PHYSICS

Physics is the most fundamental of the sciences. It explains how the physical world works and lies at the foundation of nearly all technical fields. All natural phenomena obey the laws of physics. Physicists express these laws in mathematical form, so that they can be applied to predict the behavior of all forms of matter and energy, ranging from the subatomic physics of quarks, gluons, nuclei, and electrons, to the astrophysics of planets, stars, black holes, and galaxies. Physics forms the foundation for modern technologies ranging from advanced materials to lasers used in high-speed communications and surgery, modern electronics, quantum devices for sensors and cryptography, as well as the radiation detectors and optical elements used in space telescopes.

The Missouri S&T physics department provides numerous opportunities for students to participate in cutting-edge scientific research supervised by departmental faculty. Topics include collisions between electrons, atoms, and ions; exotic interactions between atoms and ultrafast lasers; the electronic, magnetic, optical, and mechanical properties of new materials, quantum phenomena at ultralow temperatures; dark energy and the large-scale structure of the universe, as well as gravitational wave astronomy. Missouri S&T physics students often present their work at research competitions throughout the state and at national scientific meetings.

After receiving a solid foundation in the basic physics governing the behavior of matter and energy, you will be able to choose among advanced level courses to satisfy your interests. Courses available to upper-level students include astrophysics; atomic physics; solid state physics; nuclear and particle physics; optics, quantum mechanics, general relativity, and others. The curriculum also includes advanced laboratory courses where you will design and participate in original research with other enthusiastic physics majors.

In addition, the program is designed with many electives that allow physics majors to tailor their undergraduate education to their own interests. With 48 credit hours in physics, 21 in mathematics, 24 in the humanities and social sciences, 9 in chemistry, and 3 in computer science, the rest of the 120 hours are in electives that you select in consultation with your advisor. Many physics majors choose to use their electives to study other technical areas, such as mathematics, computer science, or electrical engineering. Some students get dual bachelor's degrees, with their second degree in one of these or other areas. Because there is considerable overlap in degree requirements, a dual degree usually requires no more than one extra semester of undergraduate study.

Physics majors have broad career perspectives, from academic research to industry, spanning fields from technology to medicine, finance, and law. About two- thirds of our graduates go on to graduate school, many at some of the most prestigious first-tier schools in the country. Those who complete their physics education with a bachelor's degree have been very successful in finding exciting employment opportunities in today's high-tech industries. Missouri S&T physics graduates have gone on to lead and manage major research efforts at leading industrial companies, to be professors and chairmen at leading academic universities, and to work in areas ranging from law and medicine to ecophysics and astrophysics.

Bachelor of Science Physics

A minimum of 120 credit hours is required for a bachelor of science degree in physics and an average of at least two grade points per credit hour must be obtained. These requirements for the B.S. degree are in addition to credit received for algebra, trigonometry, and basic ROTC.

The physics curriculum requires twelve semester hours in humanities, exclusive of foreign language, and must include ENGLISH 1160 or ENGLISH 3560. A minimum of nine semester hours is required in social sciences, including either HISTORY 1300, HISTORY 1310, HISTORY 1200, or POL SCI 1200. Specific requirements for the bachelor degree are outlined in the sample program listed below

Freshman Year

First Semester	Credits	Second Semester	Credits
CHEM 1310	4	CHEM 1320	3
CHEM 1319	1	HISTORY 1200, or 1300, or 1310, or POL SCI 1200	3
CHEM 1100	1	PHYSICS 1135	4
ENGLISH 1120	3	MATH 1215	4
PHYSICS 1101	1		
MATH 1214 or 1211	4		
	14		**14**

Sophomore Year

First Semester	Credits	Second Semester	Credits
ENGLISH 1160	3	MATH 3304	3
MATH 2222	4	PHYSICS 2129	3
COMP SCI 1500 or 1972 ***and*** 1982	3	PHYSICS 2305	3
PHYSICS 2135	4	PHYSICS 2401	3
Elective[1]	3	Elective[1]	3
	17		**15**

Junior Year

First Semester	Credits	Second Semester	Credits
PHYSICS 3201	3	PHYSICS 3211	3
PHYSICS 3119	3	PHYSICS 3129	3
Physics Area Focus Course[4]	3	Math/Stat Elective[2]	3
Math/Stat Elective[2]	3	Electives[1]	6
Electives[1]	3		
	15		**15**

Senior Year

First Semester	Credits	Second Semester	Credits
PHYSICS 4211	3	PHYSICS 4311	3
PHYSICS 4301	3	Physics Elective[3]	3
Physics Area Focus Course[4]	3	Electives[1]	9
Electives[1]	6		
	15		**15**

Total Credits: 120

Note: The minimum credit hours required for a bachelor of science in physics is 120 hours. No more than two of the required physics and mathematics courses with a grade of “D” may be used to meet

graduation requirements. Upon petition to and approval by the physics faculty, three semester hours of advanced ROTC (military science or aerospace credit studies) credit can be counted as elective credit to meet requirements for graduation.

1 30 hours of electives are required in addition to the math/stat electives[2], physics electives[3], and physics area focus courses[4]. These electives shall include six hours of social studies and nine hours of humanities. At least three of the humanity hours must be literature and at least three must be at the 3000 level or above not including Special Problems courses (PHILOS 4345 recommended). 15 hours of free electives may be used to develop an emphasis area. At least 15 hours of elective credit shall be in courses at the 3000 level or above.

2 Six hours of mathematics or statistics beyond MATH 3304 are required. MATH 3108, MATH 5222, MATH 5325, or MATH 5351 are recommended.

3 In addition to the specific 3000 and 4000 level physics courses listed (PHYSICS 3119, PHYSICS 3129, PHYSICS 3201, PHYSICS 3211, PHYSICS 4211, PHYSICS 4301, PHYSICS 4311), and in addition to the two physics area focus courses[4], one other physics 3000 level or higher course is required.

4 Two physics area focus courses are required. Students can pick from PHYSICS 4323, PHYSICS 4553, Physics 4333, and Physics 4343-Atomic Physics.

Emphasis in Secondary Education

Students may develop an emphasis area in secondary education that will allow them to teach physics in grades 9-12 in Missouri. Please contact the Department of Teacher Education for a complete list of requirements.

In addition to maintaining a 3.0 content and professional requirement GPA, students must pass the appropriate content assessment to be eligible for student teaching. Missouri S&T allows students to choose their student teaching placement, if the district agrees and a qualified cooperating teacher is available. This program is approved by the Missouri Department of Elementary and Secondary Education. License reciprocity determinations outside of Missouri can be found at https://teaching.missouri.edu/student/state-authorization/mst/licensure (https://teaching.missouri.edu/student/state-authorization/mst/licensure/).

a. Professional requirements courses:

EDUC 1040	Perspectives In Education	2
EDUC 1174	School Organization and Administration For Teachers	2
PSYCH 2300	Educational Psychology	3
or EDUC 2102	Educational Psychology	
ENGLISH 3170	Teaching And Supervising Reading and Writing	3
EDUC 2310	Education Of The Exceptional Child	3
EDUC 3216	Instructional Literacy in the Content Area	3
EDUC 3280	Instructional Strategies in the Content Area	3
EDUC 3340	Assessment of Student Learning	3
PSYCH 3310	Developmental Psychology	3
EDUC 4298	Student Teaching Seminar	1

Fifteen of these credit hours may be used to substitute for six hours of mathematics electives, six hours of physics electives, and three hours of computer science courses.

b. Clinical experience courses:

EDUC 1104	Teacher Field Experience I	1
EDUC 1164	Teacher Field Experience II	2
EDUC 3298	Teacher Field Experience III	1
EDUC 4299	Student Teaching	12

c. Take these additional courses:

SP&M S 1185	Principles Of Speech	3
POL SCI 1200	American Government	3
PSYCH 1101	General Psychology	3
BIO SCI 1113	General Biology	3
PHYSICS 1605	Environmental Physics I	3
HISTORY 3530	History of Science	3
A 3 hour Art/Music/Theater elective		3

d. Complete the requirements for teacher certification listed in this catalog.

Physics Minor Curriculum

The minor in physics is a flexible program whose goal is to increase the breadth and competency of science and engineering students in modern or classical physics. Science students pursuing the physics minor will be interested in a deeper understanding of fundamental physical processes. Engineering students who intend to work in research or advanced development may use a physics minor to acquire a thorough knowledge of atomic, condensed matter, and environmental physics.

The physics minor consists of the following courses:

The introductory physics sequence:		
PHYSICS 1111 & PHYSICS 2111	General Physics I and General Physics II	8
or PHYSICS 1135 & PHYSICS 2135	Engineering Physics I and Engineering Physics II	
One course in modern physics:		
PHYSICS 2305	Introduction To Modern Physics	3
or PHYSICS 2311	Modern Physics I	

12 additional credit hours of physics courses at the 2000 level or above.

The program will be designed to conform to the individual's interests and needs.

Marco Cavaglia, Professor
PHD International School for Advanced Studies, Trieste, Italy

Aleksandr Chernatynskiy, Associate Professor
PHD University of Louisville

Mina Esmaeelpour, Assistant Professor
PHD Lehigh University

Daniel Fischer, Associate Professor
PHD Heidelberg University

Halyna Hodovanets, Assistant Professor
PHD Iowa State University

Yew San Hor, Associate Professor
PHD Rutgers University

Ulrich Jentschura, Professor
PHD Dresden University of Technology

Lia Katsimiga, Assistant Teaching Professor
PHD University of Athens

Hyunsoo Kim, Assistant Professor
PHD Iowa State University

Ioulia Y. Medvedeva, Professor
PHD Russian Academy of Science

James Musser, Teaching Professor
PHD Texas A&M University

Symeon Mystakidis, Assistant Professor
PHD University of Hamburg

Jerry L Peacher, Professor
PHD Indiana University Bloomington

Joel Peacher, Lecturer
MS University of Missouri-Rolla

Shun Saito, Assistant Professor
PHD University of Tokyo, Japan

Jayson Summers, Academic Specialist
MS Missouri Univeristy of Science and Technology

Steffen Thomas Vojta, Curators Distinguished Professor
PHD Chemnitz University of Technology, Germany

Agnes Vojta, Teaching Professor
PHD Technical University Dresden

Alexey Georgiyevich Yamilov, Professor
PHD The City University of New York

PHYSICS 1001 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

PHYSICS 1101 Introduction To Physics (LEC 1.0)
An introduction to the study of physics and its intellectual and professional opportunities. The student will be acquainted with the various areas of physics and with departmental and campus facilities useful to their future studies. Required of all freshman majors.

PHYSICS 1111 General Physics I (LEC 4.0)
An introduction to the fundamental ideas of physics, including mechanics, heat, and sound. Prerequisite: Preceded by Math 1208 or Math 1214.
PHYSICS 1111 - MOTR PHYS 150: Physics I
PHYSICS 1111 - MOTR PHYS 150L: Physics I with Lab

PHYSICS 1119 General Physics Laboratory (LAB 1.0)
Experiments related to topics studied in Physics 1111. Prerequisites: Preceded or accompanied by Physics 1111.
PHYSICS 1119 - MOTR PHYS 150L: Physics I with Lab

PHYSICS 1135 Engineering Physics I (LAB 1.0 and LEC 1.5 and RSD 1.5)
An introduction to mechanics, with an emphasis on topics needed by engineering students, including kinematics, dynamics, statics, and energetics. Prerequisite: A grade of "C" or better in Math 1208 or Math 1211 or Math 1214.
PHYSICS 1135 - MOTR PHYS 200L: Advanced Physics I with Lab

PHYSICS 1145 College Physics I (LAB 1.0 and LEC 3.0)
An introduction to the ideas of physics, including mechanics, heat, and sound. Prerequisites: Math 1160 and either of Math 1120 or Math 1140.
PHYSICS 1145 - MOTR PHYS 150: Physics I
PHYSICS 1145 - MOTR PHYS 150L: Physics I with Lab

PHYSICS 1505 Introductory Astronomy (LEC 3.0)
An introductory course in basic astronomy designed primarily for students other than those in science and engineering. Topics include history, the sky, the solar system, stars, stellar evolution, galaxies and the origin and evolution of the universe. Credit will not be given for both Physics 1505 and Physics 1515.
PHYSICS 1505 - MOTR ASTR 100: Astronomy
PHYSICS 1505 - MOTR ASTR 100L: Astronomy with Lab

PHYSICS 1509 Astronomy Laboratory (LAB 1.0)
A science laboratory course in which the student analyzes and interprets astronomical data and makes observations with a telescope. Prerequisite: Preceded or accompanied by Physics 1505 or 1515.
PHYSICS 1509 - MOTR ASTR 100L: Astronomy with Lab

PHYSICS 2001 Special Topics (IND 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

PHYSICS 2111 General Physics II (LEC 4.0)
An introduction to the fundamental ideas of physics including electricity, magnetism, and light. Prerequisites: Preceded by Physics 1111 or Physics 1135 and preceded or accompanied by Math 1221 or Math 1215.

PHYSICS 2119 General Physics Laboratory (LAB 1.0)
Experiments related to topics studied in Physics 2111. Prerequisite: Preceded or accompanied by Physics 2111.

PHYSICS 2129 Intermediate Physics Laboratory (LAB 2.0 and LEC 1.0)
A laboratory study of the principles of instrumentation used in all modern branches of physics. Analog and digital methods of data gathering are surveyed. Laboratory practice evolves from elementary operations to the design and assembly of a simple instrument.

PHYSICS 2135 Engineering Physics II (LAB 1.0 and LEC 1.5 and RSD 1.5)
An introduction to electricity, magnetism, and light, with emphasis on topics needed by engineering students. Prerequisites: Physics 1135 or Physics 1111, Math 1221 or Math 1215.

PHYSICS 2145 College Physics II (LAB 1.0 and LEC 3.0)
An introduction to the ideas of physics, including electricity, magnetism, and light. Prerequisites: Math 1160, Physics 1145.

PHYSICS 2305 Introduction To Modern Physics (LEC 3.0)
An elementary survey of the modern concepts in physics and their applications; relativity, quantum mechanics, atomic physics, solid state physics, nuclear and particle physics. Prerequisites: Math 2222 and Physics 2135 or 2111.

PHYSICS 2311 Modern Physics I (LEC 3.0)
An introduction to quantum mechanics, atomic physics, and solid state physics. Topics include historically important experiments and interpretations. Prerequisites: Physics 2135 or 2111, preceded or accompanied by Math 3304 or 3329.

PHYSICS 2401 Introduction To Theoretical Physics (LEC 3.0)
Fundamental physical concepts are elaborated in mathematical terms emphasizing the coherence and economy of Physics. Topics include elementary vector analysis, introduction to physical mechanics (motion of a point mass, conservation laws, relativity), Fourier series, and introduction to partial differential equations. Prerequisites: Math 3304 co-requisite; Physics 2135 or 2111.

PHYSICS 3000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

PHYSICS 3001 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

PHYSICS 3119 Advanced Physics Laboratory I (LAB 3.0)
A laboratory study of the principles of basic experiments in all major branches of physics. The experiments stress design of apparatus, and procedures and analysis in projects involving electronic, optical, mechanical, and vacuum techniques. Prerequisite: Physics 2129.

PHYSICS 3129 Advanced Physics Laboratory II (LAB 3.0)
A senior laboratory involving experimental design. The student must specify his objectives, assemble apparatus, take measurements, analyze the results, form conclusions, write a report, and deliver an oral presentation of the results. Prerequisite: Physics 2129.

PHYSICS 3201 Physical Mechanics (LEC 3.0)
This course covers topics of rigid body motion in three dimensions, moving coordinate frames, two body collisions, conservation laws, small oscillations, generalized coordinates, and LaGrange's and Hamilton's equations. Prerequisite: Physics 2401.

PHYSICS 3211 Electricity And Magnetism I (LEC 3.0)
A study of electric and magnetic fields, leading to Maxwell's equations. Topics covered include the electrostatic field, the electric potential, and the electrostatic field in matter. Prerequisite: Physics 2401.

PHYSICS 4001 Special Topics (LEC 3.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

PHYSICS 4099 Undergraduate Research (IND 0.0-6.0)
This course is designed for the undergraduate student who wishes to engage in research. It is not to be used for graduate credit nor for more than six credit hours of undergraduate credit. The subject and credit are to be arranged with the instructor.

PHYSICS 4203 Introduction To General Relativity (LEC 3.0)
An introduction to the theory of general relativity. Topics covered include the formalism of general relativity, Einstein's gravitational field equations, the Schwarzschild solution, black holes, and cosmological models of the universe. Prerequisite: Physics 2401.

PHYSICS 4211 Electricity And Magnetism II (LEC 3.0)
A continuation of Physics 3211. Topics covered include the magnetostatic field, the magnetic vector potential, the magnetostatic field in matter, electrodynamics, and electromagnetic waves. Prerequisite: Physics 3211.

PHYSICS 4301 Introduction To Quantum Mechanics (LEC 3.0)
The fundamental concepts, postulates and methods of quantum mechanics and their applications to physical systems. Topics include solutions of the Schrodinger equation for simple systems and operator methods. Prerequisites: Physics 2305 or 2311, 2401.

PHYSICS 4311 Thermal Physics (LEC 3.0)
A study of the equilibrium states of matter as governed by the first and second laws of thermodynamics. Emphasis is placed on the microscopic approach with an introduction to statistical mechanics. Topics include the kinetic theory of (uniform) gases, phase equilibria in pure systems, and an introduction to quantum statistics. Prerequisite: Physics 2305 or 2311.

PHYSICS 4323 Elementary Solid State Physics (LEC 3.0)
An introductory study of the structure and physical Properties of crystalline solids. Included are topics in crystal structure, x-ray diffraction, crystal binding, thermal properties of solids, free electron theory and elementary energy band theory. Prerequisites: Math 3304 and Physics 2305 or 2311.

PHYSICS 4333 Nuclear and Particle Physics (LEC 3.0)
An introduction to nuclear and particle physics. Topics include nuclear models, decays, and reactions, and elementary particles and fundamental forces. Prerequisites: Physics 2305 and Math 3304.

PHYSICS 4343 Atomic Physics (LEC 3.0)
An introduction into the structure and dynamics of atomic and molecular systems and their interaction with light. Topics include basic theories, fine and hyperfine interaction, QED corrections, energy shifts in external fields, electron correlation effects, and spectroscopic methods (e.g., laser spectroscopy, electron spectroscopy, atomic clocks). Prerequisites: Physics 2305.

PHYSICS 4503 Classical Optics (LEC 3.0)
Physical optics and advanced topics in geometrical optics. Topics include ray propagation, electromagnetic propagation, mirrors, lenses, interference, diffraction, polarization, imaging systems, and guided waves. Prerequisites: Math 2222 and Physics 2135 or 2111. (Co-listed with Elec Eng 5200).

PHYSICS 4513 Laser Physics (LEC 3.0)
The generation of coherent radiation by lasers and the interaction of laser radiation with matter. Topics include stimulated emission, population inversion, optical cavities, optical gain, properties of laser media and other applications. Prerequisite: Physics 2305 or 2311.

PHYSICS 4523 Principles Of Engineering Materials (LEC 3.0)
Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Aero Eng 3877, Chem Eng 5300, Met Eng 5810, Cer Eng 5810).

PHYSICS 4533 Transport in Nanostructures: An Introduction (LEC 3.0)
The course overviews how wave interference, energy quantization and tunneling phenomena influence the wave (electron and light) transport in modern nanostructured materials and devices such as quantum dots, quantum wells, quantum wires, and photonic crystals. Prerequisite: Physics 2305 or 2311.

PHYSICS 4543 Plasma Physics I (LEC 3.0)
Single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory. Diffusion of plasma in electric and magnetic fields. Analysis of laboratory plasmas and magnetic confinement devices. Introduction to plasma kinetic theory. Prerequisite: Aero Eng 3131 or Mech Eng 3131 or Physics 3211 or Nuc Eng 3221 or Elec Eng 3600. (Co-listed with Aero Eng 5570, Mech Eng 5570, Nuc Eng 4370).

PHYSICS 4553 Astrophysics (LEC 3.0)
The structure, physical characteristics and evolution of stars, binary systems, nebulae and galaxies. Prerequisite: Physics 2305.

PHYSICS 4605 Physics For Elementary School Teachers (LAB 1.0 and LEC 2.0)
A nonmathematical review of the fundamental ideas of physics, including mechanics, matter, energy, sound, electricity, magnetism, astronomy, and light. Emphasis is placed on the development of hands-on activities. (For elementary school teachers or Master of Science for Teachers candidates only.).

PHYSICS 4625 Science Education and Quantitative Literacy for Middle School Teachers (LEC 3.0)
An integrated science-mathematics course for middle school teachers. Course covers selected science/mathematics topics/skills specified in Missouri standards for grades 5-7. Inquiry based methods of teaching these topics in an integrated manner will be emphasized. Prerequisite: Current enrollment in a Teacher Education Program or a full or part-time teacher in a K-12 school. (Co-listed with Stat 5904).

PHYSICS 5000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

PHYSICS 5001 Special Topics (IND 0.0 and LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

PHYSICS 5333 Subatomic Physics (LEC 3.0)
An introduction to elementary particles. Topics include particle properties, nuclear forces, particle interactions, the Standard Model for quarks and leptons, fundamental forces in gauge field theory models, and the role of elementary particle interactions in cosmology. Prerequisite: Physics 3311.

PHYSICS 5403 Computational Physics (LAB 1.0 and LEC 3.0)
An introduction to modern computer simulations for solving physics problems. The course will be project-oriented with examples including planetary motion, chaotic dynamics, quantum scattering, structure of atoms and clusters, molecular dynamics, and Monte-Carlo simulations. Prerequisites: Physics 2305 or Physics 2311; Math 3304; programming experience.

PHYSICS 5409 Computational Physics Laboratory (LAB 3.0)
Computational project-based studies in the areas of fundamental, applied, and data-driven physics and astronomy with connections to chemistry and materials science. Topics include atomistic and ab-initio computer simulations for quantum materials, semiconductors, extreme-environment ceramics, alloys, etc. The course covers algorithms, interpolations, experimental or theoretical data processing, analysis and visualization as well as an introduction to Linux, bash-scripting and parallel computing at an HPC cluster. Prerequisites: Physics 2305.

PHYSICS 5413 Chaos, Fractals, and Nonlinear Dynamics (LEC 3.0)
An introduction into nonlinear dynamics, deterministic chaos, and fractals. Topics covered include phase plane analysis, iterated maps, routes to chaos, Lyapunov exponents, strange attractors and pattern formation with applications to chaotic vibrations, population dynamics, chemical oscillations and lasers. Prerequisites: Math 3304; Physics 2135 or Physics 2111.

PHYSICS 5503 Fourier Optics (LEC 3.0)
Applications of Fourier analysis and linear system theory to optics. Topics include scalar diffraction theory, Fourier transforming properties of lenses, optical information processing, and imaging systems. Prerequisites: Both Elec Eng 3430 and Elec Eng 3600 or Physics 4211. (Co-listed with ELEC ENG 5210).

PHYSICS 5513 Fiber And Integrated Optics (LEC 3.0)
Introduction to optical waveguides and their applications to communication and sensing. Topics include dielectric waveguide theory, optical fiber characteristics, integrated optic circuits, coupled-mode theory, optical communication systems, and photonic sensors. Prerequisite: Elec Eng 3600 or Physics 4211. (Co-listed with Elec Eng 5220).
