PHYSICS AND ASTRONOMY

PHYSICAL THERAPY
(See Health Services)

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, 206 Mathematical Sciences 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:

29:118 Introduction to Physics I, II, III (each) 5 s.h.
22M:103, 104 Elementary Theoretical Mechanics 6 s.h.
22M:105 Advanced Calculus 3 s.h.
29:129, 130 Electricity and Magnetism 8 s.h.
4:4 General Chemistry 4 s.h.
and an additional semester hours chosen from the following:
29:117 Optics 4 s.h.
29:118 Kinetic Theory and Thermodynamics 3 s.h.
29:120 Introduction to Astrophysics I 3 s.h.
29:121 Introduction to Astrophysics II 3 s.h.
29:133, 134 Advanced Laboratory 4 s.h.
29:141, 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 or 4 s.h.
29:194 Plasma Physics 3 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.

Honors in Physics or Astronomy

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

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:

29:61, 62 General Astronomy 8 s.h.
29:17, 18, 19 Astronomy I, II, III (each) 5 s.h.
29:120, 121 Introductory Astrophysics I, II 6 s.h.
22M:103, 104 Elementary Theoretical Mechanics 6 s.h.
29:117 Optics 4 s.h.
29:119 Stellar Dynamics and Galactic Structure 3 s.h.
29:129, 130 Electricity and Magnetism 8 s.h.

For students who plan to pursuing graduate study in astronomy, a selection of further courses from the following list is recommended:

22M:105 Advanced Calculus 3 s.h.
22M:115 Numerical Methods in Mathematics 3 s.h.
22M:116 Numerical Solutions of Differential Equations 3 s.h.

29:118 Kinetic Theory and Thermodynamics 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.
29:195 Introductory Solid State Physics 3 or 4 s.h.
29:194 Plasma Physics 3 s.h.

Graduate Program

Two advanced degrees are offered in physics, the Master of Science (with or without thesis) and the Doctor of Philosophy; and in 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.

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 residence. 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 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 courses (total of 36 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-fifth 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:

22M:101 Differential Equations 3 s.h.
29:117 Optics 4 s.h.
29:118 Kinetic Theory and Thermodynamics 3 s.h.
22M:103, 104 Elementary Theoretical Mechanics 6 s.h.
22M: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.
29:193 Introductory Solid State Physics 3 or 4 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 and 172 during his first year of residence. Study of scientific Russian or German is recommended, but is not required of M.S. candidates.

Master of Science Degree in Astronomy

The M.S. 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 is feasible to complete:

22M:115 Numerical Methods in Mathematics 3 s.h.
22M:116 Numerical Solution of Differential Equations 3 s.h.
PHYSICS AND ASTRONOMY

Instructors: Donald C. Eemark, George P. Haskell, Yoichi Terasaki.


Graduate College Research Assistants: Francis B. Hock, William T. Teeters, Paul F. Tumulty.


National Science Foundation Fellow: Granville J. Smith.


Rockefeller Foundation Scholar: Celso R. Roque.

COURSE DESCRIPTIONS

Physics

Primarily for Undergraduates

29.1 College Physics

4 s.h.

Open to freshmen. For premedical, predental 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.4. Both semesters and summer session. Instructors: Carpenter, Nelson.

29.2 College Physics

4 s.h.

Continuation of 29.1, which is prerequisite. Electricity, magnetism, and light. Both semesters and summer session. Instructors: Nelson, Carpenter.

29.7 General Physics

4 s.h.

For engineering students. Three lectures and one three-hour laboratory each week on mechanics, heat and sound. Prerequisite or corequisite, Mathematics 22M.6. Both semesters. Instructors: Frank, Garnett.

29.8 General Physics

4 s.h.

Continuation of 29.7, which is prerequisite. Electricity, magnetism, and light. Both semesters. Instructors: Klink, Mcclintom.

29.9 Introduction to Modern Physics

3 or 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 22M.7. Instructor: Krimgis.

29.17 Introductory Physics I

5 s.h.

Classical and modern physics for physics majors, honors students and others by permission of the instructor. Four lecture-discussion sections and one laboratory per week. Corequisite, Mathematics 22M.6. Staff.

29.18 Introductory Physics II

5 s.h.

A continuation of 29.17, which is prerequisite. Corequisite, Mathematics 22M.7. Staff.

29.19 Introductory Physics III

5 s.h.

A continuation of 29.18, which is prerequisite. Staff.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.93</td>
<td>Reading in Physics</td>
<td>cr.arr.</td>
<td>Consult head of department before registering. Staff.</td>
</tr>
<tr>
<td>29.99</td>
<td>Honors Seminar</td>
<td>cr.arr.</td>
<td>For junior and senior honors candidates majoring in physics or astronomy. Guidance in conducting original scholarly investigations. Staff.</td>
</tr>
<tr>
<td>29.103</td>
<td>Reading in Physics</td>
<td>cr.arr.</td>
<td>Consult head of department before registering. Staff.</td>
</tr>
<tr>
<td>29.117</td>
<td>Optics</td>
<td>4 s.h.</td>
<td>Geometrical and physical optics. Lectures and laboratory exercises on the properties of lenses and simple optical instruments; phenomena of propagation of electromagnetic waves, interference, diffraction and polarization. Three lectures and one laboratory each week. Instructor: Niem.</td>
</tr>
<tr>
<td>29.128</td>
<td>Electronics</td>
<td>3 s.h.</td>
<td>Characteristics of vacuum tubes and transistors. Design and study of analog and digital circuits. Two lectures and one laboratory each week. Prerequisite, 29.129 or Electrical Engineering 55:54. Instructor: Enemark.</td>
</tr>
<tr>
<td>29.129</td>
<td>Electricity and Magnetism</td>
<td>4 s.h.</td>
<td>Fundamental principles, including the phenomenological foundations of Maxwell's equations and their application. Three lectures and one laboratory each week. Instructor: Waggoner.</td>
</tr>
<tr>
<td>29.130</td>
<td>Electricity and Magnetism</td>
<td>4 s.h.</td>
<td>Continuation of 29.129, which is prerequisite. Three lectures and one laboratory each week. Instructor: Waggoner.</td>
</tr>
<tr>
<td>29.133</td>
<td>Advanced Laboratory</td>
<td>2 s.h.</td>
<td>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 or 29.19, and 29.129. Instructor: Haskell.</td>
</tr>
<tr>
<td>29.134</td>
<td>Advanced Laboratory</td>
<td>2 s.h.</td>
<td>Course 29.133 is not prerequisite. Instructor: Haskell.</td>
</tr>
<tr>
<td>29.171</td>
<td>Methods of Theoretical Physics</td>
<td>3 s.h.</td>
<td>Linear algebra, integration methods, complex variables, transforms, special functions. Prerequisite, Mathematics 22M:105. Instructor: Payne.</td>
</tr>
<tr>
<td>29.191</td>
<td>Atomic Physics</td>
<td>3 s.h.</td>
<td>Introductory quantum theory and wave mechanics, relativity, atomic and molecular spectra, atomic structure, X rays. Prerequisite, 29.9 or 29.19. Instructor: Carlson.</td>
</tr>
<tr>
<td>29.192</td>
<td>Nuclear Physics</td>
<td>3 s.h.</td>
<td>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: Carlson.</td>
</tr>
<tr>
<td>29.193</td>
<td>Introductory Solid State Physics</td>
<td>3 or 4 s.h.</td>
<td>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. One semester hour of laboratory experiments in solid state physics required for students specializing in solid state physics. Staff.</td>
</tr>
<tr>
<td>29.194</td>
<td>Plasma Physics</td>
<td>4 s.h.</td>
<td>Introduction to physics of ionized gases, including: orbit theory, guiding center motion, adiabatic invariance; description of plasmas by fluid variables and distribution functions; linearized wave motions and instabilities; plasma radiations; production and diagnostics of plasmas. Prerequisites, 29.139 and some knowledge of vector analysis. Instructor: Gurnett.</td>
</tr>
<tr>
<td>29.211</td>
<td>Mechanics of Continua</td>
<td>3 s.h.</td>
<td>Hydrostatics, dynamics of ideal fluids, both compressible and incompressible; viscous flow; the classical theory of elasticity. Prerequisites, Mathematics 22M:103, 104, and 29.171, 172, or the equivalent. Instructor: Frank.</td>
</tr>
<tr>
<td>29.214</td>
<td>Classical Electrodynamics</td>
<td>3 s.h.</td>
<td>Special relativity, motion of charges in fields, theories of radiation reaction, special topics. Prerequisite, 29.213. Instructor: Norbeck.</td>
</tr>
<tr>
<td>29.220</td>
<td>Individual Critical Study</td>
<td>cr.arr.</td>
<td>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.</td>
</tr>
<tr>
<td>29.245</td>
<td>Quantum Mechanics I</td>
<td>3 s.h.</td>
<td>Nonrelativistic quantum mechanics; Schrodinger 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. Instructor: Edwards.</td>
</tr>
<tr>
<td>29.246</td>
<td>Quantum Mechanics II</td>
<td>3 s.h.</td>
<td>Continuation of 29.245.</td>
</tr>
<tr>
<td>29.249</td>
<td>Advanced Nuclear Physics</td>
<td>3 s.h.</td>
<td>The phenomena of nuclear physics and their interpretation. Static properties of nuclei, nuclear momenta, shell model, collective model, gamma transitions, beta decay, nuclear reaction mechanisms and other topics. Prerequisites, 29.191, 192 and 245. May be repeated. Instructor: Carpenter.</td>
</tr>
<tr>
<td>29.250</td>
<td>Advanced Nuclear Physics</td>
<td>3 s.h.</td>
<td>Continuation of 29.249.</td>
</tr>
<tr>
<td>29.266</td>
<td>Seminar: Space Physics</td>
<td>cr.arr.</td>
<td>Discussion of current research. Instructor: Van Allen.</td>
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PHYSICS AND ASTRONOMY

29.269 Special Topics in Nuclear Physics
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. Instructor: Coester.

29.271 Theoretical Solid State Physics
3 s.h.

29.272 Theoretical Solid State Physics
3 s.h.
Continuation of 29.271.

29.273 Relativity
3 s.h.
Relativistic formulation of mechanics and electrodynamics; Einstein's theory of gravitation. Instructors: Klink, Noerdlinger.

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 non-equilibrium statistical mechanics, or quantum statistical mechanics. Instructor: Montgomery.

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: Mc Clement.

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, auroras and the geomagnetically trapped radiation. May be repeated. Staff.

29.281 Research in Physics
Prerequisite, consent of head of department. Staff.

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 magnetic variations and magnetic storms. May be repeated. Staff.

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's equation and linearized wave motion; shocks, nonlinear plasma modes, and instabilities; fluctuations and radiation processes; magnetohydrodynamics; recent papers. Prerequisites, 29.212, 213, or consent of instructor. Instructor: Montgomery.

29.295 Advanced Plasma Physics II
3 s.h.
Continuation of 29.294. May be repeated. Instructor: Montgomery.

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: Van Allen.

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: Van Allen.

29.71 Astronomical Laboratory
1 s.h.
Visual and photographic observations with the 5-inch and 24-inch telescopes. Theory and practice in astronomical photography. Laboratory work in data reduction and computation. One laboratory period each week. Prerequisites, 29.61 and consent of instructor. May be repeated. Staff.

29.94 Reading in Astronomy
Consult head of department before registering. Staff.

29.99 Honors Seminar
See Physics.

For Undergraduates and Graduates

29.104 Reading in Astronomy
Consult head of department before registering. Staff.

29.105 General Astronomy
4 s.h.
Summers only.

29.119 Stellar Dynamics and Galactic Structure
3 s.h.

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, 29.19 and Mathematics 22M.7, or equivalents. Instructor: Terasita.

29.121 Introduction to Astrophysics II
3 s.h.
Continuation of 29.120, which is prerequisite. Instructor: Terasita.

29.131 Radio Astronomy
2 s.h.
Current developments in radio astronomy; radio-frequency radiation from the sun, stars, planets, and interstellar matter. Observational techniques. Prerequisite, 29.120. Instructor: Van Allen.

29.137 Astronomical Laboratory
1 s.h.
Advanced laboratory work and observing with the 24-inch telescope. Techniques of astronomical photography, photometry and spectrophotography. Laboratory work in data reduction, instrument calibration and numerical computation. Prerequisites, 29.121 and consent of instructor. May be repeated. Staff.

29.220 Individual Critical Study
See Physics.

29.232 Theoretical Astrophysics I
(Physics of the Stellar Atmosphere)
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. Instructor: Matsuura.

29.233 Theoretical Astrophysics II
(Physics of the Interstellar Medium)
3 s.h.

29.234 Stellar Structure and Stellar Evolution
2 s.h.

29.235 Solar and Planetary Physics
2 s.h.

29.265 Seminar: Astrophysics
Discussion of current research. Staff.

29.268 Special Topics in Astrophysics
Special lectures on current topics in astrophysics. Staff.

29.282 Research in Astronomy
Prerequisite, consent of head of department. Staff.

Primarily for Graduates

179