Physics and Astronomy

STATE UNIVERSITY OF IOWA

Iowa City

CALENDAR

SUMMER SESSION	**1965**
Last date for applications for admission or transfer	May 27, Thursday
Orientation for new undergraduate students	June 7, Monday
Registration for 8-week and 12-week sessions, 9 a.m.	June 8, Tuesday
Opening of classes, 7 a.m.	June 9, Wednesday
University Holiday, offices closed	July 4 and 5, Sunday and Monday
Close of 8-week session classes, 5 p.m.	August 4, Wednesday
University Commencement, 7:30 p.m.	August 4, Wednesday
Opening of Independent Study Unit for Law and Graduate students	August 5, Thursday
Close of 12-week session classes, 5 p.m.	August 25, Wednesday
Close of Independent Study Unit	September 1, Wednesday
University Holiday, offices closed	September 6, Monday
FIRST SEMESTER	**1964-65**
Last date for applications for admission or transfer	September 1, Tuesday
Reporting date for new undergraduates who have not completed the Placement Tests, 1 p.m.	September 11, Friday
Orientation for all new undergraduates, 7:30 p.m.	September 13, Sunday
Beginning of registration	September 14, Monday
Opening of classes, 7:30 a.m.; University Induction Ceremony, 9:25 a.m.	September 17, Thursday
Homecoming, classes suspended, Friday 12:20 p.m.	October 23 and 24, Friday & Saturday
Beginning of Thanksgiving recess, 12:20 p.m.	November 25, Wednesday
University Holiday, offices closed	November 26, Thursday
Resumption of classes, 7:30 a.m.	November 30, Monday
Beginning of Holiday recess, 5:30 p.m.	December 18, Friday
University Holiday, offices closed	December 24, Thursday
	December 25, Friday
University Holiday, offices closed	January 1, Friday
Resumption of classes, 7:30 a.m.	January 4, Monday
Close of First Semester classes, 5:30 p.m.	January 20, Wednesday
Beginning of Examination Week, 8 a.m.	January 22, Friday
Close of Examination Week, 5:30 p.m.	January 29, Friday
University Commencement, 10 a.m.	January 30, Saturday
SECOND SEMESTER	**1964-65**
Last date for applications for admission or transfer	January 21, Thursday
Beginning of registration, 8 a.m.	February 1, Monday
Opening of classes, 7:30 a.m.	February 3, Wednesday
Foundation Day	February 25, Thursday
Beginning of Easter recess, 5 p.m.	April 9, Friday
Resumption of classes, 7:30 a.m.	April 19, Monday
Beginning of Examination Week, 8 a.m.	May 25, Tuesday
University Holiday, offices closed	May 30 and 31, Sunday and Monday
Close of Second Semester classes, 5:30 p.m.	June 2, Wednesday
University Commencement, 9:30 a.m.	June 4, Friday
Alumni Day	June 5, Saturday
FIRST SEMESTER	**1965-66**
Last date for applications for admission or transfer	September 7, Tuesday
Reporting date for new undergraduates who have not completed the Placement Tests, 1 p.m.	September 17, Friday
Orientation for all new undergraduates, 7:30 p.m.	September 19, Sunday
Beginning of registration	September 20, Monday
Opening of classes, 7:30 a.m.; University Induction Ceremony, 9:25 a.m.	September 23, Thursday
Homecoming, classes suspended, Friday 12:20 p.m.	October 8 and 9, Friday & Saturday
Beginning of Thanksgiving recess, 12:20 p.m.	November 24, Wednesday
University Holiday, offices closed	November 25, Thursday
Resumption of classes, 7:30 a.m.	November 29, Monday
Beginning of Holiday recess, 5:30 p.m.	December 17, Friday
University Holiday, offices closed	December 23, Thursday
	December 24, Friday
University Holiday, offices closed	December 31, Friday
Resumption of classes, 7:30 a.m.	January 3, Monday
Close of First Semester classes, 5:30 p.m.	January 26, Wednesday
Beginning of Examination Week, 8 a.m.	January 28, Friday
Close of Examination Week, 5:30 p.m.	February 4, Friday
University Commencement, 10 a.m.	February 5, Saturday

PHYSICS

AND ASTRONOMY

PHYSICS AND ASTRONOMY

Head of Department, James A. Van Allen
Office, 108 Physics Building

Associate Head of Department and
Undergraduate Adviser, Edward B. Nelson
Office, 127 Physics Building

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

Career Opportunities

Persons possessing a mastery of physics and astronomy are in great 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:

29:7, 8	General Physics	8 s.h.
29:9	Introduction to Modern Physics	4 s.h.
22:4, 5 6, 7	College Algebra and Trigonometry, Analytical Geometry and Calculus	16 s.h.
22:103	Elementary Theoretical Mechanics	3 s.h.
29:129, 130	Electricity and Magnetism	8 s.h.
4:1 *or* 4:3	General Chemistry	4 s.h.

and 6 additional semester hours of physics and mathematics chosen from the following:

22:104	Elementary Theoretical Mechanics	3 s.h.
22:105	Advanced Calculus	3 s.h.
22:111, 112	Introduction to Analysis I, II	6 s.h.
29:117	Optics	4 s.h.
29:118	Kinetic Theory and Thermodynamics	3 s.h.
29:133, 134	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.

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

1. to take 29:171, 172, Methods of Theoretical Physics during their junior year;
2. to acquire reading facility in either Russian or German; and
3. to go beyond the minimum requirements listed above to the greatest feasible extent.

Honors in Physics

The elementary physics offerings are now arranged with 29:7, 8 as the appropriate selections for Honors candidates. Selected junior and senior majors take up to 8 semester hours of Honors Seminar 29:99 as part of their program for the degree Bachelor of Arts with Honors.

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

Undergraduate Major in Astronomy

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

29:7, 8	General Physics	8 s.h.
29:9	Introduction to Modern Physics	4 s.h.
29:61, 62	General Astronomy	8 s.h.
22:4, 5, 6, 7	College Algebra and Trigonometry, Analytic Geometry and Calculus	16 s.h.
29:71	Astronomical Laboratory	1 s.h.
22:103	Elementary Theoretical Mechanics	3 s.h.
29:119	Practical Astronomy	2 s.h.
29:120, 121	Introduction to Astrophysics I, II	6 s.h.

and 6 additional semester hours in astronomy, physics, and mathematics chosen from the following:

22:104	Elementary Theoretical Mechanics	3 s.h.
22:105	Advanced Calculus	3 s.h.
29:117	Optics	4 s.h.
29:118	Kinetic Theory and Thermodynamics	3 s.h.
29:129, 130	Electricity and Magnetism	8 s.h.
29:131	Radio Astronomy	2 s.h.
29:191	Atomic Physics	3 s.h.
29:192	Nuclear Physics	3 s.h.

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

1. to take 29:129, 130 Electricity and Magnetism, during their junior or senior year;
2. to acquire reading facility in either Russian or German; and
3. to go beyond the minimum requirements listed above to the greatest feasible extent.

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 and astrophysics.

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 general examination in all principal areas of the subject at the level of advanced undergraduate work. The examination is ordinarily 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 Master of Science 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 by a faculty committee appointed by the Dean of the Graduate College.

The program for the M.S. degree with thesis requires at least 24 semester hours of graduate course work and a thesis based on an original experimental or theoretical investigation by the candidate.

The program for the M.S. degree without thesis comprises a somewhat broader program of study (total of 38 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 (for which a maximum of 4 semester hours of credit is allowed). 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 completed satisfactorily at least the following courses or their equivalents as an undergraduate or a graduate, either at this University or elsewhere:

22:101	Differential Equations	3 s.h.
29:117	Optics	4 s.h.
29:118	Kinetic Theory and Thermodynamics	3 s.h.
22:103, 104	Elementary Theoretical Mechanics	6 s.h.
22:105	Advanced Calculus	3 s.h.
29:129, 130	Electricity and Magnetism	8 s.h.
29:133, 134	Advanced Laboratory	4 s.h.
29:191	Atomic Physics	3 s.h.
29:192	Nuclear Physics	3 s.h.

His plan of study should provide for as much advanced work as his aptitude and previous preparation permit. If he expects to continue toward a Ph.D. degree, he should take 29:171, 172 during his first year of residency. Study of scientific Russian or German is recommended, but is not required of M.S. candidates.

Master of Science Degree in Astronomy

The Master of Science degree is offered with thesis or without thesis. The general nature of the program of study for either degree is similar to that for the corresponding M.S. degree in Physics (q.v.).

Specific departmental requirements for the M.S. degree in astronomy are:

The substantial equivalent of the undergraduate major program in astronomy listed in earlier paragraphs, and as many of the following courses as feasible:

22:115	Numerical Methods in Mathematics	3 s.h.
22:116	Numerical Solution of Differential Equations	3 s.h.
29:131	Radio Astronomy	2 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.
29:232, 233	Theoretical Astrophysics I, II	6 s.h.
29:234	Stellar Structure and Stellar Evolution	2 s.h.
29:235	Solar Physics	2 s.h.

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 course work in both classical and modern theoretical physics for all candidates, whether their specialized research is to be in an experimental or a theoretical area.
2. Comprehensive examinations.
3. Participation in advanced seminars.
4. Successful conduct of a major original research in experimental physics, theoretical physics, or astronomy and the preparation and defense of a written dissertation based on this work.

Emphasis is laid on the capabilities developed and the 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 and 193	Atomic, Nuclear and Solid State Physics
29:205	Classical Mechanics
29:212	Statistical Mechanics
29:213, 214	Electromagnetic Theory
29:245, 246	Quantum Mechanics

Advanced mathematics such as the theory of functions of a complex variable and vector and tensor analysis are used freely in these courses. An introduction to these fields is given in Methods of Theoretical Physics 29:171, 172. 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 candidate is admitted to the comprehensive examinations he must acquire and demonstrate to the appropriate foreign language department the ability to read papers on physics in any two of the following three foreign languages—German, Russian, and French.

Each candidate must present and defend an original proposition of a research or speculative nature as a part of his comprehensive examination.

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. 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. An IBM 7040 digital computer and the associated facilities of the University Computer Center are available for research by students and staff of the department.

Experimental research is conducted in the fields of nuclear structure physics, cosmic rays, atmospheric and space physics, astrophysics, and solid state physics.

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

Persons qualified for graduate study are invited to apply for fellowships and assistantships. Inquiries should be directed to the departmental office.

STAFF

Professors: Richard R. Carlson, Max Dresden, Edward B. Nelson, James A. Van Allen.

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

Associate Professors: Francis T. Cole (on leave 1963-64), Satoshi Matsushima (Astronomy), Edwin Norbeck, William R. Savage.

National Science Foundation Visiting Associate Professor in Astronomy (1964-65): Hans G. Groth.

Assistant Professors: Raymon T. Carpenter, Kenneth W. Edwards, Harold Leinbach, Doraswamy Venkatesan.

Instructors: Donald C. Enemark, Frank D. Feiock, Allan S. Krass.

Graduate Teaching Assistants: Mr. Alfonso Albano, Mr. Ricardo Artigas, Mr. Allen Bashian, Mr. Joaquin Betancourt, Mr. Constantine Fatouros, Mr. Dorian M. Hatch, Mr. Gobind Kumar, Mr. Andrew Lacis, Mr. Sterling L. Levie, Mr. Philip McClean, Mr. Amador C. Muriel, Mr. George W. Pfeiffenberger, Mr. Subbiah Sankaran, Mr. Paul F. Tumulty, Mr. Richard Vawter, Mr. Chen-Show Wang.

Research Associates: Dr. James T. Cushing, Dr. Richard Fong, Mr. Louis A. Frank, Dr. Wei-Ching Lin, Dr. Kai-Wai Wong.

Research Engineer: Mr. Dale L. Chinburg.

Research Physicists: Mr. Donald E. Stilwell, Mr. James D. Thissell, Mr. William A. Whelpley.

Graduate College Research Assistants: Mr. Tsu-Teh Chou, Mr. Yoichi Terashita, Mr. Medville Throop.

Graduate Research Assistants: Mr. Robert M. Bahnsen, Mr. Edward H. Berkowitz, Mr. James R. Cessna, Mr. Yun-Leei Choiu, Mr. Kenneth Coop, Mr. George D. Ford, Mr. Theodore A. Fritz, Mr. George Frohwein, Mr. Medley W. Greene, Mr. Vincent P. Hart, Mr. Dale W. Heikkinen, Mr. Hoyt R. Hiddleston, Mr. Joseph E. Johnson III, Mr. Kenneth G. Kibler, Mrs. Hsey-Er Lin, Mr. Michael D. Mancusi, Mr. Robert A. Mendelson, Mr. Dennis P. O'Leary, Mr. William F. Parks, Mr. Wayne A. Seale, Mr. Richard Swisher, Mr. Daniel Tambasco, Mr. Michael J. Wiemer, Mr. William Wen Yeh, Mr. Edward Yen.

U. S. Steel Foundation Fellow: Mr. Robert L. McGrath.

National Aeronautics and Space Administration Graduate Trainees: Mr. Thomas P. Armstrong, Mr. John D. Craven, Mr. R. Walker Fillius, Mr. Donald Gurnett, Mr. James E. Hansen, Mr. Rollin C. Harding, Mr. H. Kent Hills, Mr. Stamatios Krimigis, Mr. Walter C. Nodean, Mr. Stanley D. Shawhan, Mr. Harold E. Taylor, Mr. Charles D. Wende.

National Aeronautics and Space Administration International Fellow: Mr. Saiyed M. Zaki.

COURSE DESCRIPTIONS

Physics

Primarily for Undergraduates

29:1 College Physics — *4 s.h.*

Open to freshmen. For premedical, predental, and pharmacy students and for others interested in elementary physics. Descriptive lectures and laboratory and problem work in mechanics, heat, and sound. Prerequisite or corequisite, Mathematics 22:4. Both semesters and summer session. Instructors: Nelson, Savage.

*Not in residence 1963-64.

29:2 College Physics *4 s.h.*

Continuation of 29:1, which is prerequisite. Electricity, magnetism, and light. Both semesters and summer session. Instructors: Leinbach, Venkatesan.

29:7 General Physics *4 s.h.*

For engineering students, Honors students, and majors in physics, astronomy, and other sciences. Three lectures and one three-hour laboratory-recitation each week on mechanics, heat, and sound. Prerequisite or corequisite, Mathematics 22:6. Both semesters. Instructor: Norbeck.

29:8 General Physics *4 s.h.*

Continuation of 29:7 which is prerequisite. Electricity, magnetism, and light. Both semesters. Instructors: Van Allen, Venkatesan.

29:9 Introduction to Modern Physics *4 s.h.*

Electronic, atomic, and nuclear phenomena from an experimental and interpretative point of view. Three lectures and one laboratory each week. Prerequisites, 29:1, 2 or 29:7, 8 and Mathematics 22:6. Instructor: Carpenter.

29:93 Reading in Physics *cr.arr.*

Consult head of department before registering. Staff.

29:99 Honors Seminar *cr.arr.*

For junior and senior Honors candidates majoring in physics or astronomy. Guidance in conducting original scholarly investigations. Staff.

For Undergraduates and Graduates

(These courses presuppose a working knowledge of differential and integral calculus and completion of 29:7, 8 or equivalent.)

29:103 Reading in Physics *cr.arr.*

Consult head of department before registering. Staff.

29:117 Optics *4 s.h.*

Geometrical and physical optics. Lectures and laboratory exercises on the properties of lenses and simple optical instruments, and on the phenomena of propagation of electromagnetic waves, interference, diffraction, and polarization. Three lectures and one laboratory each week. Instructor: Leinbach.

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 applications. Instructor: Venkatesan.

29:128 Electronics *3 s.h.*

Characteristics of vacuum tubes and transistors. Design and study of analog and digital circuits. Prerequisite, 29:129 or Electrical Engineering 55:54. Instructor: Enemark.

29:129 Electricity and Magnetism *4 s.h.*

Fundamental principles, including the phenomenological foundations of Maxwell's equations and their applications. Three lectures and one laboratory each week. Instructor: Norbeck.

29:130 Electricity and Magnetism *4 s.h.*

Continuation of 29:129, which is prerequisite. Three lectures and one laboratory each week. Instructor: Norbeck.

29:133 Advanced Laboratory *2 s.h.*

Laboratory study of fundamental atomic constants, radioactivity, X rays, optical spectroscopy, cosmic rays, and solid state physics. One laboratory period each week. Prerequisites, 29:9 and 29:129. Instructor: Nelson.

29:134 Advanced Laboratory *2 s.h.*

29:133 is not prerequisite. Instructor: Nelson.

29:171 Methods of Theoretical Physics *3 s.h.*

Vector and tensor analysis, matrices and linear vector spaces, and systems of orthogonal functions. Instructor: Edwards.

29:172 Methods of Theoretical Physics *3 s.h.*

Continuation of 29:171. Calculus of variations. Green's functions, and integral equations. Instructor: Edwards.

29:191 Atomic Physics *3 s.h.*

Introductory quantum theory and wave mechanics, relativity, atomic and molecular spectra, atomic structure, X rays. Prerequisite, 29:9. Instructor: Carpenter.

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, experimental techniques. Instructor: Carpenter.

29:193 Introductory Solid State Physics *3 s.h.*

Phenomenological and theoretical properties of solids, classification of solids and crystal structures, electronic and magnetic processes in materials, thermal and optical properties of solids. Instructor: Savage.

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. Topological methods. Prerequisites, Mathematics 22:103. Instructor: Feiock.

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 22:103, 104 and 29:171, 172, or the equivalent. (Not given 1964-65.) Staff.

29:212 Statistical Mechanics *3 s.h.*

The problem of Boltzmann. The H-theorem, general principles of classical statistical mechanics. Specific heat theory, nonideal gases. Stochastic processes. Einstein-Bose and Fermi-Dirac statistics and applications. Prerequisites, 29:118, Mathematics 22:103, 104 and 29:171, 172 or the equivalent. Instructor: Dresden.

29:213 Classical Electrodynamics *3 s.h.*

Advanced electro-magnetostatics, boundary value problems, Green's functions, Maxwell's equations, radiation theory, physical optics, multipole expansion of radiation field. Prerequisites, 29:129, 130 and 29:171, 172 or equivalent. Instructor: Krass.

29:214 Classical Electrodynamics *3 s.h.*

Special relativity, motion of charges in fields, theories of radiation reaction, special topics. Prerequisite, 29:213. Instructor: Krass.

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. Staff.

29:245, 246 Quantum Mechanics I, II *3, 3 s.h.*

Non-relativistic and relativistic quantum mechanics, Schrodinger wave mechanics, operator procedures, many particle systems, second quantization, relativistic equations, the S matrix, diagrammatic techniques. Prerequisites, 29:191, 171, 172. Instructor: Dresden.

29:249, 250 Advanced Nuclear Physics *3, 3 s.h.*

The phenomena of nuclear physics and their interpretation. Static properties of nuclei, nuclear moments, shell model, collective model, γ transitions, β decay, nuclear reaction mechanisms and other topics. Prerequisites, 29:191, 192 and 245. Instructor: Carlson.

29:262 Seminar: Solid State Physics *cr.arr.*

Discussion of current research. Instructor: Savage.

29:265 Seminar: Theoretical Physics *cr.arr.*

Discussion of current research. Instructors: Dresden, Edwards.

29:266 Seminar: Space Physics *cr.arr.*

Discussion of current research. Instructors: Van Allen, Leinbach.

29:267 Seminar: Nuclear Physics *cr.arr.*

Discussion of current research. Staff.

29:269 Special Topics in Nuclear Physics *cr.arr.*

Advanced lectures on one or more of the following topics: nuclear models and their relations, theory of nuclear reactions, weak interactions, heavy ion reactions. Prerequisites, 29:249, 250. May be repeated. Staff.

29:272 Theory of Solids *3 s.h.*

General systematization of solid state theory. Electrons in periodic force fields. The zone scheme, distinctions between conductors and insulators, the effective mass motion, Fermi statistics. Thermal and magnetic properties of metals. Conductivity calculations. Collective theories of electron interactions. Prerequisites, 29:245 and 212, or equivalent. Instructor: Dresden.

29:273 Relativity *3 s.h.*

Relativistic formulation of mechanics and electrodynamics; Einstein's theory of gravitation. Staff.

29:274 Quantum Statistical Mechanics *3 s.h.*

The ensembles in quantum theory. Quantum mechanical partition function. Density matrix techniques. Applications to equilibrium and non-equilibrium situations. Non-ideal Fermi-Dirac and Einstein-Bose systems. Superconductivity. Prerequisites, 29:245 and 212, or equivalent. Instructor: Dresden.

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, many body problems. The topics discussed will vary from year to year as circumstances demand. Prerequisites, 29:245, 246. May be repeated. Instructor: Dresden.

29:278 Solar Terrestrial Physics *2 s.h.*

Phenomena in the solar atmosphere, corpuscular and electro-magnetic radiation in interplanetary space, the geomagnetic field and interplanetary magnetic fields, magnetic storms, aurorae and the geomagnetically trapped radiation may be repeated. Instructor: Van Allen.

29:281 Research in Physics *cr.arr.*

Prerequisite, consent of head of department. May be continued for an indefinite number of semesters and in the summer. Staff.

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

Continuous and molecular physics of neutral and ionized gases. Absorption of solar radiation in ionizing and dissociative effects in relation to ionosphere, ozone layer, and chemical processes in ionosphere and electric currents, associated with daily magnetic variations and magnetic storms. Staff.

Astronomy

Primarily for Undergraduates

29:61 General Astronomy *4 s.h.*

Open to freshmen. Descriptive lectures and laboratory work in elementary astronomy. Solar system, earth, time, telescope, moon, and planets. One laboratory per week for observation with the telescope and problem work. Prerequisite, at least one year each of high school algebra and geometry. Instructor: Matsushima.

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

Continuation of 29:61. Stellar astronomy. Motions and physics of the stars; systems of stars; interstellar matter; galaxies. Instructor: Matsushima.

29:71 Astronomical Laboratory *1 s.h.*

Visual and photographic observations with the five-inch refractor and the twelve-inch Cassegrain-Newtonian reflector. Darkroom photographic work. Laboratory work in astronomical computations. One laboratory period each week. Prerequisite, 29:62. May be repeated. Staff.

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

Consult head of department before registering. Staff.

29:99 Honors Seminar *cr.arr.*

(See *Physics*.)

For Undergraduates and Graduates

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

Consult head of department before registering. Staff.

29:119 Practical Astronomy *2 s.h.*

Determination of time, latitude, longitude, and azimuth. Engineer-

ing and satellite astronomy. Computation of orbits. A few laboratory periods included. Prerequisite, Mathematics 22:5 or equivalent. Staff.

29:120 Introduction to Astrophysics I *3 s.h.*

Basic problems and methods of astrophysics. Radiation and spectra of the earth's atmosphere, the sun, stars, nebulae, and interstellar matter. Prerequisites, 29:9 and Mathematics 22:7 or equivalents. Instructor: Matsushima.

29:121 Introduction to Astrophysics II *3 s.h.*

Continuation of 29:120, which is prerequisite. Instructor: Matsushima.

29:131 Radio Astronomy *2 s.h.*

Current developments in radio astronomy; radio-frequency radiations from the sun, stars, planets and interstellar matter. Observational techniques. Prerequisite, 29:120. Instructor: Leinbach.

29:137 Astronomical Laboratory *1 s.h.*

Advanced laboratory work with the twenty-four-inch Cassegrain reflector. Astronomical photometry and spectroscopy. Numerical computations in orbit theory and eclipses. Prerequisite, 29:121. May be repeated. Staff.

Primarily for Graduates

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

(See *Physics.*)

29:232 Theoretical Astrophysics I (Physics of the Stellar Atmosphere) *3 s.h.*

Prerequisite, consent of instructor. Theory of stellar photospheres and the continuous spectra of stars. Formation of absorption lines in the spectra of stars. Offered in 1963-64 and in alternate years thereafter. Instructor: Matsushima.

29:233 Theoretical Astrophysics II (Physics of the Interstellar Medium) *3 s.h.*

Continuation of 29:232. Interstellar matter, nebulae, novae, and galactic radiation. Offered in 1963-64 and in alternate years thereafter. Instructor: Matsushima.

29:234 Stellar Structure and Stellar Evolution *2 s.h.*

Structure of stellar interiors. Nuclear-genesis and chemical synthesis in stars, and the evolution of stars. Offered in 1964-65 and in alternate years thereafter. Instructor: Matsushima.

29:235 Solar Physics *2 s.h.*

Physics of solar chromosphere and corona. Optical and radio-frequency radiations from the sun. Offered in 1964-65 and in alternate years thereafter. Instructor: Matsushima.

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

Discussion of current research. Staff.

29:268 Special Topics in Astrophysics *cr.arr.*

Special lectures on current topics in astrophysics. Staff.

FOR FURTHER INFORMATION

INFORMATION FOR PROSPECTIVE STUDENTS. This small booklet gives condensed general information concerning University colleges, schools, and other units. Also included: information on admission, fees, scholarships, student aid, housing, and student personnel services.

DESCRIPTIVE BOOKLETS. These booklets are available in the following fields: Botany; Business Administration; Comparative Literature; Dental Hygiene; Dentistry; Education; Engineering; Engineering-Liberal Arts; Financial Aids; Fine Arts; Graduate Study in English; Home Economics; Honors Program; Humanities; Journalism; Languages; Law; Liberal Arts; Medical Technology; Medicine; Mortuary Science (pre-); Museum Training; Nuclear Science and Technology; Nursing; Pharmacy; Physical Therapy; Physical Education (Men); Physical Education (Women); Religious Opportunities; Roentgenologic Technique; Sciences; Social Work; and Speech, Dramatic Arts and Television.

CATALOGUE SECTION REPRINTS. Sections of the General University Catalogue (similar to this booklet) pertaining to the following areas of study are available in reprint form: Colleges—Business Administration, Dentistry, Education, Engineering, Graduate, Law, Liberal Arts, Medicine, Nursing and Pharmacy. Schools and Departments—American Civilization, Art, Botany, Chemistry, Child Development, Economics, English, European Literature and Thought, Foreign Studies, Geography and Geology, General Science, Health Services, History, Home Economics, Humanities, Journalism, Languages, Library Education, Mathematics, Microbiology, Museum Training, Music, Nuclear Science, Oriental Studies, Philosophy, Physical Education (Men), Physical Education (Women), Physics and Astronomy, Political Science, Psychology, Religion, Social Studies, Social Work, Sociology and Anthropology, Speech, Dramatic Art and Television, Speech Pathology and Audiology, Zoology, and Health Services.

TO OBTAIN INFORMATION on any of the above fields or application forms for admission, write to the Director of Admissions, University Hall, State University of Iowa, Iowa City.

FOR INFORMATION about married student or dormitory housing and application forms, write to the Dormitory Assignment Office, University Hall, State University of Iowa, Iowa City. For information about off-campus housing, and sororities and fraternities, write to the Office of Student Affairs, University Hall, State University of Iowa, Iowa City. For information about scholarships and loans, and student employment, write to the Director of Financial Aids, Old Dental Building, State University of Iowa, Iowa City.