Welcome

These catalog pages are here to guide you regarding the central facts of the degree programs offered by the Department of Physics and Astronomy. To learn about the student activities, faculty members, research programs, resources, and culture of the Department of Physics and Astronomy, please visit our Departmental Web Site (http://cas.umkc.edu/physics).

Degree Programs

Undergraduate

The Department of Physics and Astronomy offers programs of study leading to the Bachelor of Arts (BA) and Bachelor of Science (BS). The Physics BS degree may be taken with an Emphasis in Astronomy. Through coordination with the School of Computing and Engineering, a program of study can be designed for motivated students that results in a Physics BS and an Electrical & Computer Engineering BS double degree within five years. The department also offers minors in Physics or Astronomy and provides courses for students in the School of Education to meet the requirements for Teacher Certification in Physics.

Graduate

The Department of Physics and Astronomy offers a Master of Science (MS) degree in Physics with thesis and non-thesis options through the College of Arts and Sciences. The Department of Physics is an academic discipline that is eligible for full participation in UMKC’s Interdisciplinary Ph.D. (IPhD) program. Qualified students may select Physics as their coordinating unit or co-discipline when applying for admission or preparing their IPhD plan of study. (Visit the School of Graduate Studies (Catalog (http://catalog.umkc.edu/colleges-schools/graduate-studies), Web (http://sgs.umkc.edu)) for details about the IPhD program.)

Student Support

Advising System

Students who wish to major or minor in Physics should seek the advice of the undergraduate advisor, Professor Fred Leibsle (leibslef@umkc.edu).

Students who wish to minor in Astronomy or pursue the Physics BS with an Emphasis in Astronomy should seek the advice of the undergraduate advisor for astronomy, Professor Dan McIntosh (mcintoshdh@umkc.edu).

Students who wish to pursue graduate studies (MS / IPhD) should seek the advice of the graduate advisor, Professor Da-Ming Zhu (zhud@umkc.edu).

Tutoring

Tutoring is freely available for undergraduate students taking courses from the department. The tutoring room is #259, Flarsheim Hall. Ask your instructor for the tutoring schedule.

Contact

Electronic

Email: physics-astronomy@umkc.edu
Web: http://cas.umkc.edu/physics
Office: (816) 235-1604
Fax: (816) 235-5221

Mailing Address

University of Missouri-Kansas City
Department of Physics and Astronomy
5100 Rockhill Road
Kansas City, MO 64110-2499

Physical Location

5110 Rockhill Road, Room 257
Robert H. Flarsheim Science and Technology Hall (http://www.umkc.edu/virtualtour/flarsheim-hall.asp)

Faculty

Physics & Astronomy Faculty

Department Chair:
Jerzy M. Wrobel
Undergraduate Advisor (Physics):
Fred M. Leibsle

Undergraduate Advisor (Astronomy):
Daniel H. McIntosh

Graduate Advisor:
Da-Ming Zhu

Curators’ Professors:
Wai-Yim Ching, Michael B. Kruger

Professors:
Jerzy M. Wrobel (chair), Da-Ming Zhu, Anthony N. Caruso

Associate Professors:
Fred M. Leibsle, Elizabeth P. Stoddard, Daniel H. McIntosh

Assistant Professors:
Mark Brodwin, Paul M. Rulis

Assistant Teaching Professor:
Robert C. Riggs

Professors Emeriti:
Paul J. Bryant, Richard D. Murphy, Marvin R. Querry (Curators’ Professor), George A. Russell (President Emeritus, University of Missouri), John R. Urani

Associate Professors Emeriti:
James R. Beacham, Richard C. Waring

James R. Beacham, associate professor emeritus of physics; B.S., M.S., Ph.D. (Purdue University).

Mark Brodwin\textsuperscript{2,3} Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=brodwin); assistant professor of physics; B.S. (McGill University); M.S., Ph.D. (University of Toronto).

Paul J. Bryant; professor emeritus of physics; B.S. (Rockhurst College); M.S., Ph.D. (St. Louis University).

Anthony Caruso\textsuperscript{2,3} Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=priour); associate professor of physics; B.A. (Bethany College); M.S., Ph.D. (University of Nebraska).

Wai-Yim Ching\textsuperscript{2,3} Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=ching); curators’ professor of physics; B.S. (University of Hong Kong); M.S., Ph.D. (Louisiana State University).

Y. C. Jerry Jean\textsuperscript{2,3} Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=jean); professor of chemistry and physics; B.S. (Taipei Institute of Technology Taiwan); Ph.D. (Marquette University).

Michael B. Kruger\textsuperscript{2,3} Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=kruger); chair, department of physics, and curators’ professor of physics; B.S. (State University of New York-Stony Brook); Ph.D.(University of California-Berkeley).

Fred M. Leibsle\textsuperscript{2,3} Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=leibsle); associate professor of physics; B.S. (University of Wisconsin); Ph.D. (University of Illinois).

Daniel H. McIntosh\textsuperscript{2,3} Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=mcintosh); assistant professor of physics; B.S. (University of California, LA); Ph.D. (University of Arizona).

Richard D. Murphy\textsuperscript{2,3} Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=murphy); professor emeritus of physics; B.A. (University of Colorado); M.A., Ph.D. (University of Minnesota).

Marvin R. Querry; former vice chancellor, academic affairs, and curators’ professor emeritus of physics; B.S. (University of Missouri-Kansas City); M.S., Ph.D. (Kansas State University).

Paul Rulis\textsuperscript{2,3} Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=rulis); assistant professor of physics; B.S. (Virginia Tech); M.S., Ph.D. (University of Missouri-Kansas City).
George A. Russell; president emeritus, University of Missouri, and professor emeritus of physics; B.S. (Massachusetts Institute of Technology); M.S., Ph.D. (University of Illinois).

Elizabeth P. Stoddard Contact Information https://cf1.umkc.edu/intapps/lookup/?LastName=stoddard; associate professor of physics; B.A. (William Jewell College); M.S., Ph.D. (Washington University).

John R. Urani Contact Information https://cf1.umkc.edu/intapps/lookup/?LastName=urani; professor emeritus of physics; B.S., M.S., Ph.D. (University of Missouri-Columbia).

Richard C. Waring; associate professor emeritus; B.A. (William Jewell College); M.A. (University of Arkansas).

Jerzy Wrobel Contact Information https://cf1.umkc.edu/intapps/lookup/?LastName=wrobel; professor of physics; M.S., Ph.D. (Wroclaw Technical University).

Da-Ming Zhu Contact Information https://cf1.umkc.edu/intapps/lookup/?LastName=zhu; professor of physics; B.S. (University of Science and Technology of China); M.S., Ph.D. (University of Washington).

1 Associate or Adjunct Graduate Faculty
2 Members of UMKC Graduate Faculty
3 Members of UMKC Doctoral Faculty
4 Located at UM-St. Louis campus

Undergraduate Admissions

Undergraduate Admissions

There are no special prerequisites for beginning either the Bachelor of Arts (BA) or the Bachelor of Science (BS) degree programs in Physics. High-school physics and a good working knowledge of algebra and arithmetic are desirable for entering the BS program. However, any deficiencies may be overcome by taking the appropriate coursework. In order to ensure that the appropriate courses are taken, students are encouraged to consult with the undergraduate advisor for physics (Professor Fred Leibsle, leibslef@umkc.edu) or the undergraduate advisor for astronomy (Professor Dan McIntosh, mcintoshdh@umkc.edu) before beginning the major.

Students that are interested in pursuing Teacher Certification in Physics should contact the School of Education (Catalog, Web) for admissions and advising.

Undergraduate Degrees

- Bachelor of Science: Physics (http://catalog.umkc.edu/colleges-schools/arts-sciences/academic-departments-programs/physics-astronomy/physics-bs)
- Bachelor of Science: Physics with an Emphasis in Astronomy (http://catalog.umkc.edu/colleges-schools/arts-sciences/academic-departments-programs/physics-astronomy/physics-bs-astro-emph)
- Bachelor of Science: Physics and Electrical & Computer Engineering Double Degree (http://catalog.umkc.edu/colleges-schools/arts-sciences/academic-departments-programs/physics-astronomy/physics-engineering)
- Bachelor of Arts: Physics (http://catalog.umkc.edu/colleges-schools/arts-sciences/academic-departments-programs/physics-astronomy/physics-ba)
- Physics Minor (http://catalog.umkc.edu/colleges-schools/arts-sciences/academic-departments-programs/physics-astronomy/physics-minor)
- Astronomy Minor (http://catalog.umkc.edu/colleges-schools/arts-sciences/academic-departments-programs/physics-astronomy/astronomy-minor)
- Teacher Certification in Physics (http://catalog.umkc.edu/colleges-schools/arts-sciences/academic-departments-programs/physics-astronomy/teacher-certification-physics)

Career Implications of the Bachelor's Degree in Physics

The BS/BA degree is recommended for students interested in seeking employment in any organization that requires a strong science or technology background. Graduates with a physics degree who enter fields other than science and technology generally find that the reasoning skills and quantitative problem-solving strategies that are developed in a physics program will help their career advancement.

Students that earn a BS degree in Physics are well positioned for continuing their education in graduate school and professional/medical school while those attaining a BS or BA degree in Physics are well positioned for entering the job market in virtually any field of endeavor. There are many career opportunities for holders of either the BS or BA degree in Physics including such possibilities as: researcher in a government/corporate lab, engineer (electrical, mechanical, etc.), science journalist, technology entrepreneur, financial/actuarial analyst, hardware/software developer, chemist, K-12 educator, materials scientist, meteorologist/seismologist, health practitioner, legal analyst, elected political official, etc.
Graduate
Graduate Degrees:

- Master of Science in Physics (http://catalog.umkc.edu/colleges-schools/arts-sciences/academic-departments-programs/physics-astronomy/master-of-science-physics)
- Interdisciplinary Ph.D. Program in Physics (School of Graduate Studies Catalog Section) (http://catalog.umkc.edu/colleges-schools/graduate-studies/physics)

Astronomy Courses

ASTR 150 Astronomy: Motions of the Cosmos Credits: 3
An introductory exploration of modern topics in astronomy with an emphasis on developing conceptual models for the fundamental laws of gravity and motion crucial to the formation of stars and planetary systems, the growth of black holes and galaxies, and the evolution of cosmic structure.
Cross Listings: NAT-SCI 150, PHY-SCI 150, PHYSICS 150.

ASTR 153L Introductory Astronomy Laboratory Credits: 2
An introductory exploration of astronomical phenomena and concepts through quantitative laboratory activities requiring data collection, analysis and interpretation. This course is open to students from all majors.
Cross Listings: NAT-SCI 153L, PHY-SCI 153L, PHYSICS 153L.

ASTR 155 Astronomy: Starlight and Star Stuff Credits: 3
An introductory exploration of modern topics in astronomy with an emphasis on developing conceptual models for the interactions between light and matter crucial to the life and death of stars, the analysis of starlight and interstellar chemistry, and the interpretation of cosmic history.

ASTR 353 Practical Astronomy Credits: 3
A practical overview of the basic methods of observational astronomy research, including the principles of telescopes, detectors and measurement theory.
Prerequisites: PHYSICS 240 PHYSICS 250, MATH 210 or MATH 220.
Cross Listings: PHYSICS 353.

ASTR 355 Stellar Astrophysics Credits: 3
A mathematical and conceptual overview of the observed properties of stars and the fundamental astrophysics of radiative transfer, hydrostatic equilibrium, atomic processes and thermonuclear energy production that govern their structure, atmospheres and remnants.
Prerequisites: PHYSICS 240 PHYSICS 250, MATH 210 or MATH 220.
Cross Listings: PHYSICS 355.

ASTR 356 Galaxies Credits: 3
A mathematical and conceptual overview of the observed properties and astrophysics of galaxies highlighting star formation and evolution, the interstellar medium, the Milky Way, galaxy populations and demographics, active galactic nuclei, and galaxy formation and evolution.
Prerequisites: PHYSICS 240 PHYSICS 250, MATH 210 or MATH 220.
Cross Listings: PHYSICS 356.

ASTR 465 Cosmology Credits: 3
This course provides a foundation in both physical and observational cosmology. Students will acquire both a mathematical and conceptual understanding of the formation and dynamics of the Universe.
Prerequisites: PHYSICS 240 PHYSICS 250, MATH 210 or MATH 220.
Cross Listings: PHYSICS 465.

Physical Science Courses

PHY-SCI 110 Foundations Of Physical Sciences I Credits: 4
Fundamental principles and concepts of the various physical and mathematical sciences, integrated by the history and philosophy of science.

PHY-SCI 110L Foundations Of Physical Sciences, Laboratory I Credit: 1
General laboratory and discussion sessions on various topics in the physical and mathematical sciences.

PHY-SCI 130 Physics of Sports Credits: 3
A course intended for liberal arts students focusing on the physics involved in different sports. Physical laws and technological developments that impact sports will be studied.
Cross Listings: PHYSICS 130 and NAT-SCI 130.
PHY-SCI 140 How Things Work Credits: 3
A course intended for liberal arts students focusing on the principles of operations, histories, and relationships of objects from our daily environment. The areas of investigation include mechanical and thermal objects, electromagnetism, light, special materials and nuclear energy.

Co-requisites: PHY-SCI 140L.

Cross Listings: PHYSICS 140, NAT-SCI 140.

PHY-SCI 140L How Things Work Laboratory Credit: 1
Simple experiments based on everyday experiences are analyzed in terms of conceptual physics. The material includes elements of mechanics of a rigid body, elastic properties of matter, fluid dynamics, thermodynamics, electromagnetism, optics and modern physics.

Co-requisites: PHY-SCI 140.

Cross Listings: PHYSICS 140L and NAT-SCI 140L.

PHY-SCI 150 Astronomy: Motions of the Cosmos Credits: 3
An introductory exploration of modern topics in astronomy with an emphasis on developing conceptual models for the fundamental laws of gravity and motion crucial to the formation of stars and planetary systems, the growth of black holes and galaxies, and the evolution of cosmic structure.

Cross Listings: ASTR 150, PHYSICS 150, NAT-SCI 150.

PHY-SCI 153L Introductory Astronomy Laboratory Credits: 2
An introductory exploration of astronomical phenomena and concepts through quantitative laboratory activities requiring data collection, analysis and interpretation. This course is open to students from all majors. Concurrent enrollment in either PHY-SCI 150 or PHY-SCI 155 is encouraged but not required.

Cross Listings: PHYSICS 153L and PHY-SCI 153L.

PHY-SCI 155 Astronomy: Starlight and Star Stuff Credits: 3
An introductory exploration of modern topics in astronomy with an emphasis on developing conceptual models for the interactions between light and matter crucial to the life and death of stars, the analysis of starlight and interstellar chemistry, and the interpretation of cosmic history.

Cross Listings: ASTR 155, PHYSICS 155, NAT-SCI 155.

PHY-SCI 171 Physics For Future Presidents Credits: 3
A course intended for liberal arts students focusing on the physics they need to be informed citizens in a democracy. Energy, global warming, terrorism, and health are examples of the important topics examined from the perspective of how science should inform policy.

Cross Listings: PHYSICS 171, NAT-SCI 171.

PHY-SCI 410A Selected Topics In Contemporary Science Credits: 3
PHY-SCI 410B Selected Topics In Contemporary Science Credits: 3
PHY-SCI 410C Selected Topics in Contemporary Science Credits: 3
PHY-SCI 410P Selected Topics In Contemporary Science Credits: 3
Selected Topics In Contemporary Science
PHY-SCI 410PF Selected Topics In Contemporary Science Credits: 3
PHY-SCI 435 Selected Topics In The History Of Science Credits: 3
Selected Topics In The History Of Science
PHY-SCI 435P Selected Topics In The History Of Science Credits: 3
PHY-SCI 435PF Selected Topics In The History Of Science Credits: 3

Physics Courses

PHYSICS 130 Physics of Sports Credits: 3
A course intended for liberal arts students focusing on the physics involved in different sports. Physical laws and technological developments that impact sports will be studied.

Cross Listings: NAT-SCI 130, PHY-SCI 130.

PHYSICS 131L Backyard Physics Credit: 1
This laboratory course uses readily available ingredients to develop a conceptual understanding of the laws of nature and mathematics. Experiments can be conducted in the residence hall, apartment, park or home using everyday, inexpensive equipment and materials.

PHYSICS 140 How Things Work Credits: 3
A course intended for liberal arts students focusing on the principles of operations, histories, and relationships of objects from our daily environment. The areas of investigation include mechanical and thermal objects, electromagnetism, light, special materials and nuclear energy.

Co-requisites: PHYSICS 140L.

Cross Listings: NAT-SCI 140 and PHY-SCI 140.
PHYSICS 140L How Things Work Laboratory Credit: 1
A course intended for liberal arts students focusing on the principles of operations, histories and relationships of objects from our daily environment. The areas of investigation include mechanical and thermal objects, electromagnetism, light, special materials and nuclear energy.
Co-requisites: PHYSICS 140.

Cross Listings: NAT-SCI 140L and PHY-SCI 140L.

PHYSICS 150 Astronomy: Motions of the Cosmos Credits: 3
An introductory exploration of modern topics in astronomy with an emphasis on developing conceptual models for the fundamental laws of gravity and motion crucial to the formation of stars and planetary systems, the growth of black holes and galaxies, and the evolution of cosmic structure.
Cross Listings: NAT-SCI 150, PHY-SCI 150, ASTR 150.

PHYSICS 153L Introductory Astronomy Laboratory Credits: 2
An introductory exploration of astronomical phenomena and concepts through quantitative laboratory activities requiring data collection, analysis and interpretation. This course is open to students from all majors. Concurrent enrollment in either Physics 150 or Physics 155 is encouraged but not required.

PHYSICS 155 Astronomy: Starlight and Star Stuff Credits: 3
An introductory exploration of modern topics in astronomy with an emphasis on developing conceptual models for the interactions between light and matter crucial to the life and death of stars, the analysis of starlight and interstellar chemistry, and the interpretation of cosmic history.

PHYSICS 171 Physics for Future Presidents Credits: 3
A course intended for liberal arts students focusing on the physics they need to be informed citizens in a democracy. Energy, global warming, terrorism, and health are examples of the important topics examined from the perspective of how science should inform policy.

PHYSICS 210 General Physics I Credits: 4
Introduction to mechanics, wave motion and sound and heat and thermodynamics. Three hours lecture and two hours laboratory per week.
Co-requisites: At least MATH 110, MATH 120 suggested.

PHYSICS 220 General Physics II Credits: 4
Introduction to electricity and magnetism, light and optics and modern physics. Three hours lecture and two hours laboratory per week.
Prerequisites: Physics 210.

PHYSICS 240 Physics For Scientists and Engineers I Credits: 5
Introduction to mechanics, wave motion and sound and heat and thermodynamics.

PHYSICS 250 Physics For Scientists and Engineers II Credits: 5
Introduction to electricity and magnetism, light and optics and modern physics. Four hours lecture and two hours laboratory per week.
Prerequisites: PHYSICS 240.
Co-requisites: MATH 220.

PHYSICS 310 Mechanics I Credits: 3
Advanced statics and dynamics of particles and rigid bodies including gravitation.
Prerequisites: One year of physics and calculus.

PHYSICS 311 Mechanics II Credits: 3
Continuation of Mechanics I, including mechanics of continuous media, Lagranges equations, tensor algebra and theory of small vibrations.
Prerequisites: PHYSICS 310.

PHYSICS 330 Methods Of Theoretical Physics I Credits: 3
Introduction to mathematical and numerical methods used in the theoretical modeling of physical systems. Treatments of linear systems in scientific and engineering applications will be emphasized.
Prerequisites: Math 250.

PHYSICS 350 Modern Physics With Engineering Applications Credits: 3
An introduction to the theories that revolutionized science and technology in the twentieth century. Topics include special and general relativity, introductory quantum mechanics and atomic structure. Inventions and applications based on these are also examined.
Prerequisites: MATH 210 and MATH 220 and either PHYSICS 210 or PHYSICS 240 and PHYSICS 250.
PHYSICS 353 Practical Astronomy Credits: 3
A practical overview of the basic methods of observational astronomy research, including the principles of telescopes, detectors and measurement theory.
**Prerequisites:** PHYSICS 240 and PHYSICS 250, MATH 210 or MATH 220.

**Cross Listings:** ASTR 353.

PHYSICS 355 Stellar Astrophysics Credits: 3
A mathematical and conceptual overview of the observed properties of stars and the fundamental astrophysics of radiative transfer, hydrostatic equilibrium, atomic processes and thermonuclear energy production that govern their structure, atmospheres and remnants.
**Prerequisites:** PHYSICS 240 and PHYSICS 250, MATH 210 or MATH 220.

**Cross Listings:** ASTR 355.

PHYSICS 356 Galaxies Credits: 3
A mathematical and conceptual overview of the observed properties and astrophysics of galaxies highlighting star formation and evolution, the interstellar medium, the Milky Way, galaxy populations and demographics, active galactic nuclei, and galaxy formation and evolution.
**Prerequisites:** PHYSICS 240 and PHYSICS 250, MATH 210 or MATH 220.

**Cross Listings:** ASTR 356.

PHYSICS 385L Physics of Electronics Credits: 3
An introduction to the solid state physics of basic electronic components and their operation through both theory and practical labwork.
**Prerequisites:** PHYSICS 220 or PHYSICS 250.

PHYSICS 395L Computer Interfacing Laboratory Credits: 3
An introduction to data acquisition and automation by computer interfacing transduction and control equipment through the serial and parallel buses. The course is multidisciplinary, balancing the physics of transduction to the computer science of automation programming to the electrical engineering of bus protocols. Both high- and low-level programming are taught within the context of automating an experimental procedure. Digital-to-analog and analog-to-digital conversion is also covered.
**Prerequisites:** PHYSICS 385L.

PHYSICS 410 Thermal Physics Credits: 3
A study of the laws of thermodynamics and their applications, with an introduction to kinetic theory. Statistical methods are emphasized.
**Prerequisites:** One year of physics and calculus.

PHYSICS 420 Optics Credits: 3
Geometrical optics, physical optics and introduction to selected topics in modern optics.
**Prerequisites:** One year of physics and MATH 210 and MATH 216.

PHYSICS 437 Particle Physics Credits: 3
Essential aspects of modern physics are examined in a historical context, and also in terms of the standard model describing concisely the fundamental interactions among particles. Conservation laws are discussed, and recent developments such as String Theory are considered. Physics 437 is also offered as Physics 5537.
**Prerequisites:** PHYSICS 240, PHYSICS 250, PHYSICS 350 or PHYSICS 472.

PHYSICS 450 Introduction To Solid State Physics Credits: 3
Crystal structure and binding, elementary lattice dynamics and energy band theory. Free electron models, theory of semiconductors and metals.
**Prerequisites:** PHYSICS 310 or PHYSICS 410.

PHYSICS 460 Electricity And Magnetism I Credits: 3
Static electric fields in free space and material media; Kirchoff’s laws and direct current circuits; static magnetic fields.
**Prerequisites:** One year of physics and calculus.

PHYSICS 461 Electricity And Magnetism II Credits: 3
Magnetostatics; alternating current circuits; Maxwell’s equations and radiation; special relativity; topics in electromagnetism.
**Prerequisites:** PHYSICS 460.

PHYSICS 465 Cosmology Credits: 3
This course provides a foundation in both physical and observational cosmology. Students will acquire both a mathematical and conceptual understanding of the formation and dynamics of the Universe.
**Prerequisites:** PHYSICS 240 and PHYSICS 250, MATH 210 or MATH 220.

**Cross Listings:** ASTR 465.
PHYSICS 472 Introduction To Quantum Mechanics Credits: 3
Introduction to the theory and applications of quantum mechanics with emphasis on the mathematical treatment of modern physics.
Prerequisites: PHYSICS 350.

PHYSICS 476LW Advanced Laboratory Credits: 3
This course offers a selection of important experiments in physics, performed with modern instrumentation. It is designed to give students a deeper understanding of physics and help them develop experimental abilities and improve their communication skills.
Prerequisites: RooWriter.
Co-requisites: PHYSICS 350.

PHYSICS 490 Special Problems Credits: 1-3
The kind of problem and the amount of credit to be given by arrangement with the department.

PHYSICS 499 Undergraduate Research Credits: 1-3
Independent student research on a physics/astrophysics project under the supervision of a faculty member. Projects will engage students in aspects of the scientific process including data collection and analysis, research methods and strategies, scientific discussion and written/oral communication. Requires a minimum of 3-4 hours of research per week for each credit hour.

PHYSICS 5500 Methods Of Mathematical Physics I Credits: 3
Intended to provide the student with the advanced mathematical techniques needed for beginning graduate studies in the physical sciences. Content includes real variables, infinite series, complex analysis, linear algebra and partial differential equations.

PHYSICS 5501 Methods Of Mathematical Physics II Credits: 3
A continuation of Physics 500 which includes Sturm-Liouville operators, special functions, Fourier transforms, distributions and Green functions, Laplace transforms, linear groups and tensor analysis.

PHYSICS 5505 Survey Of Recent Development In Physics Credits: 3
Specifically designed to help high school and junior college science teachers keep pace with current developments in various subdivisions of physics and their impact on society and technology. (Not applicable for graduate degree in Physics).
Prerequisite: Baccalaureate degree and one year science teaching experience.

PHYSICS 5510 Theoretical Mechanics I Credits: 3
A review of undergraduate mechanics precedes the study of generalized classical mechanics in this course. Topics include variational principles, Lagrangian and Hamilton methods, conservation laws and Hamilton-Jacobi theory.

PHYSICS 5511 Theoretical Mechanics II Credits: 3
A continuation of PHYSICS 5510, this course covers topics such as normal coordinates, small oscillations, continuum mechanics and special/general relativity.

PHYSICS 5520 Electromagnetic Theory And Applications I Credits: 3
Electrostatics, magnetostatics and various approaches in solving boundary value problems of electromagnetism, Green’s functions, conformal transformations and polynomial expansions, Maxwell’s equations and waves.

PHYSICS 5521 Electromagnetic Theory And Applications II Credits: 3
Waveguides, fiber optics, radiation systems and antenna for wireless communications, scattering and diffraction of electromagnetic waves, multipole fields, special relativity and relativistic particle dynamics and radiation.

PHYSICS 5530 Quantum Mechanics I Credits: 3
Review of elementary methods, formal preliminaries, axioms, commuting operators, angular momentum, static perturbation theory, Wigner-Eckart theorem.

PHYSICS 5531 Quantum Mechanics II Credits: 3
Time dependent perturbation theory, scattering, applications to atoms, molecules and nuclei, reactions, relativistic methods.

PHYSICS 5535 Optical Properties Of Matter Credits: 3
Maxwell’s equations and the dielectric function, absorption and dispersion, free-electron metals, interband transitions, dispersion relations and sum rules, self-consistent field approximation, current-current correlations and the fluctuation-dissipation theorem, plasmons and characteristic energy loss.
Prerequisites: PHYSICS 450, PHYSICS 460, PHYSICS 461, PHYSICS 472, PHYSICS 5500.

PHYSICS 5537 Particle Physics Credits: 3
Essential aspects of modern particle physics are examined in a historical context, and also in terms of the standard model describing concisely the fundamental interactions among particles. Conservation laws are discussed, and recent developments such as String Theory are considered.
Prerequisites: (for undergraduates) PHYSICS 240, PHYSICS 250, and PHYSICS 350 or PHYSICS 472.

Cross Listings: PHYSICS 437.
PHYSICS 5540 Statistical Physics I Credits: 3
Statistical mechanics as a basis for thermodynamics; classical distribution functions; quantum statistical mechanics, kinetic theory, transport phenomena; application to systems of interacting particles.
**Prerequisites:** PHYSICS 410, PHYSICS 472.

PHYSICS 5541 Statistical Physics II Credits: 3
Special topics in advanced statistical physics including: second quantization, modern many body theory, interacting Fermi and Bose systems, superfluidity and superconductivity, renormalization group and computer simulation techniques.
**Prerequisites:** PHYSICS 5540.

PHYSICS 5550 Atomic And Molecular Structure Credits: 3
Experimental results and theoretical models by quantum mechanics. Special emphasis on the interaction between radiation and matter.

PHYSICS 5553 Practical Astronomy Credits: 3
A practical overview of the basic methods of observational astronomy research, including the principles of telescopes, detectors and measurement theory, as well as hands-on experience with data reduction and analysis. This course is open to graduate students from all majors.

PHYSICS 5555 Stellar Astrophysics Credits: 3
A mathematical and conceptual overview of the observed properties of stars and the fundamental astrophysics of radiative transfer, hydrostatic equilibrium, atomic processes and thermonuclear energy production that govern their structure, atmospheres and remnants.

PHYSICS 5556 Galaxies Credits: 3
A mathematical and conceptual overview of the observed properties and astrophysics of galaxies highlighting star formation and evolution, the interstellar medium, the Milky Way, galaxy populations and demographics, active galactic nuclei, and galaxy formation and evolution.

PHYSICS 5560 Nuclear Physics Credits: 3
Fundamental properties of the atomic nucleus discussed in terms of experimental results and theoretical models. Quantum and statistical mechanics are used where appropriate.

PHYSICS 5565 Cosmology Credits: 3
This course provides a foundation in both physical and observational cosmology. Students will acquire both a mathematical and conceptual understanding of the formation and dynamics of the Universe.

PHYSICS 5570 Quantum Theory Of Solids I Credits: 3

PHYSICS 5571 Quantum Theory Of Solids II Credits: 3
Topics will include crystal imperfections, impurities and defects, optical properties of metals and semiconductors, electron-lattice interaction and transport theory, superconductivity and theory of disordered systems.

PHYSICS 5580 Physics Seminar Credit: 1
Contemporary publications and research.

PHYSICS 5585 Physics of Electronics Credits: 3
An introduction to the solid state physics of basic electronic components and their operation through both theory and practical lab work.

PHYSICS 5590 Topics In Physics Credits: 1-3
Contemporary publications and research.

PHYSICS 5590A Topics In Physics Credits: 1-3
Contemporary publications and research.

PHYSICS 5590B Special Topics Credits: 1-3

PHYSICS 5590R Topics in Physics Credits: 1-3
Contemporary publications and research.

PHYSICS 5595L Computer Interfacing Laboratory Credits: 3
An introduction to computer interfacing through the use of serial and parallel ports and digital-to-analog and analog-to-digital converters. The course also introduces digital filtering techniques, data analysis techniques, and graphical presentation of data. The programming techniques are taught using high level programming languages currently used in research and development labs.

PHYSICS 5599 Research And Thesis Credits: 1-9
Research for thesis in partial fulfillment of the master’s degree in physics.

PHYSICS 5680 Research Seminar Credits: 1-2
Seminars on current research topics of research programs in the department and those of external distinguished scientists. (Must be taken by Physics Ph.D. students).
PHYSICS 5690 Special Research Topics Credits: 1-3
A lecture course presenting advanced research-level topics. **Prerequisites:** Ph.D. candidacy. This course is intended to allow faculty and visiting scholars to offer special courses in selected research areas.

PHYSICS 5699 Research And Dissertation Credits: 1-9
Research for dissertation in partial fulfillment of the Ph.D. degree requirements in physics.

PHYSICS 5899 Required Graduate Enrollment Credit: 1

PHYSICS H150 Honors: Introduction To Astronomy Credits: 3
Honors: Introduction To Astronomy

PHYSICS H220 General Physics II Credits: 4
Fundamental principles of physics including sound, electricity, magnetism, optics, elementary modern physics, and applications of these principles to different interdisciplinary natural science. **Prerequisites:** PHYSICS 210 (or equivalent).

PHYSICS H240 Physics For Science And Engineering I Credits: 5
Introduction to mechanics, wave motion and sound and heat and thermodynamics. **Co-requisites:** MATH 210.

PHYSICS H250 Physics For Science And Engineering II Credits: 5
Introduction to electricity and magnetism, light and optics and modern physics. **Prerequisites:** PHYSICS 240. **Co-requisites:** MATH 220.