inadequate proof or justification and the complete omission of some points. Typical are conclusions that a soft landing on Icarus is not feasible, that only a transverse velocity increment will cause the asteroid to miss the earth, and that only a single design effort of the space vehicle could be considered and the omission of any comment as to whether the impulse resulting from plasma formation is significant. Glaring is the failure to mention political and international considerations. In a realistic situation, other nations would certainly be concerned about the danger and would be capable of contributing to the solution, and the absence of cooperation and exchange of information could negate some of the efforts.

Most nuclear engineers are likely to be disappointed in the fact that there are no nuclear analyses, only nuclear effects analyses, in this book. While the advertising states "This book includes studies of all aspects . . . including . . . 'design' of the nuclear warhead," the "design" is covered in three sentences and a figure giving only the estimated outside dimensions and weight for a 100-megaton nuclear device.

The cratering technology used is most elementary and readily available in the literature. This, together with meteorite impact analysis, is used to get the impulse delivered to the asteroid.

Although the analysis of the plasma formation resulting from x-ray absorption is interesting, there is no analysis of the impulse due to this plasma formation (the energy input is appreciable). Lacking also is any correlation between the shock produced by the plasma formation and the cratering data.

While the chosen approach (that of utilizing existing hardware to the fullest extent) was the best, the resulting report does not provide aerospace engineers with much in the way of original ideas, although it may suggest taking a closer look at adapting existing equipment to present problems.

To evaluate this book as a text useful in Systems Engineering, we note that Systems Engineering falls into two overlapping categories:

1) The activity that brings the efforts of engineers of several disciplines to bear on a large-scale social problem. In this concept, the inputs, constraints, resources, and objectives are enumerated, alternative solutions are evaluated, and a detailed solution is made with emphasis on the evaluation of "trade-offs." This definition is closely akin to Project Engineering, and many engineers would insist that Systems Engineering is nothing but *good* engineering practice.

2) The discipline that utilizes the techniques of optimization, feedback and control, systems dynamics, computer technology, numerical analysis, linear programming, and human factors engineering combined with good basic engineering practice, economics, politics, and cultural factors, to obtain an optimum solution to a large-scale problem.

The MIT approach is obviously that given in definition (1). This is clear from the fact that they have a course, not a program; their students retain their original discipline identity and are not called "system engineers"; the emphasis is on interdisciplinary effort, compromise, etc., as a means of completing a project.

Project Icarus is not the best to illustrate the systems approach. The magnitude of the problem and the fixed, short, time schedule demand the largest of the operational space hardware and the largest operational nuclear explosives. In much of the project there is little opportunity for compromise or trade-offs. Alternate approaches are sometimes enumerated, but the choice is usually so limited or obvious that analysis and evaluation are not necessary. The book gives the impression that the design proceeded in a series of steps, with negligible interaction except with the previous step, the emphasis being clearly on the decisions and results, not on the path to the results.

However, in a tight time schedule, as in this project, parallel efforts are necessary, which often produce pressures for decisions and tradeoffs between various efforts. These undoubtedly occurred in the class but do not appear in the report.

In describing an immense project in 115 pp., this book does not go into sufficient detail or depth to aid in teaching any of the fields touched upon. A text on Systems Engineering based on the MIT experience could be quite useful, but it should cover items such as:

1) The mechanics of teaching a Systems Engineering course. The Preface to this book lists 21 students and 8 faculty. How much time do the students devote to the course? How much faculty effort is required? What are the room space requirements? What are the costs for lecturers, report preparation and distribution, secretarial services, etc.?

2) Information on class organization, student leadership, methods of interacting, etc.

3) Utilization of time. How much of the 15 weeks is spent in assembling information, preliminary design, evaluation, and final design? Are these times the same for each of the student groups?

4) Problem areas, such as late decisions, absence of decisions, meeting of deadlines, lack of data, quality of leadership, etc.

5) The interactions between phases of the work during design.

6) Any special optimizing or scheduling techniques, used in the design phase.

Such points are absent from the book, for it was not prepared as an expository of the MIT method of teaching Systems Engineering. A professor using this book in teaching, either for developing an approach or for the subject matter, would have to be well versed in his field to pick out and use the pertinent points. If he is this knowledgeable initially, the book becomes a case study and of lesser value in teaching the basic subject.

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CAUTION—TRITIUM AT WORK

Title Biological Effects of Transmutation and Decay of Incorporated Radioisotopes

Publisher International Atomic Energy Agency, Vienna, 1968

Pages 244

Price $5.00

Reviewer Bernard Strauss

A radioisotope incorporated by an organism may produce damage either as a result of the radiation emitted or as a result of the transmutation which is a concomitant of the decay event. In a certain proportion of decay events, the transmuted atom is ejected from the molecule in which it occurs, or, if the recoil energy is insufficient, the atom remains in place leaving a molecule with changed structure. For example, in the $^{32}P \rightarrow {}^{32}S$ transmutation the newly formed S atom may be forcibly ejected from the molecule in which its parent phosphorus occurred. Even if the newly formed S remains in place, the molecule may disintegrate due to the instability of the chemical binding in which S replaces P. Transmutation-induced damage is greatest when atoms involved in bivalent linkages decay; destruction of a phosphorus atom in a nucleic acid chain results in chain breakage. On the other hand, the transmutation from ^{3}H to ^{3}He produces only minor structural damage but leaves a positively charged molecule.

The decay of incorporated isotopes can also result in radiation damage. If an isotope emits an energetic beta particle, such radiation damage will occur at some distance from the site of the decay. However, the energy from a weak beta particle is absorbed close to the site of the radioactive decay. As pointed out in this volume by Oliver, the maximum dose rate for tritium decay occurs within a sphere of 6 μm radius which is comparable to the size of the mammalian cell nucleus. The site at which tritium decay occurs is therefore important.

There are then two possible sources of damage due to an incorporated radioisotope, radiation and transmutation. The problem is whether these can be distinguished, i.e., whether a biological effect accompanying radioactive decay is due to the radiation accompanying disintegration or to the transmutation that occurs at each decay event.

This volume is the report of a panel called to discuss these questions and held in Vienna, October 9-13, 1967 under the auspices of the International Atomic Energy Agency. The foreword to the volume defines the aim of the discussions: To investigate the modes and mechanisms of action associated with transmutation and radiation decay events; to achieve a clearer picture of the present status of such studies; and to "go some way towards defining the hazards of using labelled compounds in human beings and standards for setting body-burden levels."

Fourteen contributions are published along with the discussion that follows each paper. These include discussions on the effects of incorporated ^{32}P, ^{3}H, and ^{14}C in bacteria and bacteriophage by Apelgot, Drobnik, Koch, and Person, in yeast by Moustacchi, in *Drosophila* by Kieft, Oftedal, and Kaplan, in mammalian cells by Cleaver and Oliver, and in chick embryos labeled with ^{32}P by Szabo and his collaborators. The volume contains a short general review by Feinendegan and concludes with three papers on radiation chemistry by Adams, Kacena, and Getoff. There is a final section of general conclusions.

These conclusions should be briefly summarized since they are the major result of the meeting: the lethal effect of tritium decay is due