

28:248 *Sociology of Sports* 2 or 3 s.h.

Role and meaning of organized sports and individual sport participation in primitive and in contemporary cultures around the world.

28:249 *Seminar: Improvement of Instruction in Elementary School Physical Education* 2 s.h.

28:250 *Seminar: Current Developments in Physical Education* 2 s.h.

28:252 *Individual Differences in Activity Classes* 2 s.h.

Modification of the activity curriculum to accommodate atypical students. Includes discussion on fear cases in swimming, methods of teaching for the low-motor individual and the physically disabled.

28:256 *Professional Writing* 3 s.h.  
Critical review of physical education and related writing of all types. Individual projects on writing for publication or presentation at professional meetings.

28:260 *High School Physical Education Program* 3 s.h.

Curriculum design for the high school girl.

28:301 *Seminar in Research* 2 or 4 s.h.  
For Ph.D. candidates.

28:305 *Advanced Kinesiology* 2 s.h.  
Advanced study of muscle action and laboratory techniques for analysis of muscular action and motor performance. Prerequisites, anatomy, kinesiology, college physics.

28:310 *Neuromuscular Bases of Motor Function* 3 s.h.

Research in perception and kinesthesia involved in motor learning and skilled performance.

28:311 *Seminar: Gross Motor Learning* 2 s.h.

28:401 *Thesis* cr.arr.  
Prerequisite, consent of instructor.

PHYSICAL THERAPY

(See *Interdisciplinary Programs and General Science*)

PHYSICS AND ASTRONOMY

Head of Department, James A. Van Allen  
Office, 203 Physics Research Center

Associate Head of Department and  
Undergraduate Adviser, Edward B. Nelson  
Office, 157 Physics Research Center

The Department of Physics and Astronomy provides an opportunity for comprehensive study of all basic aspects of these subjects and for individual scholarly work at an advanced level.

Persons possessing a mastery of physics and astronomy are in demand as teachers in universities and colleges and as research workers in government and industrial laboratories. Those with a good working knowledge of these subjects at the B.A. level find many opportunities in high school teaching and in a variety of administrative and technical pursuits.

Undergraduate Major in Physics

The following courses or their equivalents are required for the Bachelor of Arts degree with a major in physics:

22M:25, 26, 27, 28 Calculus I, II, III and Introduction to Linear Algebra 16 s.h.

or  
22M:35, 36, 37, 38 Engineering Mathematics I, II, III, IV 16 s.h.

PHYSICS AND ASTRONOMY

29:17, 18, 19 29:118	Introductory Physics I, II, III Kinetic Theory and Thermodynamics	12 s.h. 3 s.h.
29:129, 130 29:132 29:191	Electricity and Magnetism Intermediate Laboratory Atomic Physics	6 s.h. 6 s.h. 3 s.h.
22M:130, 131	Elementary Theoretical Mechanics	6 s.h.
4:5, 4:6	Principles of Chemistry and Elementary Chemistry Laboratory	5 s.h.
or 4:8, 4:9	General Chemistry II and General Chemistry Laboratory	5 s.h.

Undergraduate majors who plan to pursue graduate study in physics are advised to:

1. Take 29:171, 172 Methods of Theoretical Physics;
2. Acquire reading facility in either Russian or German; and
3. Go beyond the minimum requirements listed above to the greatest feasible extent.

Undergraduate Major in Astronomy

Astronomy includes the subdisciplines of astrophysics, classical astronomy, radio astronomy, and space astronomy. A balanced and integrated program of astronomy, physics, and mathematics courses is required for the Bachelor of Arts degree in astronomy. The purpose of this program is to prepare the student for a career or advanced study in astrophysics, radio astronomy, or space astronomy.

The following courses or their equivalents are required for the Bachelor of Arts degree with a major in astronomy.

22M:35, 36, 37, 38	Engineering Mathematics I, II, III, IV	16 s.h.
29:17, 18, 19 29:61, 62 29:119, 120	Introductory Physics I, II, III General Astronomy Introduction to Stellar Astrophysics I, II	12 s.h. 8 s.h. 6 s.h.
29:129, 130 29:132 29:137 29:191	Electricity and Magnetism Intermediate Laboratory Astronomical Laboratory Atomic Physics	6 s.h. 4 s.h. 2 s.h. 3 s.h.
22M:130, 131	Elementary Theoretical Mechanics	6 s.h.

Undergraduate majors in astronomy who plan to pursue graduate study in astrophysics are advised to:

1. Go beyond the minimum requirements listed above to the greatest feasible extent.
2. Take 29:117 Optics  
29:118 Kinetic Theory and Thermodynamics  
29:171, 172 Methods of Theoretical Physics.
3. Acquire reading facility in one or more of the following languages: Russian, German, and French.

Honors Work in Physics or Astronomy

Selected junior and senior majors take 6 to 8 semester hours of 29:99 Honors Thesis and prepare an undergraduate thesis as part of their program for the degree Bachelor of Arts with Honors in Physics or in Astronomy.

For the general requirements of the College of Liberal Arts, see *College of Liberal Arts*.

Graduate Program

Two advanced degrees are offered in physics, the Master of Science (with or without thesis) and the Doctor of Philosophy; and one in astronomy, the Master of Science (with or without thesis). A student who wishes to pursue a program in astronomy beyond the M.S. level may qualify for a Doctor of Philosophy degree in physics with specialization and a dissertation in astronomy or astrophysics.

An interdepartmental program leading to the M.S. and Ph.D. degrees in chemical physics is also available.

## PHYSICS AND ASTRONOMY

Each entering graduate student is assigned to a faculty adviser who will assist him in preparing a plan of study and in guiding his progress. A graduate student becomes a candidate for an advanced degree in physics or astronomy only after he has passed a qualifying examination in all principal areas of the subject at the level of advanced undergraduate work. The examination is given in February of each year and must be taken by all first-year graduate students. Ordinarily, a candidate for an advanced degree should begin research in his chosen specialty during his second year of residency. His thesis or essay adviser then becomes his general adviser and the chairman of his final examination committee.

For the general requirements for admission to the Graduate College and for advanced degrees, see *Graduate College*.

*Master of Science degree in physics.* The M.S. degree is offered with thesis or without thesis. Either degree may be an intermediate step toward a Ph.D. degree, or it may be a terminal degree. The final examination in either case is an oral one conducted by a committee of three members of the Graduate Faculty appointed by the Dean of the Graduate College.

The program for the M.S. degree with thesis requires 30 semester hours of graduate work and a thesis based on an original experimental or theoretical investigation by the candidate. No more than 6 of the minimal 30 semester hours may be for research (29:281).

The program for the M.S. degree without thesis requires 30 semester hours of graduate work, an independent study of the literature on a chosen topic, and the preparation of a critical essay on that topic. No more than 4 of the minimal 30 semester hours may be for the critical essay (29:220). Up to one-third of the graduate program may be in related scientific fields other than physics and mathematics, e.g., chemistry, astronomy, engineering, etc.

The candidate for either of the M.S. degrees must have satisfactorily completed the following courses or their equivalents as an undergraduate or a graduate:

29:117	Optics	3 s.h.
29:118	Kinetic Theory and Thermodynamics	3 s.h.
22M:130, 131	Elementary Theoretical Mechanics	6 s.h.
29:129, 130	Electricity and Magnetism	6 s.h.
29:133	Advanced Laboratory	4 s.h.
29:171, 172	Methods of Theoretical Physics	6 s.h.
29:191	Atomic Physics	3 s.h.
29:192	Nuclear Physics	3 s.h.
29:193	Introductory Solid State Physics	3 s.h.

His plan of study should provide for as much advanced work as his aptitude and previous preparation permit.

*Master of Science degree in astronomy.* The M.S. degree is offered with thesis or without thesis. The requirements for the two degrees are the same as for the corresponding degrees in physics (see above), with the following exceptions:

Delete:  
29:192 Nuclear Physics 3 s.h.  
29:193 Introductory Solid State Physics 3 s.h.

Add:  
29:119, 120 Introduction to Stellar Astrophysics I, II 6 s.h.  
29:121 Solar System Astrophysics 3 s.h.  
29:137 Astronomical Laboratory 2 s.h.

If the student intends to continue for a Ph.D. in physics with an astrophysics specialization he should take the following courses as soon as possible:

29:131	Radio Astronomy	3 s.h.
29:232, 233	Theoretical Astrophysics I and II	6 s.h.
29:234	Stellar Structure and Evolution	4 s.h.
29:235	Special Topics in Planetary and Space Science	2 s.h.
29:263	Seminar: Astrophysics	cr. arr.

An individual plan of study must be worked out by each candidate early in his graduate study.

*Doctor of Philosophy degree in physics.* The program of study for the Ph.D. degree with major in physics includes:

1. Thorough coursework in both classical and modern theoretical physics for all candidates, whether their spec-

ialized research is to be in an experimental or a theoretical area.

2. Comprehensive examinations.

3. Participation in advanced seminars.

4. Original research in experimental physics, theoretical physics, or astrophysics; and the preparation of a written dissertation based on this work.

5. Successful defense of the dissertation in a final oral examination conducted by a committee of five members of the Graduate Faculty appointed by the Dean of the Graduate College.

Emphasis is on the capabilities developed and knowledge gained rather than on the particular courses taken, credits acquired, or other aspects of the means to the end. Although no specific courses are required, the following are recommended as preparation for the comprehensive examinations:

29:191, 192, 193	Atomic Physics, Nuclear Physics, and Introductory Solid State Physics
29:205	Classical Mechanics
29:212	Statistical Mechanics I
29:213, 214	Classical Electrodynamics
29:245, 246	Quantum Mechanics I, II

Advanced mathematics such as the theory of functions of a complex variable and vector and tensor analysis is used freely in these courses. An introduction to these fields is given in 29:171, 172 *Methods of Theoretical Physics*. The selection of less advanced courses will depend on the adequacy of the student's preparation for graduate work; his choice of more advanced and specialized courses will depend on the direction in which his interests develop.

Before a Ph.D. candidate is admitted to the comprehensive examinations, he must demonstrate a reading competence in French, German, or Russian by receiving a grade of 500 or better in the Educational Testing Service foreign language examination or by passing the reading examination administered by the appropriate language department; or by having satisfactorily completed 12 or more semester hours of collegiate coursework (or the equivalent) in any one of the above three foreign languages. Students whose native language is not English will be considered as special cases.

A candidate for the Ph.D. degree will not be recommended for the degree until he has written his dissertation in proper form for formal publication and has submitted it, with the approval of his research adviser, for publication to a standard scientific journal of wide distribution.

### Research

The department has an excellent library and a number of well-equipped laboratories and observatories. An IBM 360/65 digital computer and the associated facilities of the University Computer Center are available for research by students and staff of the department. Several other smaller computers are available within the department. The central machine shop is fully equipped and staffed with skilled instrument makers and machinists, and there are several electronics and machine shops for the use of advanced students and the research staff.

Experimental research is conducted in the fields of nuclear structure physics, ionospheric and space physics, astrophysics, solar and planetary physics, chemical physics, and solid state physics.

Theoretical research is devoted to atomic and nuclear theory, quantum field theory, statistical mechanics, plasma physics, theory of solids, theory of elementary particles, solar terrestrial physics, and astrophysics.

Persons qualified for graduate study are invited to apply for fellowships and assistantships. Inquiries should be directed to the Head of the Department.

### STAFF

Professors: Richard R. Carlson, Fritz Coester, Edward B. Nelson, Edwin Norbeck, James A. Van Allen.

Professors Emeriti: John A. Eldridge,\* E. P. T. Tyndall,\* Charles C. Wylie.\*

Associate Professors: Raymon T. Carpenter, Louis A. Frank, Donald A. Gurnett, William H. Klink,\*\* Georg Knorr, Edward R. McCliment, David C. Montgomery,\*\* John S. Neff, William R. Savage, Margaret A. Waggoner.\*\*

Assistant Professors: John D. Fix, Noah Hershkovitz, Glenn Joyce, Gerald L. Payne, Stanley D. Shawhan, Leonard Schlessinger, John W. Schweitzer.  
 Visiting Associate Professor: Yoshi-hiko Ichikawa.  
 Instructors: Donald C. Enemark, Milo A. Schield.  
 \*Not in residence 1970-71.  
 \*\*On leave of absence 1970-71.

COURSE DESCRIPTIONS

Physics

Prerequisites and corequisites are specified as a guide and may be waived by the instructor.

A student may not repeat for either credit or quality points an elementary course if he has already completed a higher level course for which the elementary course, or its equivalent, is a prerequisite.

Core courses: 29:1, 2 College Physics, 8 semester hours, or 29:17, 18 Introductory Physics I and II, 8 semester hours, or 29:61, 62 General Astronomy, 8 semester hours, satisfy the core requirement in natural science of the College of Liberal Arts (q.v.).

Primarily for Undergraduates

- 29:1 *College Physics* 4 s.h.  
 Open to freshmen. For premedical, pre dental, and pharmacy students and others interested in elementary physics. Descriptive lectures, laboratory, and problem work in mechanics, heat, and sound. Prerequisite or corequisite, Mathematics 22M:2 or equivalent. Both semesters and summer session.
- 29:2 *College Physics* 4 s.h.  
 Continuation of 29:1, which is prerequisite. Electricity, magnetism, light, and modern physics. Both semesters and summer session.
- 29:17 *Introductory Physics I* 4 s.h.  
 Mechanics, heat, and sound. Three lecture-discussion sessions and one laboratory per week. Recommended for majors in physics, astronomy, and other sciences and for honors students. Corequisite, Mathematics 22M:25 or 22M:35.
- 29:18 *Introductory Physics II* 4 s.h.  
 Electricity, magnetism, and light. Continuation of 29:17.
- 29:19 *Introductory Physics III* 4 s.h.  
 Atomic and nuclear physics and relativity. Continuation of 29:18.
- 29:82 *Physics I* 3 s.h.  
 Unifying principles of classical and modern physics. Mechanics, electricity, magnetism, and wave phenomena. Introduction to quantum mechanics. Primarily for junior engineering students.
- 29:83 *Physics II* 3 s.h.  
 Continuation of 29:82. Atomic and nuclear physics. Other applications of fundamental concepts to modern physics. Primarily for senior engineering students.
- 29:93 *Reading in Physics* cr.arr.  
 Consult head of department before registering.
- 29:98 *Undergraduate Seminar* 1 s.h.  
 Reading and discussion on a selected topic in physics or astronomy under guidance of an instructor. The topic and instructor will be announced in advance of each semester. May be repeated.
- 29:99 *Honors Thesis* cr.arr.  
 Supervised original research project, leading to a written report and oral defense. For junior and senior honors candidates majoring in physics or astronomy.

For Undergraduates and Graduates

- 29:103 *Reading in Physics* cr.arr.  
 Consult head of department before registering.

29:113 *Physics of Sound and Music* 3 s.h.  
 Properties of sound waves and their propagation, reflection, and absorption. Production of sound by voice and musical instruments. Musical scales. Mechanical and electronic generation, recording, and reproduction of sound. A descriptive course with no mathematical prerequisites.

29:117 *Optics* 3 s.h.  
 Geometrical and physical optics. Properties of lenses and simple optical instruments; phenomena of propagation, interference, diffraction, and polarization of light. See 29:132 for laboratory work.

29:118 *Kinetic Theory and Thermodynamics* 3 s.h.  
 The kinetic theory of matter. Macroscopic description of thermal phenomena. The fundamental laws of thermodynamics and their application.

29:127 *Electricity and Electrical Measurements* 3 s.h.  
 Electrical circuits, measurements, and electronics. Introduction to electromagnetic fields. Two lectures and one laboratory each week. Prerequisites, 29:2 or 29:18 and Mathematics 22M:26 or 22M:36.

29:128 *Electronics* 3 s.h.  
 Characteristics of vacuum tubes and transistors. Design and study of analog and digital circuits. Two lectures and one laboratory each week. Prerequisite, 29:127 or equivalent.

29:129 *Electricity and Magnetism* 3 s.h.  
 Electrostatics, magnetic fields, electromagnetic induction, and introduction to Maxwell's equations. See 29:132 for laboratory work. Prerequisite, Mathematics 22M:37 or equivalent.

29:130 *Electricity and Magnetism* 3 s.h.  
 Magnetic properties of materials, electromagnetic waves, and applications of Maxwell's equations to wave guides, optics, plasma physics, and other selected topics. Continuation of 29:129, which is prerequisite. See 29:132 for laboratory work.

29:132 *Intermediate Laboratory* 2 s.h.  
 Laboratory work in electricity, magnetism, and electronics; atomic, nuclear, and solid state physics; optics; spectroscopy. One laboratory period each week. May be repeated.

29:133 *Advanced Laboratory* 2 s.h.  
 Laboratory work in optical spectroscopy, solid state, nuclear physics, and cosmic rays. One laboratory period each week. May be repeated.

29:171 *Methods of Theoretical Physics* 3 s.h.  
 Functions of a complex variable, integration methods, linear vector spaces, and matrix algebra. Prerequisite, Mathematics 22M:28 or 22M:38.

29:172 *Methods of Theoretical Physics* 3 s.h.  
 Continuation of 29:171. Hilbert space, special functions, Fourier transform and expansions in orthogonal polynomials, differential equations, and Green's functions.

29:191 *Atomic Physics* 3 s.h.  
 Introductory quantum theory and wave mechanics, atomic and molecular spectra, and atomic structure. Prerequisite, 29:19 and Mathematics 22M:37 or equivalent. See 29:132 for laboratory work.

29:192 *Nuclear Physics* 3 s.h.  
 Nuclear masses, radioactivity, alpha, beta, and gamma ray spectra, nuclear energy levels and nuclear structure, nuclear reactions, the neutron, fission and fusion reactions, passage of radiations through matter, mesons and elementary particles, and experimental techniques. Prerequisite, 29:191 or equivalent. See 29:133 for laboratory work.



PHYSICS AND ASTRONOMY

- 29:193 *Introductory Solid State Physics* 3 s.h.  
Phenomenological and theoretical properties of solids; classification of solids and crystal structures, electronic and vibrational processes in materials; thermal, optical, magnetic, and dielectric properties of solids. Prerequisites, 29:19 and Mathematics 22M:37 or equivalent. See 29:133 for laboratory work.
- 29:194 *Plasma Physics* 3 s.h.  
Physics of ionized gases including orbit theory, guiding center motion, adiabatic invariants; description of plasmas by fluid variables and distribution functions; linearized wave motions and instabilities; magnetohydrodynamics and MHD shock waves. Prerequisites, 29:130 and a knowledge of vector analysis.
- 29:195 *Plasma Physics* 3 s.h.  
Continuation of 29:194. Linear and nonlinear solutions of the Vlasov equation, test charge problems, and the Fokker-Planck equation.

Primarily for Graduates

- 29:205 *Classical Mechanics* 3 s.h.  
Dynamics of mass points; Lagrange's and Hamilton's equations; canonical transformations and Hamilton-Jacobi theory. Prerequisite, Mathematics 22M:130.
- 29:211 *Mechanics of Continua* 3 s.h.  
Hydrostatics, dynamics of ideal fluids, both incompressible and compressible; viscous flow; the classical theory of elasticity. Prerequisites, Mathematics 22M:130, 131, and 29:171, 172 or the equivalent.
- 29:212 *Statistical Mechanics I* 3 s.h.  
The problem of Boltzmann; the H-theorem and general principles of classical statistical mechanics; specific heat theory and nonideal gases; stochastic processes; Einstein-Bose and Fermi-Dirac statistics and applications. Prerequisites, 29:118, Mathematics 22M:130, 131, and 29:171, 172 or the equivalent.
- 29:213 *Classical Electrodynamics* 3 s.h.  
Advanced electro-magnetostatics, boundary value problems, Green's functions, Maxwell's equations, radiation theory, physical optics, and multipole expansion of radiation field. Prerequisites, 29:129, 130, 171, 172, or equivalent.
- 29:214 *Classical Electrodynamics* 3 s.h.  
Special relativity, motion of charges in fields, theories of radiation reaction, and special topics. Prerequisite, 29:213.
- 29:220 *Individual Critical Study* cr.arr.  
An essay is to be written on a topic chosen in consultation with a member of the faculty. For candidates for the M.S. degree without thesis in physics or astronomy.
- 29:245 *Quantum Mechanics I* 3 s.h.  
Nonrelativistic quantum mechanics; Schrödinger wave mechanics, Hilbert space methods; perturbation theory; scattering; spin and angular momentum; identical particles; selected applications; introduction to relativistic theory. Prerequisites, 29:191, 171, 172.
- 29:246 *Quantum Mechanics II* 3 s.h.  
Continuation of 29:245.
- 29:249 *Advanced Nuclear Physics* 3 s.h.  
The phenomena of nuclear physics and their interpretation; static properties of nuclei, nuclear moments, shell model, collective model,  $\gamma$  transitions,  $\beta$  decay, nuclear reaction mechanisms, and other topics. Prerequisites, 29:191, 192, and 245. May be repeated.
- 29:250 *Advanced Nuclear Physics* 3 s.h.  
Continuation of 29:249.
- 29:261 *Seminar: Plasma Physics* cr.arr.  
Discussion of current research.
- 29:262 *Seminar: Solid State Physics* cr.arr.  
Discussion of current research.

- 29:265 *Seminar: Theoretical Physics* cr.arr.  
Discussion of current research.
- 29:266 *Seminar: Space Physics* cr.arr.  
Discussion of current research.
- 29:267 *Seminar: Nuclear Physics* cr.arr.  
Discussion of current research.
- 29:269 *Special Topics in Nuclear Physics* cr.arr.  
Advanced lectures on one or more of the following topics: nuclear models, theory of nuclear reactions, weak interactions, and heavy ion reactions. Prerequisites, 29:249, 250. May be repeated.
- 29:271 *Theoretical Solid State Physics* 3 s.h.  
Central principles of the quantum theory of solids; lattice dynamics, electronic properties, many-body effects, superconductivity, magnetism, and other topics; emphasis on the viewpoint of elementary excitations. Prerequisites, 29:193, 245, 246.
- 29:272 *Theoretical Solid State Physics* 3 s.h.  
Continuation of 29:271. May be repeated.
- 29:273 *Relativity* 3 s.h.  
Relativistic formulation of mechanics and electrodynamics; Einstein's theory of gravitation. May be repeated.
- 29:274 *Statistical Mechanics II* 3 s.h.  
Advanced topics in statistical mechanics. Content may vary from year to year, e.g., foundations of kinetic theory and nonequilibrium statistical mechanics or quantum statistical mechanics. May be repeated.
- 29:276 *Special Topics in Quantum*

*Mechanics* 3 s.h.

Contemporary topics in quantum theory; field theory, dispersion relations, group theoretic analysis of fundamental particle classification schemes, Regge poles, and many-body problems. The topics discussed will vary from year to year. Prerequisites, 29:245, 246. May be repeated.

29:278 *Solar-Terrestrial Physics* 2 s.h.  
Phenomena in the solar atmosphere; corpuscular and electromagnetic radiation in interplanetary space; the geomagnetic field and interplanetary magnetic fields; magnetic storms; aurorae and the geomagnetically trapped radiation. May be repeated.

29:281 *Research in Physics* cr.arr.  
Prerequisite, consent of head of department.

29:290 *Physics and Chemistry of the Upper Atmosphere* 2 s.h.

Physics of neutral and ionized gases; absorption of solar radiation in relation to the ionosphere, the ozone layer, and chemical processes in the ionosphere; electric currents associated with daily magnetic variations and magnetic storms. May be repeated.

29:294 *Advanced Plasma Physics I* 3 s.h.  
Statistical mechanics of plasmas; Liouville equation; BBGKY hierarchy; Fokker-Planck equation and relaxation processes; Balescu-Lenard equation; Vlasov equation and linearized wave motion; shocks, nonlinear plasma motions, and instabilities; fluctuations and radiation processes; magnetohydrodynamics; recent papers. Prerequisites, 29:212, 213 or consent of instructor. May be repeated.

29:295 *Advanced Plasma Physics II* 3 s.h.  
Continuation of 29:294. May be repeated.

Astronomy

See explanatory notes under Physics section.

Primarily for Undergraduates

29:61 *General Astronomy* 4 s.h.  
Open to freshmen. Descriptive lectures and laboratory work in elementary astronomy; study of all components

of the solar system; astronomical techniques. One laboratory per week for observation with the telescope and problem work. Prerequisites, at least one year each of high school algebra and geometry.

29:62 *General Astronomy* 4 s.h.

Continuation of 29:61. Stellar astronomy, motions and physics of the stars, systems of stars, interstellar matter, and galaxies. Prerequisite, same as 29:61.

29:94 *Reading in Astronomy* cr.arr.

Consult head of department before registering.

29:98 *Undergraduate Seminar* 1 s.h.

See *Physics*.

29:99 *Honors Thesis* cr.arr.

See *Physics*.

#### For Undergraduates and Graduates

29:104 *Reading in Astronomy* cr.arr.

Consult head of department before registering.

29:105 *General Astronomy* 4 s.h.

Abridged course offered only in the summer session and on Saturdays during the academic year. Prerequisite, same as 29:61. Primarily for secondary school and high school teachers of science.

29:119 *Introduction to Stellar Astrophysics I* 3 s.h.

Fundamentals of astronomy and stellar spectroscopy; properties of visual, spectroscopic, and eclipsing binary stars; stellar atmospheres and interiors; stellar kinematics and dynamics; distance indicators and their application to the investigation of the structure of the galaxy and extragalactic systems. Prerequisites, 29:18 and Mathematics 22M:26 or 22M:36 or equivalent. Alternate years; will be offered 1970-71.

29:120 *Introduction to Stellar Astrophysics II* 3 s.h.

Continuation of 29:119. Prerequisites, 29:19 and Mathematics 22M:26 or 22M:36 or equivalent. Alternate years; will be offered 1970-71.

29:121 *Solar System Astrophysics* 3 s.h.

Planetary surfaces, interiors, and atmospheres; comets, meteors, and asteroids; the interplanetary environment; the moon; the origin and evolution of the solar system. Prerequisites, 29:19 and Mathematics 22M:26 or 22M:36 or equivalent. Alternate years; will be offered 1971-72.

29:131 *Radio Astronomy* 3 s.h.

Current developments in radio astronomy; radio-frequency radiations from the sun, stars, planets, and interstellar matter; observational techniques. Prerequisite, 29:130. Alternate years; will be offered 1971-72.

29:137 *Astronomical Laboratory* 2 s.h.

Advanced laboratory work and observing with the 24-inch telescope; techniques of astronomical photography, photometry, and spectroscopy; laboratory work in data reduction, instrument calibration, and numerical computation. Prerequisites, 29:62 and consent of instructor. May be repeated.

29:220 *Individual Critical Study* cr.arr.

See *Physics*.

29:232 *Theoretical Astrophysics I* 3 s.h.

Theory of stellar photospheres and the continuous spectra of stars; formation of absorption lines in the spectra of stars. Prerequisite, consent of instructor. Alternate years; will be offered 1970-71.

29:233 *Theoretical Astrophysics II* 3 s.h.

Interstellar matter, nebulae, novae, and galactic radiation. Continuation of 29:232, which is prerequisite. Alternate years; will be offered 1970-71.

29:234 *Stellar Structure and Stellar Evolution* 4 s.h.

Structure of stellar interiors; nuclear-genesis and chemi-

## POLITICAL SCIENCE

cal synthesis in stars and the evolution of stars. Prerequisite, consent of instructor. Alternate years; will be offered 1971-72.

29:235 *Special Topics in Planetary and Space Science* 2 s.h.

Will include one or more of the following topics: the solar interior, photosphere, chromosphere, and corona; electromagnetic and corpuscular emissions of the sun; the interplanetary medium; internal structures, surfaces, atmospheres, and electromagnetic properties of planets; asteroids and comets. May be repeated.

29:263 *Seminar: Astrophysics* cr.arr.

Discussion of current research.

29:282 *Research in Astronomy* cr.arr.

Prerequisite, consent of head of department.

## POLITICAL SCIENCE

Chairman of Department, Russell M. Ross  
Office, 305 Schaeffer Hall

The program in political science deals with general principles of human behavior and organization which enable one to understand and explain political situations, events, and problems in the world around us. Both the undergraduate program for political science majors and the graduate program, which leads to the M.A. and the Ph.D. degrees, emphasize broad and comprehensive study, rather than narrow specialization on restricted aspects of the subject. The facilities of its Laboratory for Political Research and the Regional Social Science Data Archive afford a unique opportunity for both undergraduate and graduate students to come to grips with real problems through the analysis of real data, and, particularly at the graduate level, the methodological segments of the department's program provide opportunities for acquiring expertise and experience which are matched by very few other institutions.

At the undergraduate level the program is general and not vocational. Political science majors often enter careers in law, public service, or teaching, but many also enter careers in business, journalism, medicine, and other fields. At the graduate level the department emphasizes the general Ph.D. program, which is particularly appropriate for students planning a scholarly career. It is also suitable for entry into the executive ranks of the civil service of federal, state, and city governments. There is a special M.A. program in municipal administration, designed to prepare students for careers as city managers. The general M.A. program frequently leads to careers in civil service and in municipal or other governmental research bureaus, as well as to careers in teaching.

### Requirements for a Major

The department offers a standard major (Plan A) and a special teaching major (Plan B). The special major is for those who seek a public school teaching certificate. The standard major is for all others, whether they are pursuing a four-year program or a special combined program in liberal arts and law.

#### Plan A: The Standard Major

Undergraduates seeking a standard major must meet the following requirements:

- A. Complete at least 24 semester hours of work in political science including:
  1. 30:1 American Government
  2. Two of the following four introductory courses:
    - a) 30:10 Introduction to Political Behavior
    - b) 30:11 Introduction to Political Theory
    - c) 30:12 Introduction to Comparative Politics
    - d) 30:13 Introduction to World Politics
  3. Twelve or more semester hours of work in political science offerings numbered 100 or above. Of these no more than 6 semester hours may be in those