PHYSICS

Description
The Department of Physics and Astronomy offers programs leading to the bachelor of arts and bachelor of science degrees. Students preparing for either graduate study or a professional career in physics should pursue the bachelor of science degree with a professional option. For students who have special interests, the department offers options in optics and lasers, materials physics, and computational physics.

The courses required for the bachelor of arts degree in physics offer a broader program in science and the liberal arts suitable for a variety of pre-professional curricula and for interdisciplinary studies in areas including biophysics, chemical physics, and geophysics.

College Admission
The entrance requirements for the College of Arts and Sciences (CAS), including any of the majors or minors offered through the college, are the same as the UNL General Admission Requirements. In addition to these requirements, the College of Arts and Sciences strongly recommends a third and fourth year of one foreign language in high school. Four years of high school coursework in the same language will fulfill the College of Arts and Sciences’ language requirement. It will also allow students to continue language study at a more advanced level at UNL and provide more opportunity to study abroad.

ACADEMIC AND CAREER Advising

Academic and Career Advising Center
The Academic and Career Advising Center in 107 Oldfather Hall is the undergraduate hub for CAS students in all majors. Centrally located and easily accessed, students encounter friendly, knowledgeable people who are eager to help. Students visit the Advising Center in 107 Oldfather Hall to:

- Choose or change their major, minor, or degree program.
- Check in on policies, procedures, and deadlines.
- Get a college approval signature from the Dean’s representative, Sr. Director of Advising and Student Success.

While the assigned academic advisor should be the student’s primary contact, there are daily walk-ins from 12:30 where a general academic advisor can answer a quick question. In addition, the CAS Career Coaches are located here. They help students explore majors and minors, gain experience, and develop a plan for life after graduation. Not sure where to go or who to ask? The Advising Center team can help.

Assigned Academic Advisors
Academic advisors are critical resources dedicated to students’ academic, personal, and professional success. Every CAS student is assigned an academic advisor based on their primary major. Since most CAS students have more than just a single major, it is important to get to know the advisor for any minors or additional majors. Academic advisors work closely with the faculty to provide the best overall support and the discipline-specific expertise.

Assigned advisors are listed in MyRED (https://its.unl.edu/myunl) and their offices may be located in or near the department of the major for which they advise or in the Academic and Career Advising Center. Students who have declared a pre-health or pre-law area of interest will also work with advisors in the Exploratory and Pre-Professional Advising Center (Explore Center) in 127 Love South, who are specially trained to guide students preparing to enter a professional school.

For complete and current information on advisors for majors, minors, or pre-professional areas, contact the Arts and Sciences Academic and Career Advising Center, 107 Oldfather Hall, 402-472-4190, http://cas.unl.edu/advising.

Career Coaching
The College believes that Academics + Experience = Opportunities and encourages students to complement their academic preparation with real-world experience, including internships, research, education abroad, service, and leadership. Arts and sciences students have access to a powerful network of faculty, staff, and advisors dedicated to providing information and support for their goals of meaningful employment or advanced education. Arts and sciences graduates have unlimited career possibilities and carry with them important career competencies—communication, critical thinking, creativity, context, and collaboration. They have the skills and adaptability that employers universally value. Graduates are not only prepared to effectively contribute professionally in the real world, but they have a solid foundation to excel in an increasingly global, technological, and interdisciplinary world.

Students should contact the career coaches in the Arts and Sciences Academic and Career Advising Center in 107 Oldfather, or their assigned advisor, for more information. The CAS career coaches help students explore career options, identify ways to build experience, and prepare to apply for internships, jobs, or graduate school, including help with resumes, applications, and interviewing.

ACE Requirements
Students must complete one course for each of the ACE Student Learning Outcomes below. Certified course choices are published in the degree audit, or visit the ACE website (http://ace.unl.edu) for the most current list of certified courses.

ACE Student Learning Outcomes

<table>
<thead>
<tr>
<th>ACE 1</th>
<th>Write texts, in various forms, with an identified purpose, that respond to specific audience needs, integrate research or existing knowledge, and use applicable documentation and appropriate conventions of format and structure.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACE 2</td>
<td>Demonstrate competence in communication skills.</td>
</tr>
<tr>
<td>ACE 3</td>
<td>Use mathematical, computational, statistical, logical, or other formal reasoning to solve problems, draw inferences, justify conclusions, and determine reasonableness.</td>
</tr>
<tr>
<td>ACE 4</td>
<td>Use scientific methods and knowledge to pose questions, frame hypotheses, interpret data, and evaluate whether conclusions about the natural and physical world are reasonable.</td>
</tr>
<tr>
<td>ACE 5</td>
<td>Use knowledge, historical perspectives, analysis, interpretation, critical evaluation, and the standards of evidence appropriate to the humanities to address problems and issues.</td>
</tr>
<tr>
<td>ACE 6</td>
<td>Use knowledge, theories, and research perspectives such as statistical methods or observational accounts appropriate to the social sciences to understand and evaluate social systems or human behaviors.</td>
</tr>
</tbody>
</table>
ACE 7: Use knowledge, theories, or methods appropriate to the arts to understand their context and significance.

ACE 8: Use knowledge, theories, and analysis to explain ethical principles and their importance in society.

ACE 9: Exhibit global awareness or knowledge of human diversity through analysis of an issue.

ACE 10: Generate a creative or scholarly product that requires broad knowledge, appropriate technical proficiency, information collection, synthesis, interpretation, presentation, and reflection.

College Degree Requirements

College Distribution Requirements – BA and BS

The College of Arts and Sciences distribution requirements are common to both the bachelor of arts and bachelor of science degrees and are designed to ensure a range of courses. By engaging in study in several different areas within the College, students develop the ability to learn in a variety of ways and apply their knowledge from a variety of perspectives. All requirements are in addition to University ACE requirements, and no course can be used to fulfill both an ACE outcome and a College Distribution Requirement.

• A student may not use a single course to satisfy more than one College Distribution Requirement, with the exception of CDR Diversity. Courses used to meet CDR Diversity may also meet CDR Writing, CDR Humanities, or CDR Social Science.

• Independent study or reading courses and internships cannot be used to satisfy distribution requirements.

• Courses from interdisciplinary programs will be applied in the same area as courses from the home/cross-listed department.

College Distribution Requirements

<table>
<thead>
<tr>
<th>CDR: Written Communication</th>
<th>3</th>
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</thead>
<tbody>
<tr>
<td>Select from courses approved for ACE outcome 1.</td>
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</table>

<table>
<thead>
<tr>
<th>CDR: Natural, Physical, and Mathematical Sciences with Lab</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select from biochemistry, biological sciences, chemistry, computer science, geology, meteorology, mathematics, physics, and statistics. Must include one lab in the natural or physical sciences. Lab courses may be selected from biochemistry, biological sciences, chemistry, geology, meteorology, and physics.</td>
<td></td>
</tr>
</tbody>
</table>

Some courses from geography and anthropology may also be used to satisfy the lab requirement above. 1

<table>
<thead>
<tr>
<th>CDR: Humanities</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select from classics, English, history, modern languages and literatures, philosophy, and religious studies. 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CDR: Social Science</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select from anthropology, communication studies, geography, political science, psychology, or sociology. 3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CDR: Human Diversity in U.S. Communities</th>
<th>0-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select from a set of approved courses as listed in the degree audit.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CDR: Language</th>
<th>0-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select from a set of approved courses as listed in the degree audit.</td>
<td></td>
</tr>
</tbody>
</table>

Fulfilled by the completion of the 6-credit-hour second-year sequence in a single foreign language in one of the following departments: Classics and religious studies or modern languages and literatures. Instruction is currently available in Arabic, Chinese, Czech, French, German, Greek, Japanese, Latin, Russian, and Spanish.

A student who has completed the fourth-year level of one foreign language in high school is exempt from the languages requirement, but encouraged to continue on in their language study.

Credit Hours Subtotal: 13-32

1 See Degree Audit or a College of Arts and Sciences advisor for approved geography and anthropology courses that apply as natural science.

2 Language courses numbered 220 and below do not fulfill the CDR Humanities.

3 See Degree Audit or College of Arts and Sciences advisor for list of natural/physical science courses in anthropology, geography, and psychology that do not apply as social science.

Language Requirement

UNL and the College of Arts and Sciences place great value on academic exposure and proficiency in a second language. The UNL entrance requirement of two years of the same foreign language or the College’s language distribution requirement (CDR: Language) will rarely be waived and only with relevant documentation. See the main College of Arts and Sciences page for more details.

Scientific Base - BS Only

The bachelor of science degree requires students to complete 60 hours in mathematical, physical, and natural sciences. Approved courses for scientific base credit come from the following College of Arts and Sciences disciplines: actuarial science, anthropology (selected courses), astronomy, biochemistry (excluding BIOC 101), biological sciences (excluding BIOS 100 or BIOS 203), chemistry (excluding CHEM 101), computer science (excluding CSCE 10), geography (selected courses), geology, life sciences, mathematics (excluding courses below MATH 104), meteorology, microbiology (excluding MBIO 101), and physics.

See your Degree Audit or your assigned academic advisor for a complete list, including individual classes that fall outside of the disciplines listed above. Up to 12 hours of scientific and technical courses offered by other colleges may be accepted toward this requirement with approval of the College of Arts and Sciences. See your assigned academic advisor to start the approval process.

Minimum Hours Required for Graduation

A minimum of 120 semester hours of credit is required for graduation from the College of Arts and Sciences. A cumulative grade point average of at least 2.0 is required.

Grade Rules

Restrictions on C- and D Grades

The College will accept no more than 15 semester hours of C- and D grades from other domestic institutions except for UNO and UNK. All courses taken at UNO and UNK impact the UNL transcript. No transfer of C- and D grades can be applied toward requirements in a major or a minor. No UNL C- and D grades can be applied toward requirements in a major or a minor. International coursework (including education abroad)
with a final grade equivalent to a C- or lower will not be validated by College of Arts and Sciences departments to be degree applicable.

Pass/No Pass Privilege
The College of Arts and Sciences adheres to the University regulations for the Pass/No Pass (P/N) privilege with the following additional regulations:

- Pass/No Pass hours can count toward fulfillment of University ACE requirements and college distribution requirements up to the 24-hour maximum.
- Most arts and sciences departments and programs do not allow courses graded Pass/No Pass to apply to the major or minor. Students should refer to the department's or program's section of the catalog for clarification. By college rule, departments can allow up to 6 hours of Pass/No Pass in the major or minor.
- Departments may specify that certain courses of theirs can be taken only on a P/N basis.
- The college will permit no more than a total of 24 semester hours of P/N grades to be applied toward degree requirements. This total includes all Pass grades earned at UNL and other U.S. schools. NOTE: This 24-hour limit is more restrictive than the University regulation.

Grading Appeals
A student who feels that he/she has been unfairly graded must ordinarily take the following sequential steps in a timely manner, usually by initiating the appeal in the semester following the awarding of the grade:

1. Talk with the instructor concerned. Most problems are resolved at this point.
2. Talk to the instructor's department chairperson.
3. Take the case to the Grading Appeal Committee of the department concerned. The Committee should be contacted through the department chairperson.
4. Take the case to the College Grading Appeals Committee by contacting the Dean's Office, 1223 Oldfather Hall.

Course Level Requirements
Courses Numbered at the 300 or 400 Level
Thirty (30) of the 120 semester hours of credit must be in courses numbered at the 300 or 400 level. Of those 30 hours, 15 hours (1/2) must be completed in residence at UNL.

Residency Requirement
Students must complete at least 30 of the 120 total hours for their degree at UNL. Students must complete at least 1/2 of their major coursework, including 6 hours at the 300 or 400 level in their major and 15 of the 30 hours required at the 300 or 400 level, in residence. Credit earned during education abroad may be used toward the residency requirement only if students register through UNL.

Catalog to Use
Students must fulfill the requirements stated in the catalog for the academic year in which they are first admitted to and enrolled as a degree-seeking student at UNL. In consultation with advisors, a student may choose to follow a subsequent catalog for any academic year in which they are admitted to and enrolled as a degree-seeking student at UNL in the College of Arts and Sciences. Students must complete all degree requirements from a single catalog year. Beginning in 1990-1991, the catalog which a student follows for degree requirements may not be more than 10 years old at the time of graduation.

Learning Outcomes
Graduates of physics will be able to:

1. Demonstrate a conceptual understanding of the fundamental principles of physics.
2. Properly invoke these principles in the explanation of physical phenomena.
3. Apply these principles in the solution of problems.
4. Apply the content, stipulated in individual course syllabi, which will include, though not be limited to: the principles of force and motion and the relationships between them; the conservation, transfer, and transformations of energy; the fundamental electric and magnetic properties of matter; the fundamental properties of mechanical and electromagnetic waves; the laws of thermodynamics; and the basic application and extension of all these principles to nuclear and atomic physics.

Major Requirements
Bachelor of Science
Complete the core requirements plus one of the following options: Professional, Optics and Lasers, Materials Physics, or Computational Physics.

Core Requirements
Physics

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 201</td>
<td>Modern Topics in Physics and Astronomy</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 211</td>
<td>General Physics I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 221</td>
<td>General Physics Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 212</td>
<td>General Physics II</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 222</td>
<td>General Physics Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 213</td>
<td>General Physics III</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 223</td>
<td>General Physics Laboratory III</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 231</td>
<td>Electrical and Electronic Circuits</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 311</td>
<td>Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 431</td>
<td>Thermal Physics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 451</td>
<td>Electromagnetic Theory</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 461</td>
<td>Quantum Mechanics</td>
<td>3</td>
</tr>
</tbody>
</table>

Credit Hours Subtotal: 31

Mathematics

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 106</td>
<td>Calculus I</td>
<td>5</td>
</tr>
<tr>
<td>MATH 107</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 208</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 221</td>
<td>Differential Equations</td>
<td>3</td>
</tr>
</tbody>
</table>

Credit Hours Subtotal: 16

Chemistry

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 113</td>
<td>Fundamental Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>or CHEM 109</td>
<td>General Chemistry I</td>
<td>4</td>
</tr>
</tbody>
</table>

Credit Hours Subtotal: 4

Option Courses
Complete one of the following options described below.

<table>
<thead>
<tr>
<th>Option</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17-20</td>
</tr>
</tbody>
</table>
Credit Hours Subtotal: 17-20
Total Credit Hours 68-71

1 CHEM 113 is required for students declaring the Materials Physics Option.

Professional Option
The Professional Option is designed for students intending to pursue graduate study or employment in physics or a related scientific or engineering discipline.

Professional Option Required Courses
PHYS 441 Experimental Physics I 3
PHYS 442 Experimental Physics II 3
PHYS 452 Optics and Electromagnetic Waves 3
PHYS 462 Atoms, Nuclei, and Elementary Particles 3
Select at least 6 hours of the following: 2
PHYS 343 Physics of Lasers and Modern Optics
PHYS 361 Concepts of Modern Physics
PHYS 401 Computational Physics
PHYS 422 / ECEN 422 Introduction to Physics and Chemistry of Solids
PHYS 443 Experimental Physics III
PHYS 480 / Introduction to Lasers and Laser Applications
ECEN 480
ASTR 403 Galactic and Extragalactic Astronomy
ASTR 404 Stellar Astrophysics
ASTR 405 Physics of the Solar System
ASTR 407 Physics of the Interstellar Medium
MATH 314 Linear Algebra
or MATH 424 Introduction to Partial Differential Equations
Credit Hours Subtotal: 18
Total Credit Hours 18

2 Up to 3 hours of PHYS 391 may be counted toward these 6 hours by substitution, provided that the research project is approved by the advisor.

Optics and Lasers Option
The Optics and Lasers Option is designed for students intending to pursue graduate study or employment in optical or laser physics or in related engineering disciplines.

Optics and Lasers Option Required courses
PHYS 343 Physics of Lasers and Modern Optics 3
PHYS 441 Experimental Physics I 3
PHYS 452 Optics and Electromagnetic Waves 3
PHYS 480 / Introduction to Lasers and Laser Applications
ECEN 480
ASTR 403 Galactic and Extragalactic Astronomy
ASTR 404 Stellar Astrophysics
ASTR 405 Physics of the Solar System
ASTR 407 Physics of the Interstellar Medium
MATH 314 Linear Algebra
or MATH 424 Introduction to Partial Differential Equations
Credit Hours Subtotal: 18
Total Credit Hours 18

2 Up to 3 hours of PHYS 391 may be counted toward these 6 hours by substitution, provided that the research project is approved by the advisor.

Materials Physics Option
The Materials Physics Option is designed for students intending to pursue graduate study or employment in materials physics or in related disciplines.

Materials Physics Option Required courses
CHEM 114 Fundamental Chemistry II 3
CHEM 221 Elementary Quantitative Analysis 4
MATL 360 Elements of Materials Science 4
MATL 462 X-ray Diffraction 3
or MATL 471 Electron Microscopy of Materials
PHYS 422 / ECEN 422 Introduction to Physics and Chemistry of Solids 3
Select at least 3 hours of the following: 2
CHEM 261 Organic Chemistry
CHEM 481 Physical Chemistry I
ECEN 216 Electronics and Circuits II
PHYS 343 Physics of Lasers and Modern Optics
PHYS 401 Computational Physics
PHYS 441 Experimental Physics I
Credit Hours Subtotal: 20
Total Credit Hours 20

2 Up to 3 hours of PHYS 391 may be counted toward these 3 hours by substitution, provided that the research project is approved by the advisor.

Computational Physics Option
The Computational Physics Option is designed for students intending to pursue graduate study or employment in computational physics or in related disciplines.

Computational Physics Option Required courses
CSCE 155N Computer Science I: Engineering and Science Focus 3
CSCE 156 Computer Science II 4
CSCE 251 Unix Programming Environment 1
PHYS 401 Computational Physics 3
Select at least 6 hours of the following: 2
CSCE 235 Introduction to Discrete Structures
CSCE 310 Data Structures and Algorithms
CSCE 440 / MATH 440 Numerical Analysis I
CSCE 456 Parallel Programming
PHYS 343 Physics of Lasers and Modern Optics
PHYS 441 Experimental Physics I
Credit Hours Subtotal: 17
Total Credit Hours 17
Up to 3 hours of PHYS 391 may be counted toward these 6 hours by substitution, provided that the research project is approved by the advisor.

Bachelor of Arts
Core Requirements
The BA course requirements are designed for students pursuing careers for which the knowledge and methodology of physics are essential.

Physics
PHYS 201 Modern Topics in Physics and Astronomy 1
Select one of the following: 5
PHYS 211 General Physics I
& PHYS 221 and General Physics Laboratory I
(Preferred)
PHYS 141 Elementary General Physics I
Select one of the following: 5
PHYS 212 General Physics II
& PHYS 222 and General Physics Laboratory II
(Preferred)
PHYS 142 Elementary General Physics II
PHYS 213 General Physics III 4
PHYS 223 General Physics Laboratory III 1
PHYS 231 Electrical and Electronic Circuits 3
PHYS 311 Mechanics 3
PHYS 441 Experimental Physics I 3
Credit Hours Subtotal: 25
Mathematics
MATH 106 Calculus I 5
MATH 107 Calculus II 4
MATH 208 Calculus III 4
MATH 221 Differential Equations 3
Credit Hours Subtotal: 16
Chemistry
Select one of the following: 4
CHEM 109 General Chemistry I
CHEM 111 Chemistry for Engineering and Technology
CHEM 113 Fundamental Chemistry I
Credit Hours Subtotal: 4
Total Credit Hours 45
Specific Major Requirements
Additional Physics Courses
Select 9 hours of the following: 2 9
PHYS 343 Physics of Lasers and Modern Optics
PHYS 361 Concepts of Modern Physics
PHYS 451 Electromagnetic Theory
PHYS 461 Quantum Mechanics
PHYS 431 Thermal Physics
PHYS 480 Introduction to Lasers and Laser Applications
Credit Hours Subtotal: 9
Additional Related Courses
Select 6 hours of math, statistics, engineering or science courses at the 300 or 400 level

Additional Major Requirements
Grade Rules
C- and D Grades
A grade of C or above is required for all courses in the major and minor.

Requirements for Minor Offered by Department
Plan A Minor (19 hours)
PHYS 201 Modern Topics in Physics and Astronomy 1
Select one sequence from the following: 10
PHYS 211 General Physics I
& PHYS 221 and General Physics Laboratory I
& PHYS 212 and General Physics II
& PHYS 222 and General Physics Laboratory II
PHYS 141 Elementary General Physics I
& PHYS 142 and Elementary General Physics II
PHYS 213 General Physics III 4
PHYS 223 General Physics Laboratory III 1
Select one of the following: 3-4
Three (3) additional hours chosen from physics courses listed as requirements for the major in physics
ASTR 204 Introduction to Astronomy and
& ASTR 224 Astrophysics
and Astronomy and Astrophysics Laboratory
Total Credit Hours 19
Plan B Minor (15 hours)
PHYS 201 Modern Topics in Physics and Astronomy 1
Select one sequence from the following: 10
PHYS 211 General Physics I
& PHYS 221 and General Physics Laboratory I
& PHYS 212 and General Physics II
& PHYS 222 and General Physics Laboratory II
PHYS 141 Elementary General Physics I
& PHYS 142 and Elementary General Physics II
PHYS 213 General Physics III 4
Total Credit Hours 15
Grade Rules
C- and D Grades
A grade of C or above is required for all courses in the major and minor.
Pass/No Pass
No course taken Pass/No Pass will be counted toward the major or minor.

ASTR 103 Descriptive Astronomy
Description: Approach is essentially nonmathematical. Survey of the nature and motions of the planets, the sun, the stars, and their lives, galaxies, and the structure of the universe. Black holes, pulsars, quasars, and other objects of special interest included.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: ASTR 113; ASTR 203
ACE: ACE 4 Science

ASTR 103H Honors: Descriptive Astronomy
Prerequisites: Good standing in the University Honors Program or by invitation
Notes: Broad look at astronomy for non-science majors.
Description: Approach is essentially nonmathematical, but simple algebra is employed where appropriate. Sun and solar system, the stars, galaxies, and cosmology. Black holes, pulsars, quasars, and other objects of special interest included. Emphasis on both "what is out there" and "how we know it."
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: ASTR 113; ASTR 203
ACE: ACE 4 Science

ASTR 113 Selected Topics in Astronomy
Prerequisites: ASTR 103 or permission.
Description: A non-mathematical continuation and extension of ASTR 103, designed for students who would like a more detailed look at specific areas in astronomy. Possible topics: astronomy and relativity; life in the universe; pulsars, quasars, and black holes; evolution of galaxies, origin of the universe.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: ASTR 113; ASTR 203
ACE: ACE 4 Science

ASTR 117 Life in the Universe
Crosslisted with: BIOS 117, GEOL 117
Description: Survey of what modern science tells us about the possibilities of life elsewhere in the universe. Topics include how the Earth formed and became suitable for life, how life arose on the Earth, the conditions under which life can thrive, places in the solar system that might support life, the existence of other solar systems that might provide suitable habitats, and attempts to find evidence of life on other planets.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
ACE: ACE 4 Science

ASTR 203 Introduction to Observational Astronomy
Prerequisites: ASTR 103/ASTR 103H or equivalent
Notes: The course consists of 2 lecture hours and three evening laboratory hours per week.
Description: Exploration of equipment and techniques needed to observe and investigate the motions and objects in the night sky.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded with Option

ASTR 204 Introduction to Astronomy and Astrophysics
Prerequisites: PHYS 211/211H; MATH 107/107H; parallel ASTR 224
Notes: Survey of the sun, the solar system, stellar properties, stellar systems, interstellar matter, galaxies, and cosmology.
Description: Survey of the sun, the solar system, stellar properties, stellar systems, interstellar matter, galaxies, and cosmology.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: ASTR 224
ACE: ACE 4 Science

ASTR 224 Astronomy and Astrophysics Laboratory
Prerequisites: Parallel ASTR 204.
Description: Telescopic observations and laboratory experiments relating to observational astronomy. Obtaining digital astronomical images, the analysis of the resulting data and its astrophysical interpretation.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Grading Option: Graded with Option

ASTR 403 Galactic and Extragalactic Astronomy
Crosslisted with: ASTR 803
Prerequisites: ASTR 204 and PHYS 213, and permission.
Description: Introduction to the techniques for determining constituents and dynamics of our galaxy, including interstellar matter and theories of spiral arm formation. Extragalactic topics include basic characteristics of galaxies, active galaxies, quasars, evolution, and the cosmological distance scale.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

ASTR 404 Stellar Astrophysics
Crosslisted with: ASTR 804
Prerequisites: ASTR 204; PHYS 213; and permission.
Description: Stellar atmospheres, interiors, and evolution. Theoretical and observational aspects of stellar astronomy. The relation between observed parameters and theoretical parameters, star formation, stellar energy generation, and degenerate stars.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
ASTR 405 Physics of the Solar System
Crosslisted with: ASTR 805
Prerequisites: ASTR 204; MATH 107/107H; PHYS 142/142H or PHYS 212/212H.
Description: Celestial mechanics; tidal effects; planetary interiors; atmospheres and surfaces; comets; asteroids; and the origin of the solar system. Applying physics to the solution of solar system problems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

ASTR 407 Physics of the Interstellar Medium
Crosslisted with: ASTR 807
Prerequisites: ASTR 204 and PHYS 213.
Description: Gaseous nebulae, interstellar dust, interstellar clouds and star forming regions. Theoretical and observational aspects of the various components of the interstellar medium. Includes the physics of emission nebulae, the properties of the interstellar dust, interstellar molecules and the properties of clouds in which star formation occurs.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

ASTR 498 Special Topics
Crosslisted with: ASTR 898
Prerequisites: ASTR 204 and permission.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 9
Grading Option: Graded with Option

PHYS 115 Descriptive Physics
Description: Qualitative approach to physics for the non-science major that emphasizes concepts and how they are used to understand the everyday physical world. Newton's description of motion and forces, the atomic view of matter, kinds and transformations of energy, the nature of electricity and magnetism, sound and light waves, and subatomic particles. Some topics selected according to student interest. Recommended for all students wanting a nonmathematical look at basic discoveries of physics.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

PHYS 141 Elementary General Physics I
Prerequisites: MATH 102 or higher; or qualifying score on Math Placement Exam for MATH 106 or higher.
Notes: Credit toward the degree may be earned in only one of: PHYS 141, 141H and 151.
Description: Short course, without laboratory, for those who need one semester of elementary general physics. Emphasis on understanding our physical environment through application of principles of mechanics, heat, sound, electricity, and light.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded with Option
Prerequisite for: AGRO 458, AGRO 858, NRES 458, NRES 858, SOIL 458; ARCH 333, CNST 305; ATHT 249; FDST 363, MSYM 363; GEOL 400; MSYM 322; MSYM 262; MSYM 342; MSYM 354, SOIL 354, WATS 354; MSYM 364; MSYM 452, MSYM 852, WATS 452, AGRO 452; PHYS 142H
ACE: ACE 4 Science

PHYS 141H Honors: Elementary General Physics I
Prerequisites: Good standing with the University Honors Program; MATH 102 or higher; or qualifying score on Math Placement Exam for MATH 106 or higher.
Notes: Credit toward the degree may be earned in only one of: PHYS 141, 141H and 151.
Description: For course description, see PHYS 141.
Credit Hours: 5
Max credits per semester: 5
Max credits per degree: 5
Grading Option: Graded
Prerequisite for: AGRO 458, AGRO 858, NRES 458, NRES 858, SOIL 458; ARCH 333, CNST 305; ATHT 249; CNST 306; FDST 363, MSYM 363; GEOL 400; MSYM 109L; MSYM 232; MSYM 262; MSYM 342; MSYM 354, SOIL 354, WATS 354; MSYM 364; MSYM 452, MSYM 852, WATS 452, AGRO 452; PHYS 142; PHYS 142H
ACE: ACE 4 Science

PHYS 142 Elementary General Physics II
Prerequisites: PHYS 141 or 141H.
Description: Continuation of PHYS 141. Electricity, magnetism, optics, relativity, atomic and nuclear physics.
Credit Hours: 5
Max credits per semester: 5
Max credits per degree: 5
Grading Option: Graded with Option
Prerequisite for: BIOC 440; CNST 306; PHYS 343; PHYS 361

PHYS 142H Honors: Elementary General Physics II
Prerequisites: Good standing in the University Honors program or by invitation; PHYS 141 or 141H.
Notes: Lab fee required.
Description: For course description, see PHYS 142.
Credit Hours: 5
Max credits per semester: 5
Max credits per degree: 5
Grading Option: Graded
Prerequisite for: BIOC 440; PHYS 343; PHYS 361

PHYS 151 Elements of Physics
Prerequisites: MATH 102 or higher; or qualifying score on Math Placement Exam for MATH 106 or higher.
Notes: Credit toward the degree may be earned in only one of: PHYS 141, 141H and 151.
Description: Short course, without laboratory, for those who need one semester of elementary general physics. Emphasis on understanding our physical environment through application of principles of mechanics, heat, sound, electricity, and light.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded with Option
Prerequisite for: ARCH 333, CNST 305; ATHT 249; CNST 306; FDST 363, MSYM 363; MSYM 109L; MSYM 232; MSYM 262; MSYM 342; MSYM 452, MSYM 852, WATS 354; MSYM 364; MSYM 452, MSYM 852, WATS 452, AGRO 452; PHYS 153
ACE: ACE 4 Science
PHYS 153 Elements of Physics Laboratory
Prerequisites: PHYS 151 or parallel.
Notes: Optional lab to accompany PHYS 151.
Description: Laboratory experiments in mechanics, heat, and wave motion.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Grading Option: Graded with Option

PHYS 198 Special Topics in Physics
Prerequisite for: PHYS 212, PHYS 212H, PHYS 221
Notes: Topic varies.
Credit Hours: 1-6
Min credits per semester: 1
Max credits per semester: 6
Max credits per degree: 6
Grading Option: Graded with Option

PHYS 201 Modern Topics in Physics and Astronomy
Prerequisites: Must be a PHYS major or minor with freshman or sophomore status.
Description: Seminar/workshop that introduces students to topics in modern physics research in basic and applied areas. Students given an understanding of how their studies relate to current progress in physics and astronomy and to prepare for careers in physics-related disciplines.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Grading Option: Graded with Option

PHYS 211 General Physics I
Prerequisites: MATH 106 or parallel
Notes: One year of either high school physics or algebra-based college physics is expected.
Description: Calculus-based course intended for students in engineering and the physical sciences. Mechanics, fluids, wave motion, and heat.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded with Option
Prerequisite for: ARCH 333, CNST 305; AREN 211; ASTR 204; BSEN 244; BSEN 317; ECEN 211; GEOL 400; MECH 223; MECH 223H; MECH 250; METR 205; METR 311; METR 323; MSYM 232; MSYM 262; MSYM 342; MSYM 354, SOIL 354, WATS 354; MSYM 364; MSYM 452, MSYM 852, WATS 452, AGRO 452; PHYS 212; PHYS 212H; PHYS 221
ACE: ACE 4 Science

PHYS 211H Honors: General Physics I
Prerequisites: Physics major or good standing with the University Honors Program; MATH 106 or parallel
Notes: Ambitious students who are not in the Honors Program are encouraged to request permission to enroll.
Description: For course description, see PHYS 211.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded
Prerequisite for: ARCH 333, CNST 305; AREN 211; ASTR 204; BSEN 244; BSEN 317; ECEN 211; GEOL 400; MECH 223; MECH 223H; MECH 250; METR 205; METR 311; METR 323; MSYM 232; MSYM 262; MSYM 342; MSYM 354, SOIL 354, WATS 354; MSYM 364; MSYM 452, MSYM 852, WATS 452, AGRO 452; PHYS 212; PHYS 212H; PHYS 221
ACE: ACE 4 Science

PHYS 212 General Physics II
Prerequisites: PHYS 211 or 211H; MATH 107 or 107H or parallel.
Description: Continuation of PHYS 211. Electricity, magnetism, and optics.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded with Option
Prerequisite for: AGEN 325, BSEN 325; BIOC 440; ECEN 306; MATL 260; MATL 360; MECH 200; MECH 200H; MECH 421, MECH 821, ENGR 421; PHYS 213; PHYS 213H; PHYS 222; PHYS 231; PHYS 311; PHYS 343; PHYS 361
ACE: ACE 4 Science

PHYS 212H Honors: General Physics II
Prerequisites: Physics major or good standing with the University Honors Program; PHYS 211 or 211H; MATH 107 or 107H or parallel.
Notes: Ambitious students who are not in the Honors Program are encouraged to request permission to enroll.
Description: For course description, see PHYS 212.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded
Prerequisite for: ARCH 333, CNST 305; AREN 211; ASTR 204; BSEN 244; BSEN 317; ECEN 306; MATL 260; MATL 360; MECH 200; MECH 200H; MECH 421, MECH 821, ENGR 421; PHYS 213; PHYS 213H; PHYS 222; PHYS 231; PHYS 311; PHYS 343; PHYS 361
ACE: ACE 4 Science

PHYS 213 General Physics III
Prerequisites: PHYS 212 or 212H; MATH 208 or 208H or parallel.
Description: Continuation of PHYS 212. Relativity, quantum mechanics, atoms, and nuclei.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded with Option
Prerequisite for: PHYS 223

PHYS 213H Honors: General Physics III
Prerequisites: Physics major or good standing with the University Honors program; PHYS 212 or 212H; MATH 208 or 208H, or parallel.
Notes: Ambitious students who are not in the Honors Program are encouraged to request permission to enroll.
Description: For course description, see PHYS 213.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded
Prerequisite for: PHYS 223

PHYS 221 General Physics Laboratory I
Prerequisite for: AREN 211; ASTR 204; BSEN 244; BSEN 317; ECEN 211; GEOL 400; MECH 223; MECH 223H; MECH 250; METR 205; METR 311; METR 323; MSYM 232; MSYM 262; MSYM 342; MSYM 354, SOIL 354, WATS 354; MSYM 364; MSYM 452, MSYM 852, WATS 452, AGRO 452; PHYS 212; PHYS 212H; PHYS 221
ACE: ACE 4 Science
PHYS 222 General Physics Laboratory II
Prerequisites: PHYS 212 or 212H or parallel.
Notes: Optional lab to accompany PHYS 212.
Description: Laboratory experiments in electromagnetism and optics.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Grading Option: Graded with Option
Prerequisite for: PHYS 231

PHYS 223 General Physics Laboratory III
Prerequisites: PHYS 213 or 213H or parallel.
Notes: Optional lab to accompany PHYS 213.
Description: Experiments in atomic and nuclear physics.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Grading Option: Graded with Option

PHYS 231 Electrical and Electronic Circuits
Prerequisites: PHYS 212 and 222.
Description: Diode, transistor, and operational amplifier circuits and analog applications; gates, flip-flops, and elementary digital electronics.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

PHYS 260 Liberal Arts Physics: Matter and Motion
Prerequisites: MATH 101 or higher; or qualifying score on Math Placement Exam for MATH 102, 104, or higher.
Notes: PHYS 260 and 261 are independent and may be taken in any order.
Description: Basic concepts of physics in a historical context and in relationship to the intellectual development of humankind. Mechanics, heat gravitation, and structure of the universe.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: PHYS 262

PHYS 261 Liberal Arts Physics: Atoms and Fields
Prerequisites: MATH 101 or higher; or qualifying score on Math Placement Exam for MATH 102, 104, or higher.
Description: Basic concepts of physics in a historical context and in relationship to the intellectual development of humankind. Atomic structure of matter, states of matter, waves, and light. Practical consequences of the properties of matter and physical phenomena.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

PHYS 262 Physical Sciences by Inquiry
Prerequisites: PHYS 260 or PHYS 261 or parallel.
Notes: Intended for students planning to be elementary or middle-level teachers
Description: Selected physical science concepts using inquiry methods.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Grading Option: Graded with Option

PHYS 263 Physical Sciences by Inquiry II
Prerequisites: PHYS 260 or PHYS 261 or parallel.
Description: Selected physical science concepts using inquiry methods for advanced students.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Grading Option: Graded with Option

PHYS 268 Principles of Quantum Physics
Prerequisites: PHYS 212 or 212H or parallel.
Description: Concepts of quantum theory and computational methods.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

PHYS 298 Special Topics in Physics
Prerequisites: Permission.
Credit Hours: 1-12
Min credits per semester: 1
Max credits per semester: 12
Max credits per degree: 12
Grading Option: Graded with Option

PHYS 311 Mechanics
Prerequisites: PHYS 212 or 212H or parallel, MATH 221 or 221H or parallel.
Description: Review of vector operations and of the kinematics and dynamics of a particle. Dynamics of a system of particles, motion of rigid bodies, central force problems, collisions, Lagrangian techniques, oscillations, and coupled oscillators.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

PHYS 343 Physics of Lasers and Modern Optics
Prerequisites: PHYS 142 or 142H or 212 or 212H.
Description: Physical principles and techniques of lasers and modern optics. Emphasis on practical experience with state-of-the-art techniques and applications.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

PHYS 361 Concepts of Modern Physics
Prerequisites: PHYS 142 or 212 with a grade of C+ or better.
Description: Some of the concepts and ideas underlying modern areas of physics through readings from non-technical works by noted physicists and science writers. Includes quantum mechanics, relativity, cosmology, chaos, and examples of modern technology.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
ACE: ACE 10 Integrated Product

PHYS 391 Undergraduate Research
Prerequisites: Permission.
Description: Research participation.
Credit Hours: 1-4
Min credits per semester: 1
Max credits per semester: 4
Max credits per degree: 8
Grading Option: Graded with Option

PHYS 399H Honors Course
Prerequisites: Permission.
Credit Hours: 1-4
Min credits per semester: 1
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Crosslisted with</th>
<th>Prerequisites</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 401</td>
<td>Computational Physics</td>
<td>PHYS 801</td>
<td></td>
<td>A grade of P, C or better in PHYS 311. Re-formulation of physics problems for solution on a computer, control of errors in numerical work, and programming.</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 422</td>
<td>Introduction to Physics and Chemistry of Solids</td>
<td>PHYS 822, ECEN 422, ECEN 822</td>
<td>PHYS 213 or CHEM 481/881, MATH 221/821.</td>
<td>Introduction to structural, thermal, electrical, and magnetic properties of solids, based on concepts of atomic structure, chemical bonding in molecules, and electron states in solids. Principles underlying molecular design of materials and solid-state devices.</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 431</td>
<td>Thermal Physics</td>
<td>PHYS 831</td>
<td></td>
<td>Thermal phenomena from the point of view of thermodynamics, kinetic theory, and statistical mechanics.</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 441</td>
<td>Experimental Physics I</td>
<td>PHYS 841</td>
<td>PHYS 213, 223 and 231</td>
<td>Methods and techniques of modern experimental physics.</td>
<td>3</td>
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<tr>
<td>PHYS 442</td>
<td>Experimental Physics II</td>
<td>PHYS 842</td>
<td>PHYS 441/841 or permission</td>
<td>Continuation of PHYS 441/841.</td>
<td>3</td>
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<tr>
<td>PHYS 443</td>
<td>Experimental Physics III</td>
<td>PHYS 843</td>
<td>PHYS 442/842 or permission</td>
<td>Continuation of PHYS 442/842.</td>
<td>1-3</td>
</tr>
<tr>
<td>PHYS 443</td>
<td>Special Topics in Physics</td>
<td>PHYS 891</td>
<td>PHYS 213 and permission.</td>
<td>Topics vary.</td>
<td>1-3</td>
</tr>
<tr>
<td>PHYS 495</td>
<td>Optics and Electromagnetic Waves</td>
<td>PHYS 852</td>
<td></td>
<td>Production of electromagnetic waves, wave guides and cavities, properties of waves, plane waves, reflection and refraction, interference and coherence phenomena, polarization. Optical properties of matter.</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 461</td>
<td>Atoms, Nuclei, and Elementary Particles</td>
<td>PHYS 862</td>
<td></td>
<td>Basic concepts and experimental foundation for an understanding of the physics of atoms, nuclei, and elementary particles.</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 462</td>
<td>Electromagnetic Theory</td>
<td>PHYS 861</td>
<td>PHYS 213 and 311.</td>
<td>Basic concepts and formalism of quantum mechanics with applications to simple systems.</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 480</td>
<td>Introduction to Lasers and Laser Applications</td>
<td>PHYS 880</td>
<td>PHYS 480, PHYS 880</td>
<td>Physics of electronic transition production stimulated emission of radiation. Threshold conditions for laser oscillation. Types of lasers and their applications in engineering.</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 481</td>
<td>Quantum Mechanics</td>
<td>PHYS 851</td>
<td></td>
<td>Theory of electric and magnetic fields and their interaction with charges and currents, Maxwell's equations, electric and magnetic properties of matter.</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 482</td>
<td>General Physics</td>
<td>PHYS 880</td>
<td></td>
<td>Production of electromagnetic waves, wave guides and cavities, properties of waves, plane waves, reflection and refraction, interference and coherence phenomena, polarization. Optical properties of matter.</td>
<td>3</td>
</tr>
</tbody>
</table>
This document represents a sample 4-year plan for degree completion with this major. Actual course selection and sequence may vary and should be discussed individually with your college or department academic advisor. Advisors also can help you plan other experiences to enrich your undergraduate education such as internships, education abroad, undergraduate research, learning communities, and service learning and community-based learning.

**Physics (B.A.)**

**Physics - Professional (B.S.)**

**Career Information**

*The following represents a sample of the internships, jobs and graduate school programs that current students and recent graduates have reported.*

**Transferable Skills**

- Make predictions using mathematical, statistical, and scientific modeling methods
- Conduct and present research to large and small groups
- Apply mathematical and scientific skills to solve real-world problems
- Analyze and explain data
- Collaborate with a team to develop solutions
- Compose convincing arguments and present logical information
- Comprehend and critically evaluate complex information
- Define problems and identifying causes
- Design and implement research experiments
- Develop and defend evidence based arguments
- Communicate results of scientific experiments to scientific and non-scientific audiences
- Provide a creative, inquisitive approach to problem-solving
- Read, understand, and critically review scientific information
- Understand and practice proper laboratory safety procedures
- Understand and use proper laboratory and technical skills and instruments

**Jobs of Recent Graduates**

- Process Engineer I, Garmin - Olathe KS
- Software Developer, Applied Underwriters - Omaha NE
- Science Teacher, Lincoln Public Schools - Lincoln NE
- Software Developer Engineer, CSG International - Omaha NE
- Systems Programmer, Bryan Health - Lincoln NE
- Loan Advisor, Nelnet - Omaha NE
- Teaching Assistant, University of Nebraska-Lincoln - Lincoln NE
- Science teacher 9-12, Millard Public Schools - Omaha NE
- Technician, JA Woollam - Lincoln NE

**Internships**

- Intern, UNL Holland Computing - Lincoln NE

**Graduate & Professional Schools**

- Ph.D., Physics, Stanford University - Stanford CA
- Ph.D., Astronomy, University of California-Berkeley - Berkeley CA
- Ph.D., Geophysics, California Institute of Technology - Pasadena CA
- Ph.D., Physics, University of Wisconsin-Madison - Madison WI
- Ph.D., Physics, University of California-San Diego - San Diego CA
- Ph.D., Physics, Twin Cities-University of Minnesota - Minneapolis MN
- Ph.D., Chemistry, California Institute of Technology -
- Ph.D., Physics, University of California, Los Angeles - Los Angeles CA
- Master's Degree, Science Teaching, University of Nebraska-Lincoln - Lincoln NE
- Ph.D., Physics, University of Nebraska-Lincoln - Lincoln NE
- Ph.D., Chemical Physics, University of Maryland-College Park - College Park MD
- Medical Doctor, University of Nebraska Medical Center - Omaha NE
- Master's Degree, Engineering, University of Nebraska-Lincoln - Lincoln NE
- Ph.D., Physics, Ohio State University - Columbus OH
- Ph.D, Physics, University of Iowa - Iowa City IA