EXPERIMENTAL PHYSICS

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for science for its own sake. These may be regarded as two essential qualifications for one proposing to elect this Course.

The mathematical and theoretical aspects of the Course are described elsewhere. I desire to point out here the salient features of the laboratory side of the instruction. Course VIII offers to a greater extent than any other Course at the Institute the opportunity to become familiar as an undergraduate with the fundamental and exact methods of scientific research. This has been recognized from the beginning as an essential feature of a Course, which aims to provide a thorough foundation for further graduate study, as preparation for the career of an investigator or teacher in a higher institution of learning. To provide this training the curriculum is so planned that, parallel with the development of theoretical physics which extends continuously throughout the third and fourth year, the student is given the opportunity to carry on a large amount of correlated laboratory work culminating in his thesis. As preparation for this work he takes the Course in General Physical Measurements in the sophomore and the first part of the junior year, which is common to all Courses in science and engineering. This Course, accompanied by that of Precision of Measurements, is planned primarily to train the student at the very outset of his work in the proper method of approaching a piece of experimental investigation, whether it be purely scientific or technical, special emphasis being laid upon economy of time and labor both in performing the work and computing results. Experience gained from this training is fundamental and applicable to all experimental work quite independent of its exact nature. It is of far greater permanent value than familiarity with any particular process or method or even skill in manipulation, important as this unquestionably is. It may be of interest to note that the subject of Precision of Measurements in a more extended and specialized form was originally developed by Professor Holman for the fourth-year students in Courses VI and VIII. In recent years, however, the elements of the subject have been incorporated into nearly all the Institute Courses at the very outset of the laboratory work, to the great advantage to the latter.

For the student in Physics, the Laboratory Course in General Physics and in Heat, is followed by more advanced work in the special laboratories devoted to electrical, heat, and optical measurements, with the option of electing, if he so desires, additional advanced work, including exact physico-chemical measurements. In the advanced work the student is thrown more and more upon his own resources, specific directions giving place to references to standard treatises in English, French, and German. The experiments assume more the nature of short researches, which are to be approached, discussed and reported upon in the manner of short theses. This is particularly the case with the work in advanced physical measurements, optical laboratory, and the laboratory of chemical physics. The Rogers Laboratory may well be proud of its equipment of apparatus which is available for this instruction. Additions are certainly being made and the equipment kept abreast of the times. Although the location of the Institute precludes the possibility of certain kinds of research requiring great steadiness, the expedients which have to be adopted to overcome the effects of mechanical and magnetic disturbances, form a valuable training for the student.

During the first term of the fourth year each student, with the advice of his instructors, chooses his thesis, a particularly important matter in Course VIII, as much time in the fourth year is alloted to this work. Whenever the student has sufficient judgment to choose a suitable subject for investigation, he is encouraged to make his own selection. In this, however, his ambition frequently overleaps the mark, and problems, such, for example as the determination of the mean density of the earth, which the most skilled physicist might well hesitate to undertake, are not infrequently suggested. On the other hand, there are many interesting short researches which may be undertaken with a reasonable degree of hope of completion in the time available for thesis work. The result has been the publication of a number of undergraduate theses, which have been real contributions to science. It is not too much to say that some of these have been of a quality equal to those accepted at some institutions for higher degrees. As a preliminary step toward beginning work on his research, each student is expected to make an exhaustive study of the literature pertaining to his proposed work, this constituting a part of his work in the colloquium. He realizes here, if he has not already done so, the importance of a good reading knowledge of French and German, an indispensable accomplishment for a man of science. Students would do well to appreciate this early in their course, and make a practice of keeping up their modern languages by reading foreign literature or current scientific periodicals throughout the second and third years.

By the manner in which a student attacks and works out his thesis, much may usually be inferred of his power of independent thinking, and his probable success as a subsequent investigator. The thesis is for this reason one of the most important, if not the most important subject which the physicist undertakes in his entire course. In carrying on his investigation he comes into intimate relations with the instructor with whom he is working, and it is here that the advantage of the small number of students electing Course VIII is most evident, since far more individual attention on the part of the instructor is possible than with the great numbers of students taking the Engineering Courses.

A fifth year of graduate work, leading to the Master's degree, has been arranged to meet the needs of students who desire to continue their research work and to take additional studies, and this is highly recommended to those who feel that they can afford the time. For those who intend to become investigators, or teachers in universities or technical schools, it is almost essential at the present time that sooner or later they make their Doctor's degree. To obtain breadth of view and to increase his acquaintance with other men in the profession, the writer believes it is desirable that a student of Physics take his Doctor's degree at a different institution from that at which he has pursued his undergraduate work. For this reason the department recommends, and in a number of instances the Institute has sent, as Fellows, graduates of Course VIII, to make their Doctor's degree either abroad or with some eminent physicist at another American university. The question of the relative merits of these two courses is a broad one, on which much might be said, and on which there is probably a difference of opinion. All things considered, it is the opinion of the writer that for most American students two or three years of graduate study abroad, with the advantages which a residence in Europe offers, affords a more valuable preparation for a successful career in science than the same period of study spent at an American university.

In closing these remarks on some of the leading features of Course VIII, it may not be inappropriate to say, that at no time has the demand for scientifically trained men been so great as at present. The various Government bureaus, the Carnegie Institution, the research laboratories being established in connection with great industrial concerns and the rapidly growing western universities, all need men with the kind of education given in the Course in Physics. The demand for our men in the last few years has been far in excess of the supply. It is, of course, not necessary to reiterate that the pecuniary rewards of the teacher or scientist are never likely to be large. He must look for his chief compensations in the pleasure of his vocation, the companionship of associates of congenial tastes, the leisure for study, investigation and travel afforded by long vacations and the recognized place in the community and in society which the broad man of science is certain to attain.