

The role of Physics in Engineering Education

By R. J. Seeger*

SINCE THE ORGANIZATION of the American Society for Engineering Education in 1893, there have been many studies of engineering curricula, such as the Mann Report (Carnegie Bulletin No. 11), the Wickenden Report of 1923 (said to be "monumental"), the "Aims and Scope of Engineering Curricula" (1940), "Engineering Education after the War" (1944), and Jackson's "Present Status and Trends of Engineering Education in the United States" (1939, essentially a "supplement to the Wickenden Report").

The present ASEE Committee on Evaluation of Engineering Education proposed thirty-four searching questions at its Chicago meeting in September 1952, and suggested these as items for discussion by Institutional Committees. A group of these questions dealt with the curricular content and its relation to the objectives of engineering education. Among the fifty-three reports submitted by Institutional Committees, there is general agreement that research in physics has been constantly expanding the available knowledge in this field and that any current revision of engineering curricula must of necessity involve consideration of the inclusion of this new material into the already overcrowded physics courses. Some provocative excerpts from these reports are cited below with respect to physics.

"The injection of recent scientific advances in undergraduate curricula will prompt thinking along the lines of a five-year program."

"Additional mathematics and physics fundamental to particular departments must be added in the time available."

New material must "be crowded into the present curriculum by reducing empiricism, by a more fundamental presentation of subject matter, and by integrated study of various fields."

"Nuclear physics, some aspects of biochemistry, statistics, topology, and nomography will be translated into engineering practice within 25 years. The fundamentals could conceivably be substituted for other topics now taught."

"Atomic and nuclear physics should include the structure of the nucleus, radiation and its detection, nuclear fission and power, mass spectroscopy, wave motion, low temperature, high vacuum effects and ultrasonic spectroscopy."

"Sophomore physics should be modified by de-emphasizing mechanics, electricity, and heat, and substituting modern physics in place of these."

"A vote of one engineering faculty showed 62% favoring the introduction of nuclear physics in the present undergraduate curricula."

"Duplication of course content can be minimized by de-emphasizing such topics as mechanics, electricity, and heat in physics."

"Sophomore physics should be altered by eliminating mechanics, heat, and electricity and increasing the time for light, sound, and nuclear physics."

"Many engineering service courses are designed for students majoring in a particular field by instructors with no interest in or knowledge of the student's background."

"About 60% of one faculty voted in favor of requiring thermodynamics, heat transfer, electrical circuits and fields, electronics, differential equations, and nuclear physics for all engineers."

One local committee proposes "that all of sophomore physics be deleted and taught as separate subjects in the engineering science division. These would include mechanics, thermodynamics, electricity, light, and sound."

AT THE GAINESVILLE MEETING of the Main Committee in June 1953, two subcommittees were appointed to consider certain questions involving curricula. Excerpts from tentative drafts of their reports are given below with reference to physics.

"Much fundamental research in what is now called the engineering science was then being conducted by physicists. Since 1940 nearly all research physicists have had their interests reoriented toward nuclear problems and it seems doubtful that this interest will be adequately returned to the fields of vibrations, elasticity, plasticity, heat transfer, engineering thermodynamics, fluid flow, electronics, and the other background sciences of engineering. Hence engineers have become responsible for the continued research in all the fields of engineering science." "The first four years of the undergraduate program can hardly be identical any longer for these two types of engineering education which in this report will be called professional-general and professional-scientific." One engineer has defined engineering science as those portions of physics, chemistry, and mathematics that are no longer of interest to research physicists, chemists, and mathematicians. "The very nature of the full background is such as to call for graduate studies in the engineering sciences."

Under the curricular content recommended for professional-scientific accreditation one finds: "Physics—including an introduction to modern and nuclear physics and including that of the solid state, but excluding mechanics, electricity and heat from the elementary course if this material is adequately covered elsewhere."

Under the curricular content for professional-general accreditation one finds: "Physics—general physics and such topics of modern physics as may be appropriate

* National Science Foundation.

to the curriculum, but excluding mechanics, electricity and heat if these are covered adequately elsewhere." "Past experience would lead us to predict with reasonable assurance that the new developments in atomic, nuclear, and solid state physics . . . will become the center of rapidly developing areas of engineering practice in the years ahead."

"Physics as taught for engineers has undergone only minor changes during the past generation in which many revolutionary new concepts have been developed that are influencing engineering practice. Modern physics, including nuclear and solid state physics, should be included in undergraduate curricula. It is felt that duplication between physics and statics, dynamics, thermodynamics, and electricity should be reduced or eliminated to provide time for basic study of modern physics. The study of acoustics and optics is considered desirable rather than essential so that its consumption of time should be small."

"There is the possibility of increasing the efficiency of instruction or of eliminating some of the existing course content. Several of the Institutional Committees have discussed the excessive duplication existing between both the material covered in mathematics, physics, and mechanics, and between the material covered in these basic courses and that covered in advanced engineering courses. It is not uncommon to hear remarks regarding the inability of students to learn fundamentals of electricity in physics, and of their having to start all over again in electrical engineering. Similar remarks involve mechanics and mathematics, and college mathematics and high school mathematics. There is doubtless some truth in these statements but many times the problem is deeper and frequently is a result of lack of coordination and exchange of information among departments."

"Perhaps a more serious loss in efficiency of instruction occurs because of the lack of motivation of students in the basic courses. This lack of motivation is recognized both by mathematics, physics, and chemistry teachers, and by the engineering staff. It might be possible to improve this situation by inaugurating a single consolidated series of courses comprising the basic material in mathematics, physics, chemistry, mechanics, and thermodynamics in the first five or six semesters. It would be taught in the engineering college to provide real motivation to the assignment of strong engineering applications. Accompanying laboratory work should consist of engineering experiments and not classical experiments in physics and chemistry. Such a series of courses should develop leadership and initiative in the students. Engineering reports, including drawings, should be prepared, and nomographic charts, elementary statistical analyses and basic measurements and measuring instruments should be studied and utilized. Since such a set of courses should require considerably less time than the conventional arrangement, it would be possible to offer advanced courses in modern physics, chemistry, and mathematics in the last year of the curriculum. These courses would be taught by the staff members in the special fields. The material would

then be presented to more mature students better able to appreciate the presentation by specialists in these respective fields."

"It must be emphasized again that each school should find its own solution to the problem of increased demands. The Committee feels that the added requirements can be met within the present time framework simply by increasing the efficiency of instruction and of curriculum organization. Successful professional engineers in the industrial field depend upon increased efficiency for success, and a professional engineer in education should be no exception."

AT ITS BATON ROUGE MEETING in February 1953, the ASEE Committee on the Evaluation of Engineering Education appointed a Physics Subcommittee consisting of E. Weber (electrical engineering, Brooklyn Polytechnic Institute), chairman; A. P. Colburn (chemical engineering, University of Delaware); and R. J. Seeger (physics, National Science Foundation). This Subcommittee's report was adopted by the Main Committee in Gainesville in June 1953. It recommended that certain questions be referred to the ASEE Physics Division and certain other questions to the AAPT. In the ASEE Physics Division, the matter was referred to its Executive Committee consisting of R. J. Seeger, chairman (National Science Foundation), C. E. Bennett (University of Maine), G. P. Brewington (Lawrence Institute of Technology), G. Burnham (Norwich University), J. R. Dunning (Columbia University), E. Hutchisson (Case Institute of Technology), D. Loughridge (Northwestern University), and J. G. Potter (A & M College of Texas). In the AAPT, the matter was referred to its Committee on Engineering Education: J. H. Keenan, chairman (MIT), C. E. Bennett (University of Maine), O. W. Eshbach (Northwestern University), W. C. Kelly (University of Pittsburgh), and J. G. Potter (A & M College of Texas). These committees met jointly with the Physics Subcommittee of the Main Committee and A. Bronwell, secretary of ASEE, at the American Institute of Physics in October 1953.

These committees recommended unanimously that no action be taken by the ASEE until there has been more widespread discussion of the problem among physicists and engineers. In order to insure more widespread knowledge, they recommended that an article be written for *Physics Today* to give physicists immediately some advance information about the problems at hand. Finally, these committees recommended early institutional discussions and national symposia, as well as curricula conferences by small groups representing various points of view.

It is evident that engineers and physicists must both answer the questions: What contributions *can* physicists make to engineering education? What contributions *should* physicists make to engineering education? In short, what is the role of physics in engineering education?