value for the plan, such as History 313 (Renaissance and Reformation), Religion 303 (Christian Thought to the Reformation), Religion 203 (Problems of Religious Thought); and (c) two courses in the wider field of the plan. The thesis will be on a topic within the plan.

(b) Students who wish to combine philosophy and religion equally and who have had one introductory course in each subject (in religion, preferably 104) may take approximately half of their departmental courses in each of the two fields and the following senior comprehensive examinations:

1. History of Philosophy.
2. History of Christian thought.
3. Ethics, philosophical and religious.
4. Special subject (one of the following):
   (a) Philosophy of Art.
   (b) Philosophy of Science.
   (c) Logic and theory of knowledge.
   (d) Metaphysics.
   (e) Social philosophy and theory of value.
   (f) Philosophy of religion.
   (g) Comparative religion.

Plan V. Philosophy and American Civilization

General Supervisor: *Dr.* Smith

Junior Year: in each term two departmental courses (of which one may be 312) and one cognate course, bearing on the general subject of the plan.

Senior Year: (a) two courses in the department; (b) two courses either in the department or in another department but having a definite philosophical value for the plan, such as English 310 (American Literature), History 401 (American Democracy), Politics 301 (Constitutional Interpretation); and (c) two courses in the wider field of the plan, one or both of which will be the Conference (see Program of Study in American Civilization, p. 239). The thesis will be on a topic within the plan.

DEPARTMENT OF PHYSICS

Professors: W. Bleakney, R. Ladenburg, H. P. Robertson, A. G. Shenstone, H. D. Smyth (Chairman), E. P. Wigner†.

Associate Professors: E. M. Rogers, J. A. Wheeler, M. G. White.

Assistant Professors: D. Bancroft, E. C. Campbell, R. H. Dicke, H. Fulbright, D. R. Hamilton, D. J. Montgomery, G. T. Reynolds, R. Sherr, J. E. Walter.

Research Associate: C. C. Van Voorhis.

Visiting Lecturer: V. Bargmann.

Instructors: H. H. Hubbell, L. Lewis, L. L. Rauch, R. Schlegel, Jr., E. P. Tomlinson, J. R. Winckler.

As many of the courses listed below as may seem necessary will be given each term. Courses normally open to underclassmen are numbered from 101 to 299. Those bearing two-hundred numbers are in general of a more advanced character than those bearing one-hundred numbers. Courses numbered from 301 to 499 are intended primarily for upperclassmen.

101, 102. *Introductory Physics*

Mechanics, Properties of Matter, Heat, Light, Sound, Electricity, Magnetism and newer phenomena. This course is designed for those desiring a general course in physics. Two lectures with experimental demonstrations, two classes, and one three-hour laboratory per week. *Dr.* Schlegel.

103, 104. *Matter and Electricity*

A course in general physics with emphasis on the interpretation of the phenomena in terms of atoms, electrons, nuclei, etc. This interpretation relates apparently unconnected topics. Subjects discussed include atoms and molecules; mechanics; kinetic theory of matter; electric charges and currents; magnetism; electrons, positive rays and isotopes; natural and artificial radioactivity; induced currents; mechanical and electrical oscillations; light and other electromagnetic waves. This course is open to those men who have had an adequate school preparation in physics and who have presented four units of mathematics at entrance, or who have taken or are taking a course in mathematics in college. Two lectures with experimental demonstrations, two classes, and one three-hour laboratory per week.

105, 106. *General Physics*

Lectures with experimental demonstrations and classes. The topics of 101, 102 and 103, 104 will be treated in a more advanced manner. This course is offered

† Absent on leave, First Term, 1946-1947.

to a small group of students selected from those electing 101-2 and 103-4 who have shown marked scientific ability in their school work or otherwise. Laboratory work of a more advanced nature than is usual in freshman courses will be offered. This work will fill the requirement for entrance to an approved medical school.

201. *Introduction to Electricity and Magnetism*

Electrostatics and magnetostatics. Magnetic effects of steady currents. D-C circuits and Kirchoff's laws. Electromagnetic induction. Elementary Theory of Direct and Alternating Currents including behavior of L, R, C circuits. Lectures and laboratory. Prerequisite: Physics 101-2, 103-4, or 105-6; differential calculus, integral calculus.

202. *Optics*

Geometrical optics of lens systems. Elementary wave theory applied to Fresnel and Fraunhofer diffraction and interference of light. Resolving power of optical instruments. The use of interferometers in the measurement of optical lengths. The theory of the diffraction grating and its use in spectroscopy. Three lectures and one laboratory. *Professor* SHENSTONE.

301, 302. *Analytical Mechanics*

An introductory course on the statics and dynamics of particles and rigid bodies. Emphasis will be placed on fundamental principles and on the solution of problems. Particular attention will be given to the theory of motion under central forces, including the law of gravitation, and to systems executing small vibrations. Three classes per week. *Professor* REYNOLDS.

303. *Electromagnetic Theory*

Electric and magnetic properties of matter. Electrostatics; Laplace's equation. Displacement current. Maxwell's equations. The wave equation; propagation of plane electromagnetic waves; guided waves. Lectures and laboratory. Prerequisite: Physics, differential and integral calculus; differential equations (may be taken concurrently). *Professor* HAMILTON.

304. *Electromagnetic Theory and Physical Optics*

Maxwell's equations and the propagation of electromagnetic waves, with applications to ultra-high frequency radio waves and light. Reflection, refraction, absorption and dispersion in isotropic media. Metallic absorption and reflection. Propagation in anisotropic media. Production, analysis and interference of polarized waves. Rotary polarization. Lectures and laboratory. Prerequisites: Physics 202 and 303.

305. *Electromagnetic Theory* (primarily for students in Electrical Engineering)

Theory of electrostatics, calculation of capacity. Magnetostatics. Electromagnetic induction, calculation of self and mutual inductances. Properties of moving charges. Maxwell's field equations and electromagnetic waves. Three lectures and one laboratory. *Professor* FULBRIGHT.

401, 402. *Radiation and Matter, Atomic Physics*

Radioactivity. The Rutherford atom. The electron, its charge and mass. Black body radiation and the quantum theory. Application to photoelectric effect. Line spectra. Critical potentials. Molecular structure. Polar and non-polar molecules. Band spectra. The Bohr atom. Particles and waves. Diffraction of X-rays. Diffraction of electrons. X-rays and crystal structure. Modern quantum theory. Dielectric and magnetic properties of matter. The atomic nucleus. Artificial transformation of the nucleus. Many of the important experiments of modern physics will be repeated in the laboratory. Three lectures and one three-hour laboratory per week. *Professor* DICKE.

403, 404. *Thermodynamics, Kinetic Theory and Statistical Mechanics*

Relations of many important properties of bodies independent of any particular theory of the structure of matter. The first and second laws, equations of state, reversibility and irreversibility, entropy, free energy, and applications to physical and chemical systems. The kinetic theory of gases with applications to transport phenomena, such as viscosity, heat conduction and diffusion, collision cross-section and mean free path, size of molecules, and determination of Avogadro's number. The classical statistics of Boltzmann and the Maxwell-Boltzmann energy distribution. Applications to the distribution of velocities and the equation of state of an ideal gas. The laws of equipartition of energy and the specific heats of substances. *Professor* BLEAKNEY.

405, 406. *Introduction to Theoretical Physics*

An introductory course to the mathematical methods of physics, with applications to potential theory, hydrodynamics, and other branches of physics. Three lectures per week. *Professor* ROBERTSON.

419. *Ultra High Frequency Techniques* (Engineering 419)

Timing and control circuits employed in ultra high frequency apparatus. Electromagnetic theory of wave guides, cavities and antennae.

Prerequisites for A.B. students: Physics 303, Electrical Engineering 417.

The Students' Shop

A well-equipped student shop includes lathes, drill-presses, a milling machine, a shaper and other equipment. Informal talks on the use of these machines are given and a mechanic is in charge who instructs graduate students and qualified undergraduates in their use and supervises the making of experimental apparatus by the students themselves.

For graduate courses in Physics, see The Graduate School—Courses of Instruction.

PLAN OF STUDY FOR DEPARTMENTAL STUDENTS

Departmental Representative: *Professor* JOHN A. WHEELER, 214 Fine Hall.

The Department of Physics recognizes that there are two different possible approaches to the study of the subject. In one the experimental aspect is emphasized, in the other the theoretical and mathematical aspect is stressed.

The requirements of the department given below have been made sufficiently flexible so that the student may follow a course of study of either sort, or of an intermediate sort, according to his interest and aptitude.

The prerequisites for admission to departmental work are:

(*a*) A preliminary course in Physics 101, 102; 103, 104; 105, 106 or the equivalent.

(*b*) Mathematics 207, 208 or its equivalent. Students wishing to enter the department who have not taken 207, 208 or its equivalent may do so on condition that they take this course in their junior year.

It is desirable that men doing their upperclass work in Physics should have studied general chemistry, although this is not essential. Further, all students who consider the possibility of advanced work in Physics are strongly advised to begin the study of German at their earliest opportunity. Facility in reading German is indispensable in many fields of science. A reading knowledge of French is also desirable, but can be more readily acquired when needed. The ability to read both of these languages is not required of departmental juniors and seniors, but such ability makes possible a considerable broadening of their study.

In the above statement of prerequisites and recommendations, emphasis has naturally been put on subjects connected with possible upperclass work in the Department of Physics. The department urges, however, that a student should avoid premature concentration in scientific and mathematical studies. He should pay serious attention to the general advice as to choice of courses printed on pp. 113-115, and make the most of his opportunities to explore other fields.

In order to assure a well correlated system of courses for all students in the department and yet allow a maximum of flexibility, the following requirements and rules governing examinations have been drawn up.

A. *Minimum Basic Requirements.* The following topics should be included in the program of all students who study in the Department of Physics:

(*a*) General physics. The material of the first year courses supplemented by independent reading in the history of science, in sound, and in heat.

(*b*) Mathematics through integral calculus and the introduction to differential equations.

(*c*) Mechanics.

(*d*) Electricity.

(*e*) Optics.

(*f*) Atomic physics, including some nuclear physics and elementary quantum theory.

All of this subject matter except (*b*), the mathematics, will appear explicitly on various comprehensive examinations as noted below.

B. *Junior General Examinations.* Regardless of the courses taken in junior year the departmental examinations will consist of:

(1) Two examinations on topics (*a*), (*d*) and (*e*) of the basic list.

(2) One examination on topic (*c*) of the basic list.

C. *Senior Comprehensive Examinations.* The comprehensive examinations of senior year will be as follows:

(1) General physics.
(2) Atomic physics.
(3) One of the following subjects (to be chosen by each student not later than the beginning of the second term):
  (*a*) Advanced electricity and optics
  (*b*) Kinetic theory, thermodynamics and statistical mechanics
  (*c*) Mathematics
  (*d*) A cognate subject (such as physical chemistry, astrophysics, geophysics, etc.)
(4) An oral examination on the subject of the thesis and a related subject chosen in consultation with the Departmental Representative.

D. *Program of Courses.*

I. Junior year.

A student may enter the department without having had Physics 201, 202. If so he is advised to take it in junior year and it will be counted as a departmental course. Furthermore it should prepare him to meet requirements (*d*) and (*e*) of the minimum basic list. To prepare for requirement (*c*) of the basic list he is advised to take 301, 302 (Mechanics). If he has taken 201, 202 before entering the department he may take any upperclass departmental course for which he is prepared or a recognized cognate course as his second departmental course.

II. Senior year.

Once the student enters senior year there remains only one of the basic requirements to be met, namely, atomic physics. Usually he will prefer to prepare for his examination in this subject by taking 401, 402 although he may prefer to cover the subject in his own reading. The required two departmental courses may be chosen from any of the upperclass physics courses or cognate courses. The choice is obviously sufficiently broad so that a student may emphasize the theoretical or experimental side as he desires.

E. *Independent Work.*

I. Junior year.

The independent work will consist of reading in the history of physics, in sound and in heat, and of the writing of several papers on topics in those subjects.

II. Senior year.

Each senior will write a thesis which may be based on his own experimental work if he so elects. In addition to this he will do extensive reading in a related subject to be chosen in consultation with his adviser.