# PHYSICS (PHYS)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Description</th>
<th>Prerequisites</th>
<th>Attributes</th>
<th>Offered Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS F102X</td>
<td>Energy and Society</td>
<td>3 + 3 + 0</td>
<td>Designed for non-science majors. Designed for non-science majors. Exploring the concept of energy. Investigation of the sources, conversion, distribution and ultimate dispersion of energy, as well as the consequences of its use in the development and maintenance of modern society. May be used to fulfill part of the natural science requirement.</td>
<td>Placement in WRTG F111X or higher; placement in DEVM F105 or higher; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Spring</td>
</tr>
<tr>
<td>PHYS F103X</td>
<td>College Physics I</td>
<td>3 + 3 + 0</td>
<td>Classical physics including vectors, kinematics, Newton's Laws, momentum, work, energy, rotational motion, oscillations, waves, gravity, fluids, heat, temperature, laws of thermodynamics and kinetic theory. For mathematics, science and liberal arts majors.</td>
<td>Placement in WRTG F111X or higher; placement in DEVM F105 or higher; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Fall</td>
</tr>
<tr>
<td>PHYS F104X</td>
<td>College Physics II</td>
<td>3 + 3 + 0</td>
<td>Classical physics including vectors, kinematics, Newton's Laws, momentum, work, energy, rotational motion, oscillations, waves, gravity, fluids, heat, temperature, laws of thermodynamics and kinetic theory. For mathematics, science and liberal arts majors.</td>
<td>Placement in WRTG F111X or higher; placement in DEVM F105 or higher; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Spring</td>
</tr>
<tr>
<td>PHYS F115X</td>
<td>Physical Sciences</td>
<td>3 + 3 + 0</td>
<td>Basic concepts and general overview in physics. Presents interrelatedness and interdependence within this scientific field.</td>
<td>Placement in WRTG F111X or higher; placement in DEVM F105 or higher; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Spring</td>
</tr>
<tr>
<td>PHYS F175X</td>
<td>Introduction to Astronomy</td>
<td>3 + 3 + 0</td>
<td>Examination of the science of astronomy and its social consequences, with emphasis on the interrelationships between astronomy and other sciences. Topics covered: astronomical concepts and tools, the solar system, stellar astronomy and cosmology. Designed for non-science majors.</td>
<td>Placement in WRTG F111X or higher; placement in DEVM F105 or higher; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Fall</td>
</tr>
<tr>
<td>PHYS F211X</td>
<td>General Physics I</td>
<td>3 + 3 + 0</td>
<td>Vectors, kinematics, Newton's Laws, momentum, work, energy, rotational motion, oscillations, waves, gravity and fluids. For engineering, mathematics and physical science majors.</td>
<td>Concurrent enrollment in MATH F252X; placement in WRTG F111X or higher; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Spring</td>
</tr>
<tr>
<td>PHYS F212X</td>
<td>General Physics II</td>
<td>3 + 3 + 0</td>
<td>Heat, temperature, laws of thermodynamics, Coulomb's Law, electrical potential, capacitance, Kirchhoff's Laws, Faraday's Law, and electromagnetic waves. For engineering, mathematics and physical science majors.</td>
<td>Concurrent enrollment in MATH F253X; PHYS F211X or ES F208 or concurrent enrollment in ES F210; placement in WRTG F111X or higher; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Spring</td>
</tr>
<tr>
<td>PHYS F213X</td>
<td>Elementary Modern Physics</td>
<td>3 + 3 + 0</td>
<td>Geometrical and physical optics, elementary-level modern physics including special relativity, atomic physics, nuclear physics, solid-state physics, elementary particles, simple transport theory.</td>
<td>Placement in WRTG F111X or higher; MATH F252X; MATH F253X; PHYS F211X; PHYS F212X; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Fall</td>
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<tr>
<td>PHYS F220</td>
<td>Introduction to Computational Physics</td>
<td>3 + 3 + 0</td>
<td>Introduction to computational techniques for solving physics problems. The computer is used as a tool to provide insight into physical systems and their behavior in all areas of physics.</td>
<td>Placement in MATH F253X; PHYS F201X; PHYS F212X; PHYS F213X; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Spring</td>
</tr>
<tr>
<td>PHYS F301</td>
<td>Introduction to Mathematical Physics</td>
<td>3 + 3 + 0</td>
<td>Introduction to theoretical foundations of classical and modern physics. Includes calculus of vector fields, linear algebra and elementary tensor theory, complex analysis, ordinary linear differential equations, linear partial differential equations, Fourier analysis and probability. Physical applications include planetary motion, rotating bodies and inertia tensor, damped and driven harmonic oscillator, wave equation, Schroedinger's equation and diffusive systems.</td>
<td>PHYS F211X; PHYS F212X; PHYS F213X; MATH F253X; or permission of instructor.</td>
<td>UAF GER Natural Science Req</td>
<td>Spring</td>
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</tbody>
</table>
PHYS F341  Classical Physics I: Particle Mechanics
4 Credits
Offered Fall
Newtonian mechanics, conserved mechanical quantities, motion of systems of particles, rigid body statics and dynamics, moving and accelerated coordinate systems, rigid body rotations and Lagrangian mechanics.
Prerequisites: PHYS F211X; PHYS F212X; PHYS F220; PHYS F301; or permission of instructor.
Lecture + Lab + Other: 4 + 0 + 0

PHYS F342  Classical Physics II: Electricity and Magnetism
4 Credits
Offered Spring
Statics and dynamics of electric and magnetic fields in vacuum and in the presence of materials. Lorentz force law. Maxwell’s equations.
Prerequisites: PHYS F341 or permission of instructor.
Lecture + Lab + Other: 4 + 0 + 0

PHYS F343  Classical Physics III: Vibration and Waves
4 Credits
Offered Fall
Normal modes and small vibrations, continuum systems, wave mechanics, electromagnetic waves and radiation. Relativistic mechanics and electromagnetism.
Prerequisites: PHYS F342 or permission of instructor.
Lecture + Lab + Other: 4 + 0 + 0

PHYS F351  Thermal Physics
2 Credits
Offered Spring
Classical macroscopic thermodynamics; systems and states, equations of state, the first and second laws of thermodynamics and their consequences, entropy, enthalpy, Helmholtz and Gibbs functions, equilibrium, Maxwell’s relations.
Prerequisites: PHYS F212X, PHYS F220, PHYS F301, PHYS F341; or permission of instructor.
Lecture + Lab + Other: 2 + 0 + 0

PHYS F381  Physics Laboratory  (O, W, n)
3 Credits
Offered Fall
Laboratory experiments in classical and modern physics.
Prerequisites: COJO F131X or COJO F141X; WRTG F111X; WRTG F211X or WRTG F213X; PHYS F213X; or permission of instructor.
Lecture + Lab + Other: 1 + 6 + 0

PHYS F382  Physics Laboratory  (W, n)
3 Credits
Offered Spring
Laboratory experiments in classical and modern physics.
Prerequisites: WRTG F111X; WRTG F211X or WRTG F213X; PHYS F381; or permission of instructor.
Lecture + Lab + Other: 1 + 6 + 0

PHYS F400  Capstone Project
0 Credit
This course should be taken by students during the semester they initiate a capstone research project. The capstone project must include the evaluation of data and communication of the study intent, methods, results, interpretation and conclusion in the context of existing literature and knowledge. The capstone project may be completed as an independent study or as participation in the international University Physics Competition. The duration of the course may exceed one semester.
Prerequisites: PHYS F220; PHYS F301; or permission of the instructor.
Lecture + Lab + Other: 0 + 0 + 0

PHYS F413  Atmospheric Radiation
3 Credits
Offered Fall Odd-numbered Years
Atmospheric radiation including the fundamentals of blackbody radiation theory and radiative properties of atmospheric constituents. Discussion of gaseous absorption including line absorption, broadening effects and radiative transfer. Includes scattering, radiative properties of clouds and radiation climatology. Prerequisites/Co-requisites: ATM F401.
Cross-listed with ATM F413.
Stacked with PHYS F613 and ATM F613.
Lecture + Lab + Other: 3 + 0 + 0

PHYS F421  Quantum Mechanics  (n)
4 Credits
Offered Fall
Schrodinger’s equation, Born interpretation, operator formalism, measurement and projection, stationary states, one-dimensional systems, hydrogen atom, states of definite angular momentum, perturbation theory.
Prerequisites: PHYS F213X; PHYS F220; PHYS F301; PHYS F341; or permission of instructor.
Lecture + Lab + Other: 4 + 0 + 0

PHYS F451  Statistical Physics
2 Credits
Offered Spring
The canonical ensemble; maximizing entropy, the partition function and Helmholtz free energy, the harmonic oscillator, Einstein and Debye solids, classical systems and the ideal gas, diatomic molecules, equipartition theorem, the photon gas and the blackbody spectrum, the grand canonical ensemble, quantum statistics, Fermion and Boson systems.
Prerequisites: PHYS F342, F351, F421; or permission of instructor.
Lecture + Lab + Other: 2 + 0 + 0

PHYS F462  Geometrical and Physical Optics  (n)
4 Credits
Offered Spring
Geometrical optics, interference and diffraction theory, nonlinear optics, Fourier optics, and coherent wave theory.
Prerequisites: PHYS F213X; PHYS F301; or permission of instructor.
Lecture + Lab + Other: 3 + 3 + 0

PHYS F471A  Advanced Topics in Physics I: Condensed Matter Physics I  (n)
1 Credit
Emphasis topics provide increased breadth in basic physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.
Prerequisites: PHYS F220; PHYS F301; or permission of instructor.
Lecture + Lab + Other: 1 + 0 + 0
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<tr>
<td>PHYS F471B</td>
<td>Advanced Topics in Physics I: Condensed Matter Physics</td>
<td>1</td>
<td>Emphasis topics provide increased breadth in basic physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
</tr>
<tr>
<td>PHYS F471C</td>
<td>Advanced Topics in Physics I: Space and Auroral Physics</td>
<td>(n) 1</td>
<td>Emphasis topics provide increased breadth in basic physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
</tr>
<tr>
<td>PHYS F471D</td>
<td>Advanced Topics in Physics I: Nonlinear Dynamics  (n)</td>
<td>1</td>
<td>Emphasis topics provide increased breadth in basic physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
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<tr>
<td>PHYS F471E</td>
<td>Advanced Topics in Physics I: Biophysics         (n)</td>
<td>1</td>
<td>Emphasis topics provide increased breadth in basic physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
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<tr>
<td>PHYS F471F</td>
<td>Advanced Topics in Physics I: Nuclear and Particle Physics</td>
<td>(n) 1</td>
<td>Emphasis topics provide increased breadth in basic physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
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<tr>
<td>PHYS F471G</td>
<td>Advanced Topics in Physics I: General Relativity  (n)</td>
<td>1</td>
<td>Emphasis topics provide increased breadth in basic physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
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<tr>
<td>PHYS F471H</td>
<td>Advanced Topics in Physics I: Astrophysics        (n)</td>
<td>1</td>
<td>Emphasis topics provide increased breadth in basic physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
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<tr>
<td>PHYS F471I</td>
<td>Advanced Topics in Physics I: Mathematical Physics</td>
<td>(n) 1</td>
<td>Emphasis topics provide increased breadth in basic physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
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<tr>
<td>PHYS F471J</td>
<td>Advanced Topics in Physics I: Order of Magnitude Physics</td>
<td>1</td>
<td>Offered Fall and Spring by avoiding mathematical complexity, order-of-magnitude techniques increase our physical understanding and allow us to study difficult or intractable problems. Students will learn how to do so and apply these techniques to problems in fluid mechanics, biophysics, astrophysics, and/or other applications.</td>
<td>1 + 0 + 0</td>
</tr>
<tr>
<td>PHYS F472A</td>
<td>Advanced Topics in Physics II: Planetary Atmospheres</td>
<td>(n) 1</td>
<td>Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
</tr>
<tr>
<td>PHYS F472B</td>
<td>Advanced Topics in Physics II: Fluid Dynamics     (n)</td>
<td>1</td>
<td>Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
</tr>
<tr>
<td>PHYS F472C</td>
<td>Advanced Topics in Physics II: Plasma Physics     (n)</td>
<td>1</td>
<td>Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
</tr>
<tr>
<td>PHYS F472D</td>
<td>Advanced Topics in Physics II: Hamiltonian Mechanics</td>
<td>(n) 1</td>
<td>Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
</tr>
<tr>
<td>PHYS F472E</td>
<td>Advanced Topics in Physics II: Physics of Glaciers</td>
<td>(n, a) 1</td>
<td>Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as condensed 14-lecture, one-credit courses.</td>
<td>1 + 0 + 0</td>
</tr>
</tbody>
</table>
Lecture + Lab + Other:

**PHYS F472F  Advanced Topics in Physics II: Remote Sensing**  (n)
1 Credit
Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.

**Prerequisites:** PHYS F220; PHYS F301; or permission of instructor.

**Lecture + Lab + Other:** 1 + 0 + 0

**PHYS F472G  Advanced Topics in Physics II: Solar Physics**  (n)
1 Credit
Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.

**Prerequisites:** PHYS F220; PHYS F301; or permission of instructor.

**Lecture + Lab + Other:** 1 + 0 + 0

**PHYS F472H  Advanced Topics in Physics II: Advanced Laboratory**  (n)
1 Credit
Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.

**Prerequisites:** PHYS F220; PHYS F301; or permission of instructor.

**Lecture + Lab + Other:** 1 + 0 + 0

**PHYS F472I  Advanced Topics in Physics II: Spectroscopy**  (n)
1 Credit
Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.

**Prerequisites:** PHYS F220; PHYS F301; or permission of instructor.

**Lecture + Lab + Other:** 1 + 0 + 0

**PHYS F472J  Advanced Topics in Physics II: Cosmology**  (n)
1 Credit
Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.

**Prerequisites:** PHYS F220; PHYS F301; or permission of instructor.

**Lecture + Lab + Other:** 1 + 0 + 0

**PHYS F472K  Advanced Topics in Physics II: Quantum Computation**  (n)
1 Credit
Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.

**Prerequisites:** PHYS F220; PHYS F301; or permission of instructor.

**Lecture + Lab + Other:** 1 + 0 + 0

**PHYS F472L  Advanced Topics in Physics II: Covariant Kinematics/Dynamics**  (n)
1 Credit
Application topics provide expanded exposure to subjects in physics. Three topics are offered within the fall and spring semesters of each academic year as compressed 14-lecture, one-credit courses.

**Prerequisites:** PHYS F220; PHYS F301; or permission of instructor.

**Lecture + Lab + Other:** 1 + 0 + 0

**PHYS F472Z  Advanced Topics in Physics II: Current Topics in Physics**  (n)
1 Credit
Offered as Demand Warrents
The advanced topics modules provide expanded exposure to modern subjects in physics. Three topics are offered each semester, providing breadth beyond the core subjects of the physics undergraduate curriculum. This course will present most current material from one particular topic in physics, to be determined at the time of the offering. Students are expected to have familiarity with the core subjects in the field (classical mechanics, electromagnetism, statistical physics, quantum mechanics.)  (1+0)

**Prerequisites:** PHYS F220; PHYS F301.

**Lecture + Lab + Other:** 1 + 0 + 0

**PHYS F488  Undergraduate Research**
1-3 Credits
Advanced research topics from outside the usual undergraduate requirements.

**Prerequisites:** Permission of instructor.

**Recommended:** A substantial level of technical/scientific background.

**Lecture + Lab + Other:** 0 + 0 + 0

**PHYS F497  Individual Study**
1-9 Credits

**Lecture + Lab + Other:** 0 + 0 + 0

**PHYS F605  Physics Teaching Seminar/Practicum**
1 Credit
Offered Fall and Spring
This course will give science graduate students both lectures and hands-on training in dealing with all aspects of teaching, focused on but not exclusive to the Teaching Assistant level. Course topics include teaching pedagogy, preparation strategies, student management, time management and learning assessment.

**Prerequisites:** Graduate standing in a science discipline; or permission of the instructor.

**Lecture + Lab + Other:** 1 + 0 + 1

**PHYS F608  Core Skills for Computational Science**
3 Credits
Offered Fall
This course provides students of computational sciences, an introduction to the basic skills required to operate in the modern high performance computing (HPC) environment offered at the Arctic Regional Supercomputing Center (ARSC). Topics include an introduction to HPC, basic Unix/batch/scripting skills, performance programming, shared and distributed memory parallelism, code validation and debugging, data storage and management and data visualization. Each of these topics will be presented in lecture form. To provide additional applied knowledge, either a thorough case study by a guest speaker and/or a hands-on lab session will be given in support of each. Graduate standing in physical sciences, experience with FORTAN or C programming language or permission of instructor.

**Lecture + Lab + Other:** 3 + 0 + 0
PHYS F611 Mathematical Physics  
3 Credits  
Offered Fall  
Mathematical tools and theory for classical and modern physics. Core topics: linear algebra including eigenvalues, eigenvectors and inner products in finite dimensional spaces. Infinite series. Hilbert spaces and generalized functions. Complex analysis, including Laurent series and contour methods. Applications to problems arising in physics. Selected additional topics, which may include operator and spectral theory, groups, tensor fields and hypercomplex numbers.  
Prerequisites: MATH F302; MATH F314; MATH F421; MATH F422; or permission of instructor.  
Cross-listed with MATH F611.  
Lecture + Lab + Other: 3 + 0 + 0  

PHYS F612 Mathematical Physics  
3 Credits  
Offered Spring  
Prerequisites: PHYS/MATH F611 or equivalent; or permission of instructor.  
Cross-listed with MATH F612.  
Lecture + Lab + Other: 3 + 0 + 0  

PHYS F613 Atmospheric Radiation  
3 Credits  
Offered Fall Odd-numbered Years  
Fundamentals of blackbody radiation theory and radiative properties of atmospheric constituents. Discussion of gaseous absorption including line absorption, broadening effects and radiative transfer. Includes scattering, radiative properties of clouds, and radiation climatology. Prerequisites/co-requisites: ATM F601; graduate standing.  
Cross-listed with ATM F613.  
Stacked with PHYS F413 and ATM F413.  
Lecture + Lab + Other: 3 + 0 + 0  

PHYS F614 Ice Physics  
3 Credits  
Offered Spring Even-numbered Years  
A survey of the physics of ice, including the crystal structure and properties of ice, high pressure phases, hydrogen bonding, mechanical properties, thermal properties, electrical and acoustic properties, nucleation and growth, optical properties and surface properties (adhesion, friction).  
Prerequisites: MATH F421; MATH F422; graduate standing; or permission of instructor.  
Cross-listed with GEOS F614.  
Lecture + Lab + Other: 3 + 0 + 0  

PHYS F621 Classical Mechanics  
3 Credits  
Offered Fall Odd-numbered Years  
Lagrange's equations, two-body problem, rigid body motion, special relativity, canonical equations, transformation theory, and Hamilton-Jacobi method.  
Prerequisites: Graduate standing or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0  

PHYS F622 Statistical Mechanics  
3 Credits  
Offered Spring Even-numbered Years  
Classical and quantum statistics of independent particles, ensemble theory and applications.  
Prerequisites: PHYS F621; graduate standing; or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0  

PHYS F625 Inverse Problems and Parameter Estimation  
3 Credits  
Offered Spring Odd-numbered Years  
An inverse problem uses observations to infer properties of an unknown physical model. One example is how seismometer recordings can be used to infer the location of an earthquake. This course covers inverse theory and methods for solving inverse problems, including numerous examples arising in the natural sciences. Topics include linear regression, method of least squares, discrete ill-posed inverse problems, estimation of uncertainties, iterative optimization, and probabilistic (Bayesian) and sampling approaches. Assignments and computational laboratory exercises require familiarity with linear algebra and computational tools such as Matlab.  
Prerequisites: MATH F253X; MATH F314; or permission of instructor.  
Cross-listed with GEOS F627.  
Lecture + Lab + Other: 2 + 3 + 0  

PHYS F626 Fundamentals of Plasma Physics  
3 Credits  
Offered Fall  
Single charge particle motion in the electromagnetic fields, plasma kinetic theory, Vlasov equations for collisionless plasmas, magnetohydrodynamic equations, linear plasma waves and instabilities, nonlinear plasma waves and instabilities.  
Prerequisites: Graduate standing; or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0  

PHYS F627 Advanced Plasma Physics  
3 Credits  
Offered Spring Even-numbered Years  
Vlasov description of small amplitude waves in magnetized plasmas, advanced particle orbit theory, fluctuation and incoherent scattering theory, plasma discontinuities and collisionless shocks, weak turbulent theory, statistical theory of turbulence.  
Prerequisites: PHYS F626 or equivalent; graduate standing; or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0  

PHYS F628 Digital Time Series Analysis  
3 Credits  
Offered Spring Even-numbered Years  
Applied time series analysis, including correlation, convolution, filtering and spectral estimation of multivariate data. The statistical properties of estimators; signal detection; and array processing.  
Prerequisites: MATH F401 or equivalent; familiarity with a programming language such as C or Fortran; graduate standing; or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0
PHYS F629  Methods of Numerical Simulation in Fluids and Plasma  
3 Credits  
Offered Spring Odd-numbered Years  
The fundamentals of computer simulation for fluids and multi-particle systems. Topics include methods for the discretization of numerical solutions, and boundary and initial conditions. Methods will be applied to convection, diffusion, and steady states in fluids and plasmas.  
**Prerequisites:** Experience in programming; graduate standing; or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0

PHYS F631  Electromagnetic Theory  
3 Credits  
Offered Fall Even-numbered Years  
Electrostatics, magnetostatics, Maxwell's equations, and potentials. Lorentz equations, field energy, gauge conditions, retarded potentials, waves, radiation and tensor formulations.  
**Prerequisites:** Graduate standing or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0

PHYS F632  Electromagnetic Theory  
3 Credits  
Offered Spring Odd-numbered Years  
Electrostatics, magnetostatics, Maxwell's equations and potentials. Lorentz equations, field energy, gauge conditions, retarded potentials, waves, radiation and tensor formulations.  
**Prerequisites:** PHYS F631 or the equivalent; graduate standing; or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0

PHYS F639  InSar and its Applications  
3 Credits  
Offered As Demand Warrants  
Introduction to the concepts of repeat-pass spaceborne SAR interferometry and practical use of the technique to derive displacements of the solid Earth, glaciers, and ice sheets to a precision of a few centimeters and accurate digital elevation models of the Earth's surface.  
**Cross-listed with GEOS F639.**  
Lecture + Lab + Other: 2 + 2 + 0

PHYS F640  Auroral Physics  
3 Credits  
Offered Spring Odd-numbered Years  
Survey of aurora phenomena, the associated physical processes, and techniques used to investigate the aurora. Includes electron and proton impact spectra; physical processes that accelerate and precipitate electrons and protons; auroral currents; ionospheric effects of auroral activity; and principles for ground-based satellite spectroscopy and imaging and the measurements of magnetic and electric fields.  
**Prerequisites:** Graduate standing or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0

PHYS F647  Fundamentals of Geophysical Fluid Dynamics  
3 Credits  
Offered Fall Odd-numbered Years  
Introduction to the mechanics of fluid systems, the fundamental processes, Navier-Stokes' equations in rotating and stratified fluids, kinematics, conservation laws, vortex motion, irrotational flow, laminar flow, boundary layer phenomena, waves, instabilities, turbulent flows and mixing.  
**Prerequisites:** Graduate standing or permission of instructor.  
**Cross-listed with ATM F647.**  
Lecture + Lab + Other: 3 + 0 + 0

PHYS F648  Nonlinear Dynamics  
3 Credits  
Offered Spring Even-numbered Years  
Introduction into the dynamics of nonlinear systems. Continuous and discrete dynamical systems, stability analysis, bifurcations, limit cycle, chaos and strange attractors, fractals and dimension algorithms, controlling chaos, synchronization processes, and stochastic dynamical systems.  
**Prerequisites:** Graduate standing or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0

PHYS F650  Aeronomy  
3 Credits  
Offered Fall Even-numbered Years  
The physical and chemical processes that govern the response of planetary atmospheres to solar radiation and energetic particles. Formation of and characteristic processes in the layers within the ionosphere and basic magneto-ionic theory. Includes principles of remote sensing by lidar and radar techniques.  
**Prerequisites:** Graduate standing or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0

PHYS F651  Quantum Mechanics  
3 Credits  
Offered Fall Even-numbered Years  
Schrodinger's equations, operator formalism, correspondence principle, central force problems, perturbation theory, quantum statistical mechanics, and applications of quantum mechanics to collision problems, radiation and spectroscopy.  
**Prerequisites:** PHYS F651 or the equivalent; graduate standing; or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0

PHYS F652  Quantum Mechanics  
3 Credits  
Offered Spring Odd-numbered Years  
Schrodinger's equations, operator formalism, correspondence principle, central force problems, perturbation theory, quantum statistical mechanics, and applications of quantum mechanics to collision problems, radiation and spectroscopy.  
**Prerequisites:** PHYS F651 or the equivalent; graduate standing; or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0

PHYS F672  Magnetospheric Physics  
3 Credits  
Offered Spring Even-numbered Years  
The physics and dynamics of Earth's magnetosphere. Discusses the magnetosphere as a test bed for microscopic plasma processes equilibrium configurations, plasma instabilities, highly nonlinear eruptive plasma processes, and global dynamics which involve the interaction of various regions of the magnetosphere. Introduction to various aspects of magnetospheric physics with a systematic discussion of the various elements of the magnetosphere, their structure and dynamics, and a discussion of the relevant plasma physics.  
**Prerequisites:** PHYS F626; graduate standing; or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0
PHYS F673  Space Physics
3 Credits
Offered Alternate Fall Odd-numbered Years
Plasma physics of the heliosphere from the solar core to the interstellar medium. Includes coronal structure, interplanetary magnetic field and solar wind, shocks, interactions with planets, planetary magnetospheres, cosmic rays, solar-terrestrial relations and instrumentation.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

PHYS F692P  Seminar
1 Credit
Lecture + Lab + Other: 0 + 0 + 0

PHYS F698  Non-Thesis Research/Project
1-9 Credits
Lecture + Lab + Other: 0 + 0 + 0

PHYS F699  Thesis
1-12 Credits
Lecture + Lab + Other: 0 + 0 + 0