491, 492, 493, 494 Research
See the description of these courses at the beginning of the "Departments and Curricula" section of this catalog.

495, 496, 497, 498 Individual Study
See the description of these courses at the beginning of the "Departments and Curricula" section of this catalog.

Physical Education
See Department of Health and Human Performance.

Physical Science with a Concentration in Chemistry
Physical Science with a Concentration in Physics
See Department of Teacher Education.

Physics (PHYS)
Tommet (chair), Johnston, Lane

Physics majors learn the fundamental laws that govern the physical universe, from the smallest subatomic particle to the largest galaxies to the very structure of space and time. Emphasis is placed on general understanding, problem solving, and the communication skills essential for success in a career grounded in science. In the laboratory, students use state-of-the-art instrumentation in applying physics to a wide variety of systems. Opportunities are available for students to participate in research projects during the school year and over the summer.

There are three educational options from which to choose: a Bachelor of Science (B.S.) degree; a Bachelor of Arts (B.A.) degree; or a minor in physics. The B.S. degree provides the necessary background for students interested in graduate school, engineering or industrial work; for students interested in professional programs such as medicine or patent law, or students double majoring in areas such as mathematics or chemistry, the Bachelor of Arts degree gives a solid background in physics with the flexibility to meet other needs.

The pre-engineering program sponsored by the Department of Physics allows students to combine a liberal arts education at the University of St. Thomas with an engineering program at another institution. See the description under Pre-Professional Programs in this catalog.

For students interested in secondary education, the department offers a major for teachers of physical science with a concentration in physics, and a teaching minor in physics. See the description of these programs in the Department of Teacher Education.

For students interested in elementary education, the department participates in the Science and Mathematics Major for Elementary Education (SMEE). Further information is available under that title in this catalog.

Major in Physics (B.S.)
111 Introduction to Classical Physics I
112 Introduction to Classical Physics II
225 Introduction to Modern Physics I
226 Introduction to Modern Physics II
260 Principles of Electronic Instrumentation
310 Statistical Mechanics and Thermodynamics
341 Electricity and Magnetism
399 Advanced Physics Laboratory I
400 Advanced Physics Laboratory II
411 Theoretical Mechanics
421 Quantum Mechanics

Plus one of:
342 Electromagnetic Waves
451 Introduction to Solid State Physics

Allied requirements:
CHEM 111 General Chemistry I
CHEM 112 General Chemistry II
MATH 113 Calculus I
MATH 114 Calculus II
MATH 200 Multi-Variable Calculus
MATH 210 Linear Algebra and Differential Equations
QMCS 130 Problem Solving in the Natural Sciences

Major in Physics (B.A.)
111 Introduction to Classical Physics I
112 Introduction to Classical Physics II
225 Introduction to Modern Physics I
226 Introduction to Modern Physics II
260 Principles of Electronic Instrumentation
341 Electricity and Magnetism
399 Advanced Physics Laboratory I
400 Advanced Physics Laboratory II
411 Theoretical Mechanics

Plus one of:
310 Statistical Mechanics and Thermodynamics
342 Electromagnetic Waves
421 Quantum Mechanics
451 Introduction to Solid State Physics

Allied requirements:
MATH 113 Calculus I
MATH 114 Calculus II
MATH 200 Multi-variable Calculus
MATH 210 Linear Algebra and Differential Equations

Major for Teaching Physical Science with a Concentration in Physics
See Department of Teacher Education

Minor in Physics
111 Introduction to Classical Physics I
112 Introduction to Classical Physics II
or
109 General Physics I
110 General Physics II

Plus:
225 Introduction to Modern Physics I
Eight credits in courses numbered 226 or above

Teaching Minor in Physics
See Department of Teacher Education

101 General Physics For Liberal Arts Students (109, 111)
Intended for non-science majors; treats fundamental principles of physics and their application to familiar phenomena, stressing qualitative understanding. The course will survey topics from mechanics, fluids, temperature and heat, oscillations, waves and sound, light and optics, and properties of matter. The course consists of lecture, discussion and laboratory. This course is designed especially for elementary education majors. It is not intended for students who have had high school physics.
Prerequisite: three years of high school mathematics

102 Topical Introduction to Physics 2 credits
This course will introduce students to physics by studying a specific but broad topic. The course will have laboratory experience and will fulfill one-half of the general education laboratory science requirement. The course may be repeated for credit under different topics. Examples of topics are: light and color, physics and the human body, science of hi-fidelity, electronics of a computing machine, modern physics, and biomechanics. Offered in January Term.
Prerequisite: three years of high school mathematics

103 Physics of Energy
Intended for non-science majors; treats fundamental principles of physics and their application to understanding energy. This is an introductory course in physics with the focus on energy; it will give the underlying science and a quantitative approach to energy. Topics included are mechanics, thermodynamics, electricity and magnetism, atomic and nuclear concepts and radiation theory. The course consists of lecture, discussion and laboratory.
Prerequisite: three years of high school mathematics

104 Astronomy
Introduction to physical principles and their application to astronomy for non-science majors. Emphasis is on comprehension of ideas and principles. Topics include the motions of the sun, moon, stars and planets; properties of the solar system; the stars including giants, dwarfs, pulsars and

black holes; nebulae, galaxies and quasars; cosmology and life. The course consists of lecture, discussion and laboratory.
Prerequisite: three years of high school mathematics

105 Musical Acoustics
An introductory course intended for non-science majors; treats fundamental principles of physics and acoustics as they relate to musical sounds and musical instruments. The course consists of lecture, discussion and laboratory. This course fulfills the second-level Computer Competency requirement in the core curriculum.
Prerequisites: high school algebra and a music background (one year practice, instrument or voice, or one course)

109 General Physics I (111)
This course and its continuation 110 are a two-semester sequence of introductory physics, both classical and modern. Topics include principles of classical mechanics: description of motion, force, torque and rotational motion, energy, momentum and their conservation, fluid mechanics; thermal phenomena; oscillations, waves and sound. Appropriate topics and applications are chosen for the life-science student. The course consists of lecture, discussion and laboratory.
Prerequisite: Math placement at a level of MATH 111 or above.

110 General Physics II (112)
Continuation of 109. Topics include electricity; magnetism; light and optics; atomic, quantum and nuclear physics. The course consists of lecture, discussion and laboratory.
Prerequisite: A minimum grade of C- in 109 or 111

111 Introduction to Classical Physics I (109)
This course and its continuation 112 are intended for physical science, mathematics and pre-engineering students. The principles of classical mechanics: vectors, kinematics, particle and rigid body rotational dynamics and statics; conservation laws; fluid mechanics. The course consists of lecture, discussion and laboratory. This course fulfills the second-level Computer Competency requirement in the core curriculum.
Prerequisite: A minimum grade of C- in MATH 113

112 Introduction to Classical Physics II (110)
Continuation of 111. The principles of thermal, wave, optical and electromagnetic phenomena. The course consists of lecture, discussion and laboratory. This course fulfills the second-level Computer Competency requirement in the core curriculum.
Prerequisites: A minimum grade of C- in both 111 and MATH 114

225 Introduction to Modern Physics
This course and its continuation 226 serve as an introduction to modern physics. The topics of this first course are quantum theory of light, particle nature of matter, wave aspects of particles, quantum mechanics in one-dimension, statistical physics, lasers, solid state physics. The course consists of lecture, discussion and laboratory. This course fulfills the second-level Computer Competency requirement in the core curriculum.
Prerequisites: 110 or 112 and MATH 200

226 Introduction to Modern Physics II
Continuation of 225. Topics include atomic structure, molecular structure, relativity, nuclear physics, elementary particles, other topics of contemporary interest. The course consists of lecture, discussion and laboratory. This course fulfills the second-level Computer Competency requirement in the core curriculum.
Prerequisite: A minimum grade of C- in 225

260 Principles of Electronic Instrumentation (261, 262)
Intended to provide scientists (both physical and life) and engineers with a background in electronics and instrumentation. Course will cover analysis of basic electronic circuits used in scientific electronic instrumentation, with emphasis on a practical approach to circuits using integrated circuit devices: circuit analysis; filters; feedback; amplifiers; power supplies; oscillators; digital logic; counting, switching, timing; transducers; analog-digital conversions. The course consists of lecture, discussion and laboratory.
Prerequisite: 110 or 112 or permission of the instructor

261 Principles of Electronic Instrumentation: Analog Electronics (260) 2 credits
The analog portion of 260. This course is sometimes offered during January Term.
Prerequisite: 110 or 112 or permission of the instructor

262 Principles of Electronic Instrumentation: Digital Electronics (260) 2 credits
The digital portion of 260. Note that QMCS 340 may be substituted for this course. This course is sometimes offered during January Term.
Prerequisite: 110 or 112 or permission of the instructor

295, 296, 297, 298 Topics
The subject matter of these courses, announced in the annual *Class Schedule,* will vary from year to year, but will not duplicate existing courses. See the description of these courses at the beginning of the "Departments and Curricula" section of this catalog.

310 Statistical Mechanics and Thermodynamics
Concepts and laws of thermodynamics and of statistical mechanics. Applications of these to various systems, including gases, liquids, solids and chemical systems. Lecture and discussion.
Prerequisite: 226 or permission of the instructor

341 Electricity and Magnetism
Electrostatic and magnetostatic fields in vacuum and material media; energy and force relations; methods for the solution of static problems; fields and currents in conducting media; Maxwell's equations and time-dependent fields. Lecture and discussion.
Prerequisites: 110 or 112 and MATH 210 or permission of the instructor

342 Electromagnetic Waves
A continuation of electricity and magnetism with a view of Maxwell's equations and the resulting wave equation, traveling wave solutions and applications, radiation, interference and diffraction, optics, wave guides. Lecture and discussion.
Prerequisite: 341

399 Advanced Physics Laboratory I 2 credits
Advanced physics experiments in a number of areas including nuclear, atomic, optical and solid state physics. Some lectures and library research will be included. Four hours per week. This course partially fulfills the second-level Computer Competency requirement in the core curriculum.
Prerequisites: 226, 260 (261-262) and concurrent registration in an upper-division physics course

400 Advanced Physics Laboratory II 2 credits
Conduct a rigorous experimental physics project proposed by the student and approved by the instructor. This course partially fulfills the second-level Computer Competency requirement in the core curriculum.
Prerequisite: 399

411 Theoretical Mechanics
Newtonian dynamics of particles and systems of particles; conservation laws; moving coordinate systems; central-force motion; collisions and scattering; plane and general motion of rigid bodies; free, forced and coupled oscillations; Lagrangian dynamics. Lecture and discussion.
Prerequisite: 112, MATH 200 or permission of the instructor

421 Quantum Mechanics
Application of quantum mechanics to advanced problems in modern physics; perturbation theory; spin and its effects; identical particles; many-electron atoms; topics in scattering theory and nuclear physics. Lecture and discussion.
Prerequisite: 226 or permission of the instructor

451 Introduction to Solid-State Physics
Theory and applications of mechanical, thermal, electric, and magnetic properties of solids; band theory; semi-conductors. Lecture and discussion.
Prerequisite: 226 or permission of instructor

483, 484, 485, 486 Seminar
See the description of these courses at the beginning of the "Departments and Curricula" section of this catalog.

487, 488, 489, 490 Topics
The subject matter of these courses, announced in the annual *Class Schedule,* will vary from year to year, but will not duplicate existing courses. See the description of these courses at the beginning of the "Departments and Curricula" section of this catalog.

491, 492, 493, 494 Research
See the description of these courses at the beginning of the "Departments and Curricula" section of this catalog.

495, 496, 497, 498 Individual Study
See the description of these courses at the beginning of the "Departments and Curricula" section of this catalog.