<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Gen Ed:</th>
<th>Description</th>
<th>Prerequisites</th>
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<tbody>
<tr>
<td>PHYS 100</td>
<td>Fundamentals of Physics</td>
<td>3</td>
<td>Natural and Applied Sciences</td>
<td>Carries no credit after PHYS 111 or PHYS 211. For students in nontechnical fields. Conceptual study of laws of nature and their application, including mechanics, heat, electricity and magnetism, light, and modern physics. Three lectures per week. (Fall only)</td>
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<tr>
<td>PHYS 100L</td>
<td>Fundamentals of Physics Lab</td>
<td>1</td>
<td>Natural and Applied Sciences</td>
<td>For students in nontechnical fields. Conceptual study of laws of nature and their application, including mechanics, heat, electricity and magnetism, light, and modern physics. One 2-hour lab per week. (Spring only)</td>
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<tr>
<td>PHYS 103</td>
<td>General Astronomy</td>
<td>3</td>
<td>Natural and Applied Sciences</td>
<td>Descriptive and physical astronomy; development of astronomical thought; properties and evolution of the solar system, stars, galaxies, and the universe. (Fall only)</td>
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<tr>
<td>PHYS 104</td>
<td>Astronomy Lab</td>
<td>1</td>
<td>Natural and Applied Sciences</td>
<td>Naked eye, telescopic, and photographic observations of constellations, stars, and planets. One 2-hour lab per week. (Fall only)</td>
<td>Prereq or coreq: PHYS 103.</td>
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<tr>
<td>PHYS 111</td>
<td>General Physics I</td>
<td>3</td>
<td>Natural and Applied Sciences</td>
<td>Kinematics, forces and dynamics, conservation laws, thermodynamics, waves. Three lectures and one recitation per week.</td>
<td>Prereq: MATH 143.</td>
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<tr>
<td>PHYS 111L</td>
<td>General Physics I Lab</td>
<td>1</td>
<td>Natural and Applied Sciences</td>
<td>Kinematics, forces and dynamics, conservation laws, thermodynamics, waves. One 2-hour lab per week.</td>
<td>Prereq: MATH 143.</td>
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<tr>
<td>PHYS 112</td>
<td>General Physics II</td>
<td>3</td>
<td>Natural and Applied Sciences</td>
<td>Carries no credit after PHYS 212. Electricity, magnetism, optics, and modern physics. Three lectures and one recitation per week. (Spring only)</td>
<td>Prereq: PHYS 111/PHYS 111L.</td>
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<tr>
<td>PHYS 112L</td>
<td>General Physics II Lab</td>
<td>1</td>
<td>Natural and Applied Sciences</td>
<td>Electricity, magnetism, optics, and modern physics. One 2-hour lab per week.</td>
<td>Prereq: PHYS 111/PHYS 111L.</td>
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<tr>
<td>PHYS 200</td>
<td>(s) Physics Seminar</td>
<td>1</td>
<td></td>
<td>Introductory-level discussion of topics in modern physics; introduction to physics research topics and scientific information search techniques; written and/or oral reports of a pertinent topic in current physics. (Fall only)</td>
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<tr>
<td>PHYS 203</td>
<td>(s) Workshop</td>
<td>Credit arranged</td>
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<tr>
<td>PHYS 204</td>
<td>(s) Special Topics</td>
<td>Credit arranged</td>
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<tr>
<td>PHYS 211</td>
<td>Engineering Physics I</td>
<td>3</td>
<td>Natural and Applied Sciences</td>
<td>Kinematics and dynamics, Newton's laws, work and energy, rotational dynamics, linear and angular momentum, collisions, static equilibrium, oscillations, gravity, central forces, and thermodynamics. One 2-hour lab per week.</td>
<td>Prereq or Coreq: MATH 170.</td>
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<tr>
<td>PHYS 211L</td>
<td>Laboratory Physics I</td>
<td>1</td>
<td>Natural and Applied Sciences</td>
<td>Kinematics and dynamics, Newton's laws, work and energy, rotational dynamics, linear and angular momentum, collisions, static equilibrium, oscillations, gravity, central forces, and thermodynamics. One 2-hour lab per week.</td>
<td>Coreq: PHYS 211.</td>
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<tr>
<td>PHYS 212</td>
<td>Engineering Physics II</td>
<td>3</td>
<td>Natural and Applied Sciences</td>
<td>Electric fields and potentials, magnetic fields, capacitance and inductance, DC and AC circuits, electromagnetic waves. Three lectures and one recitation per week.</td>
<td>Prereq: PHYS 211/PHYS 211L.</td>
</tr>
<tr>
<td>PHYS 212L</td>
<td>Laboratory Physics II</td>
<td>1</td>
<td>Natural and Applied Sciences</td>
<td>Electric fields and potentials, magnetic fields, capacitance and inductance, DC and AC circuits, electromagnetic waves, mechanical waves, and geometric optics. One 2-hour lab per week.</td>
<td>Coreq: PHYS 212.</td>
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<tr>
<td>PHYS 213</td>
<td>Engineering Physics III</td>
<td>3</td>
<td>Natural and Applied Sciences</td>
<td>Fluid dynamics, waves in elastic media, sound waves, temperature, heat and thermodynamics, kinetic theory, geometric and physical optics. Three lectures and one recitation per week. (Spring only)</td>
<td>Prereq: PHYS 211/PHYS 211L.</td>
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<tr>
<td>PHYS 299</td>
<td>(s) Directed Study</td>
<td>Credit arranged</td>
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<tr>
<td>PHYS 305</td>
<td>Modern Physics</td>
<td>3</td>
<td></td>
<td>Quantum and relativity theories with applications to atomic, solid state, nuclear, and elementary particle physics. (Spring only)</td>
<td>Prereq: PHYS 212/PHYS 212L.</td>
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<tr>
<td>PHYS 213</td>
<td>Engineering Physics III</td>
<td>3</td>
<td>Natural and Applied Sciences</td>
<td>Kinematics and dynamics, Newton's laws, work and energy, rotational dynamics, linear and angular momentum, collisions, static equilibrium, oscillations, gravity, central forces, and thermodynamics. One 2-hour lab per week.</td>
<td>Prereq or Coreq: MATH 175.</td>
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</tbody>
</table>
PHYS 321 Analytical Mechanics
3 credits
Review of single-particle kinematics and dynamics; linear oscillations; Lagrangian dynamics; orbital dynamics; motion in non-inertial systems; space rotation of rigid bodies.
Prereq: PHYS 212/PHYS 212L and MATH 275
Coreq: MATH 310

PHYS 333 Statistical Thermodynamics
3 credits
Cross-listed with CHEM 495
Classical thermodynamics, entropy, thermodynamic potentials, kinetic theory, classical and quantum statistical mechanics, ensembles, partition functions, introduction to phase transitions.
Prereq: CHEM 306 or PHYS 305 or equivalent

PHYS 341 Electromagnetic Fields I
3 credits
This course is designed to provide undergraduate physics majors advanced instruction in electrostatics. The specific areas which will be covered are electric fields, electric potentials, work and energy in electrostatics, the technique of using the concept of image charges to solve for the electric field and electric potential of complex charge distributions, Laplace's and Poisson's equations, electric dipoles, polarization and polarizable materials, and the electric dipole approximation.
Prereq: PHYS 212, PHYS 212L and MATH 275

PHYS 342 Electromagnetic Fields II
3 credits
This course is designed to provide undergraduate physics majors advanced instruction in electromodynamics and magnetism. The specific areas which will be covered are magnetostatics, magnetic fields in matter, the vector potential, electrodynamics, the complete set of Maxwell's equations, electromagnetic waves, waveguides, electric and magnetic dipole radiation, retarded and advanced potentials, and radiation arising from accelerated charges and charge distributions.
Prereq: PHYS 341

PHYS 351 Introductory Quantum Mechanics I
3 credits
One-dimensional theory; free particle, bound states, potential barriers, harmonic oscillator, matrix methods, and Dirac notation; interpretations of quantum theory.
Prereq: PHYS 305, PHYS 371
Coreq: MATH 330

PHYS 371 Mathematical Physics
3 credits
Cross-listed with MATH 371
Mathematical techniques needed in upper-division physics courses, including vector analysis, matrices, Sturm-Liouville problems, special functions, partial differential equations, complex variables.
Prereq: PHYS 212/PHYS 212L and MATH 275.

PHYS 400 (s) Seminar
Credit arranged

PHYS 403 (s) Workshop
Credit arranged

PHYS 404 (s) Special Topics
Credit arranged

PHYS 407 Communicating Science
1 credit
Gen Ed: Senior Experience
Writing scientific abstracts, manuscripts, and grant proposals; peer review; presenting concepts to scientists in oral and poster form; communicating to non-scientists.
Prereq: Junior or Senior standing

PHYS 411 Advanced Physics Lab
4 credits
Research skills, group dynamics, scientific literature research/drafting, automation and design techniques to prepare students for post-graduate life in a physics laboratory setting. 1-hour distributed lecture time and 3-hr effective lab time per week. Some weeks require scheduling machine utilization time outside of standard class hours per student.
Prereq: PHYS 305 or Permission

PHYS 428 Numerical Methods
3 credits
Joint-listed with PHYS 528, Cross-listed with ENGR 428, MATH 428
Systems of equations, root finding, error analysis, numerical solution to differential equations, interpolation and data fitting, numerical integration, related topics and applications. Additional projects and/or assignments required for graduate credit.
Prereq: MATH 310.

PHYS 438 Biological Physics
3 credits
Joint-listed with PHYS 538
Physics principles applied to biological systems including organisms, cells, and biomolecules. Techniques for studying biological systems and phenomena. Additional projects/assignments required for graduate credit.
Prereq for PHYS 438: PHYS 212 or PHYS 213; Junior or Senior standing.
Prereq for PHYS 538: Graduate Standing or Permission.

PHYS 443 Optics
3 credits
Joint-listed with PHYS 543
Geometrical optics, wave optics and physical optics with emphasis on modern instrumentation and methods of measurement. Additional projects/assignments required for graduate credit.
Prereq for PHYS 443: PHYS 342.
Prereq for PHYS 543: Admission to Physics Graduate program or Permission.

PHYS 444 Quantum Optics
3 credits
Joint-listed with PHYS 544
Introduction to the physics of lasers, laser spectroscopy, non-linear optical effects, and the interaction of radiation and matter. Additional projects/assignments required for graduate credit.
Prereq for PHYS 444: PHYS 212/212L or PHYS 213, MATH 175, and Senior standing or Permission.
Prereq for PHYS 544: Admission to Physics Grad program or Permission.
PHYS 464 Materials Physics and Engineering
3 credits
Joint-listed with PHYS 564, Cross-listed with MSE 464
Materials for circuits, Magnetism and magnetic materials, Ferroelectric and piezoelectric materials, Semiconductors, Optical properties of semiconductor for optoelectronics, thermal properties, electron band theory, superconductivity. Additional projects/assignments required for graduate credit. (Spring only)
Prereq: Senior standing in an Engineering or Physics major, or PHYS 305 and PHYS 321; or Permission.

PHYS 465 Nuclear and Particle Physics
3 credits
Joint-listed with PHYS 565
Particle production and detection, properties and classification of particles, the quark model of hadrons, symmetries and conservation laws, interactions, grand unification, the strong interaction and nuclear forces, models for nuclear structure and reactions. Additional projects/assignments required for graduate credit. Cooperative: open to WSU degree-seeking students.
Prereq for PHYS 465: PHYS 305.
Prereq for PHYS 565: Admission to physics graduate program or Permission.

PHYS 484 Astrophysics
3 credits
Joint-listed with PHYS 584
Celestial mechanics; planets and planetary systems; structure and evolution of stars and star systems; special and general relativity; cosmology. Additional projects/assignments required for graduate credit. Cooperative: open to WSU degree-seeking students.
Prereq for PHYS 484: PHYS 305 or MATH 275; or Permission.
Prereq for PHYS 584: Admission to physics graduate program or Permission.

PHYS 490 Research
0-6 credits, max 6
Undergraduate research or thesis.
Prereq: Permission of Instructor.

PHYS 492 Senior Research
1 credit
Gen Ed: Senior Experience
Undergraduate research in one of the department focus areas. Scientific communication through one presentation to the scientific community and one written report.
Prereq: Junior or Senior Standing; or Permission of Instructor.

PHYS 498 (s) Internship
Credit arranged

PHYS 499 (s) Directed Study
Credit arranged

PHYS 500 Master's Research and Thesis
Credit arranged

PHYS 501 (s) Seminar
Credit arranged
Graded P/F.
Prereq: Permission

PHYS 502 (s) Directed Study
Credit arranged

PHYS 503 (s) Workshop
Credit arranged

PHYS 504 (s) Special Topics
Credit arranged

PHYS 521 Advanced Mechanics
3 credits
Classical mechanics; Lagrange's and Hamilton's principles, two-body problem, rigid body motion, special relativity, canonical transformation, Hamilton-Jacobi theory, small oscillations, and Lagrangian and Hamiltonian formulations for continuous systems and fields. Cooperative: open to WSU degree-seeking students.

PHYS 528 Numerical Methods
3 credits
Joint-listed with PHYS 428, Cross-listed with MATH 529
Systems of equations, root finding, error analysis, numerical solution to differential equations, interpolation and data fitting, numerical integration, related topics and applications. Additional projects and/or assignments required for graduate credit.
Prereq: MATH 310.

PHYS 533 Statistical Mechanics
3 credits
Ensembles, partition functions, classical and quantum statistics renormalization group, criticality, scaling, interacting systems, simulation. Cooperative: open to WSU degree-seeking students.
Prereq: PHYS 333.

PHYS 538 Biological Physics
3 credits
Joint-listed with PHYS 438
Physics principles applied to biological systems including organisms, cells, and biomolecules. Techniques for studying biological systems and phenomena. Additional projects/assignments required for graduate credit.
Prereq for PHYS 438: PHYS 212 or PHYS 213; Junior or Senior standing.
Prereq for PHYS 538: Graduate Standing or Permission.

PHYS 541 Electromagnetic Theory I
3 credits
Analytical tools and techniques describing electromagnetic phenomena, particularly Maxwell's equations, electrostatic and magnetostatic systems, including currents and their interactions and boundary value problems. Cooperative: open to WSU degree-seeking students.
Prereq: PHYS 342.

PHYS 542 Electromagnetic Theory II
3 credits
Further examinations of the analytical tools and techniques that describe electromagnetic phenomena, particularly electrodynamics, the general theory of emission, propagation and absorption of electromagnetic waves, and the relativistic formulation of electrodynamics. Cooperative: open to WSU degree-seeking students.
Prereq: PHYS 541.

PHYS 543 Optics
3 credits
Joint-listed with PHYS 443
Geometrical optics, wave optics and physical optics with emphasis on modern instrumentation and methods of measurement. Additional projects/assignments required for graduate credit.
Prereq for PHYS 443: PHYS 342.
Prereq for PHYS 543: Admission to Physics Graduate program or Permission.
PHYS 544 Quantum Optics  
3 credits
Joint-listed with PHYS 444  
Introduction to the physics of lasers, laser spectroscopy, non-linear optical effects, and the interaction of radiation and matter. Additional projects/assignments required for graduate credit.  
**Prereq** for PHYS 444: PHYS 212/212L or PHYS 213, MATH 175, and Sr standing or Permission.  
**Prereq** for PHYS 544: Admission to Physics Graduate program or Permission.

PHYS 550 Quantum Mechanics I  
3 credits
Fundamental concepts, base kets and matrix representation, position and momentum space; Schroedinger and Heisenberg picture, Schroedinger’s wave equation and solutions; theory of angular momentum. Cooperative: open to WSU degree-seeking students.  
**Prereq:** PHYS 351.

PHYS 551 Quantum Mechanics II  
3 credits
Theory of angular momentum continued; symmetries in quantum mechanics; approximation methods, time-dependent and time-independent perturbation theory, applications to atomic systems; radiation theory, theory of scattering. Cooperative: open to WSU degree-seeking students.  
**Prereq:** PHYS 550.

PHYS 564 Materials Physics and Engineering  
3 credits
Joint-listed with PHYS 464, Cross-listed with MSE 564  
Materials for circuits, Magnetism and magnetic materials, Ferroelectric and piezoelectric materials, Semiconductors, Optical properties of semiconductor for optoelectronics, thermal properties, electron band theory, superconductivity. Additional projects/assignments required for graduate credit. (Spring only)  
**Prereq:** Senior standing in an Engineering or Physics major, or PHYS 305 and PHYS 321; or Permission.

PHYS 565 Particle and Nuclear Physics  
3 credits
Joint-listed with PHYS 465  
Particle production and detection, properties and classification of particles, the quark model of hadrons, symmetries and conservation laws, interactions, grand unification, the strong interaction and nuclear forces, models for nuclear structure and reactions. Additional projects/assignments required for graduate credit. Cooperative: open to WSU degree-seeking students.  
**Prereq** for PHYS 465: PHYS 305.  
**Prereq** for PHYS 565: Admission to Physics Graduate program or Permission.

PHYS 571 Mathematical Methods of Physics  
3 credits
Methods and problems. Cooperative: open to WSU degree-seeking students.  
**Prereq:** PHYS 322 or Permission.