PHYSICS

The principles of physics provide the underpinnings for many of the scientific and technological advances of the last several decades.

Experimental research facilities are available in the areas of condensed matter, surface science, biophysics, and optics. Theoretical studies are conducted in relativity and cosmology, high energy physics, biophysics, medical imaging, and condensed matter physics. Observational studies focus on relativistic astrophysics, multi-messenger astronomy, and galaxy evolution. Joint study with other departments can also be arranged.

Programs

- Physics, BS (http://catalog.uwm.edu/letters-science/physics/physics-bs)
- Physics, Minor (http://catalog.uwm.edu/letters-science/physics/physics-minor)
- Physics, MS (http://catalog.uwm.edu/letters-science/physics/physics-ms)
- Physics, PhD (http://catalog.uwm.edu/letters-science/physics/physics-phd)

Astronomy Courses

ASTRON 103 Survey of Astronomy
3 cr. Undergraduate.
History of astronomy; planets; stellar evolution, nucleosynthesis; death of stars: white dwarfs, neutron stars, black holes; galaxies and quasars; expansion of the universe, dark matter; the big bang.
Prerequisites: math placement level 10.
General Education Requirements: NS
Last Taught: Spring 2018, Fall 2017, Spring 2017, Fall 2016.
Current Offerings: http://uwm.edu/schedule

ASTRON 104 Astronomy Laboratory
1 cr. Undergraduate.
Observations of planets, stars, stellar clusters, and galaxies; related experiments. Correlated with Atron 103.
Prerequisites: Astron 103(C) or Atron 211(C).
General Education Requirements: NS+
Last Taught: Spring 2018, Fall 2017, Spring 2017, Fall 2016.
Current Offerings: http://uwm.edu/schedule

ASTRON 185 Astronomy for Pre-Education Majors
3 cr. Undergraduate.
Space: how we know and what we know; the solar system, stars, galaxies, and the universe. 2 hrs lec, lab.
Prerequisites: none.
General Education Requirements: NS+
Current Offerings: http://uwm.edu/schedule

ASTRON 194 First-Year Seminar:
3 cr. Undergraduate.
Specific topics are announced in the Schedule of Classes each time the class is offered.
Prerequisites: none.
Course Rules: Open only to freshmen. Students may earn cr in just one L&S First-Year Sem (course numbers 192, 193, 194).
General Education Requirements: NS
Current Offerings: http://uwm.edu/schedule

ASTRON 199 Independent Study
1-3 cr. Undergraduate.
For further information, consult dept chair.
Prerequisites: 2.5 gpa; writ cons instr, dept chair & asst dean for SAS.
Course Rules: May be retaken to 6 cr max.
Current Offerings: http://uwm.edu/schedule

ASTRON 211 Principles of Astronomy
3 cr. Undergraduate.
Light and matter; planets; stellar evolution, nucleosynthesis; death of stars; white dwarfs, neutron stars, black holes; galaxies, quasars; expansion of universe, dark matter; big bang.
Prerequisites: Physics 120(P) or 209(P) or cons instr.
General Education Requirements: NS
Last Taught: Fall 2017, Fall 2015, Fall 2013.
Current Offerings: http://uwm.edu/schedule

ASTRON 289 Internship in Astronomy, Lower Division
1-6 cr. Undergraduate.
Application of basic principles of astronomy in a research, business, organizational, educational, political, or other appropriate setting.
Prerequisites: intro course in astron; 2.25 gpa; cons supervising faculty member.
Course Rules: One cr earned for academic work based on 40 hours in internship. May be retaken to 6 cr max.
Current Offerings: http://uwm.edu/schedule

ASTRON 299 Ad Hoc:
1-6 cr. Undergraduate.
Course created expressly for offering in a specified enrollment period. Requires only dept & assoc dean approval. In exceptional circumstances, can be offered in one add'l sem. May be retaken w/chg in topic.
Prerequisites: none; add'l prereqs may be assigned to specific topic.
Last Taught: Fall 2007.
Current Offerings: http://uwm.edu/schedule

ASTRON 400 Astrophysics I
3 cr. Undergraduate.
Introductory astrophysics for students with junior-/senior-level background in mathematics and physics. Light and matter; stars and the sun; extrasolar planets; compact objects.
Prerequisites: Astron 103(P) or 211(P) or cons instr, Physics 309(P); Physics 317(R) recom.
Last Taught: Fall 2016, Fall 2014, Fall 2012, Fall 2010.
Current Offerings: http://uwm.edu/schedule
Physics Courses

PHYSICS 100 Quantitative Preparation for Physics
2 cr. Undergraduate.
Introductory course in general physics designed for the student with little or no previous science training.
Prerequisites: Math Placement Level 10.
Course Rules: Fee for 3 cr assessed. Not open to students w/cr in Physics 110(ER), 120(ER), or 209(ER).
Last Taught: Spring 2015, Fall 2014, Spring 2014, Fall 2013.
Current Offerings: http://uwm.edu/schedule

PHYSICS 107 Physics in Everyday Life
3 cr. Undergraduate.
Selected topics for citizens in a technological world. Emphasis on those aspects of science important to an understanding of our surroundings. For non-science majors.
Prerequisites: none.
Course Rules: May not be taken conc with or after having taken Physics 120(ER) or 209(ER).
General Education Requirements: NS
Current Offerings: http://uwm.edu/schedule

PHYSICS 108 Laboratory for Physics in Everyday Life
1 cr. Undergraduate.
Experiments correlated with Physics 107.
Prerequisites: Physics 107(C).
General Education Requirements: NS+
Last Taught: Spring 2018, Fall 2017, Spring 2017, Fall 2016.
Current Offerings: http://uwm.edu/schedule

PHYSICS 110 Physics for the Health Professions
4 cr. Undergraduate.
An introductory course without laboratory for students in health-related pre-professional programs. Topics include mechanics, fluids, heat, sound, electricity, magnetism, electrical devices, optics, and radioactivity. 3 hrs lec, 1 hr dis.
Prerequisites: H.S. general science; Math Placement Level 20.
Course Rules: May not be taken conc with or after having taken Physics 120(ER) or 209(ER).
General Education Requirements: NS
Last Taught: Fall 2017, Fall 2016, Spring 2016, Fall 2015.
Current Offerings: http://uwm.edu/schedule

PHYSICS 120 General Physics I (Non-Calculus Treatment)
4 cr. Undergraduate.
Mechanics, wave motion, heat, and sound. 3 hrs lec, 2 hrs dis.
Prerequisites: Math Placement Level 30 or grade of C or better in Physics 100(P); HS trig or Physics 100 strongly recom.
Course Rules: Any combination of Physics 120, 121, 209, 214, 219 carries max 5 cr toward graduation.
General Education Requirements: NS
Current Offerings: http://uwm.edu/schedule

PHYSICS 121 General Physics Laboratory I (Non-Calculus Treatment)
1 cr. Undergraduate.
Experiments correlated with lecture material of Physics 120.
Prerequisites: Physics 120(C).
Course Rules: Any combination of Physics 120, 121, 209, 214, 219 carries max 5 cr toward graduation.
General Education Requirements: NS+
Current Offerings: http://uwm.edu/schedule

PHYSICS 122 General Physics II (Non-Calculus Treatment)
4 cr. Undergraduate.
Electricity, optics, modern physics. 3 hrs lec, 2 hrs dis.
Prerequisites: Physics 120(NP).
Course Rules: Any combination of Physics 122, 123, 210, 215, 220 carries 5 cr max toward graduation.
General Education Requirements: NS
Current Offerings: http://uwm.edu/schedule

PHYSICS 123 General Physics Laboratory II (Non-Calculus Treatment)
1 cr. Undergraduate.
Experiments on topics related to the lecture material of Physics 122.
Prerequisites: Physics 122(C).
Course Rules: Any combination of Physics 122, 123, 210, 215, 220 carries 5 cr max toward graduation.
General Education Requirements: NS+
Current Offerings: http://uwm.edu/schedule

PHYSICS 214 Electricity and Modern Physics
3 cr. Undergraduate.
Continuation of Physics 120; for students with little or no previous science training.
Prerequisites: Math Placement Level 30 or grade of C or better in Physics 100(P); HS trig or Physics 100 strongly recom.
Course Rules: Any combination of Physics 120, 121, 209, 214, 219 carries max 5 cr toward graduation.
General Education Requirements: NS+
Current Offerings: http://uwm.edu/schedule

PHYSICS 219 Modern Physics Laboratory
1 cr. Undergraduate.
Experiments correlated with lecture material of Physics 214.
Prerequisites: Physics 120(NP).
Course Rules: Any combination of Physics 120, 121, 209, 214, 219 carries 5 cr max toward graduation.
General Education Requirements: NS+
Current Offerings: http://uwm.edu/schedule
PHYSICS 185 Basic Physics for Teachers
3 cr. Undergraduate.
Simple machines; work, energy and power; heating and cooling; static electricity and elementary electrical circuits; waves. 2 hrs lec; 2 hrs lab/dis.
Prerequisites: Math 175(P) & cons instr.
Course Rules: Not open for cr to students with cr in Physics courses numbered 110 or above.
General Education Requirements: NS
Current Offerings: http://uwm.edu/schedule

PHYSICS 194 First-Year Seminar
3 cr. Undergraduate.
The specific topics are announced in the Schedule of Classes each time the class is offered.
Prerequisites: none.
Course Rules: Open only to freshmen. Students may earn cr in just one L&S First-Year Sem (course numbers 192, 193, 194).
General Education Requirements: NS
Last Taught: Fall 2017, Fall 2015, Fall 2014, Fall 2013.
Current Offerings: http://uwm.edu/schedule

PHYSICS 199 Independent Study
1-3 cr. Undergraduate.
For further information, consult dept chair.
Prerequisites: 2.5 gpa; writ cons instr, dept chair & asst dean for SAS.
Course Rules: May be retaken to 6 cr max.
Current Offerings: http://uwm.edu/schedule

PHYSICS 209 Physics I (Calculus Treatment)
1 cr. Undergraduate.
Experiments in mechanics, wave motion, sound, and heat. 8 hrs lec/lab.
Prerequisites: Physics 107(P), 110(P), 120(P), or 209(P).
Course Rules: Not open to students w/cr in Physics 209. Any combination of Physics 120, 121, 209, 214, 219 carries max 5 cr toward graduation.
General Education Requirements: NS
Last Taught: Fall 2017, Fall 2016, Fall 2015.
Current Offerings: http://uwm.edu/schedule

PHYSICS 210 Physics II (Calculus Treatment)
3 cr. Undergraduate.
Experiments in mechanics, wave motion, heat, and thermodynamics. 3 hrs lab.
Prerequisites: Physics 209(P); Math 229(C) or Math 233(C).
Course Rules: Not open to students w/cr in Physics 209. Any combination of Physics 120, 121, 209, 214, 219 carries max 5 cr toward graduation.
General Education Requirements: NS
Current Offerings: http://uwm.edu/schedule

PHYSICS 215 Lab Physics II (Calculus Treatment)
1 cr. Undergraduate.
Experiments in electricity, magnetism, and optics. 3 hrs lec.
Prerequisites: Physics 210(C).
Course Rules: Any combination of Physics 122, 123, 210, 215, 220 carries max 5 cr toward graduation.
General Education Requirements: NS+
Current Offerings: http://uwm.edu/schedule

PHYSICS 219 Physics I: Calculus-Based, Studio Format
5 cr. Undergraduate.
Basic kinematics; Newton. Selected topics in mechanics, wave motion, sound, and heat. 8 hrs lec/lab.
Prerequisites: Math 227(C), 228(C), or 232(C).
Course Rules: Not open to students w/cr in Physics 209. Any combination of Physics 120, 121, 209, 214, 219 carries max 5 cr toward graduation.
General Education Requirements: NS+
Last Taught: Fall 2017, Fall 2016, Fall 2015.
Current Offerings: http://uwm.edu/schedule

PHYSICS 220 Physics II: Calculus-Based, Studio Format
5 cr. Undergraduate.
Electromagnetic field theory and optics. Prerequisites: grade of C or better in Physics 219(NP); Math 229(C) or 233(C).
Course Rules: Not open to students w/cr in Physics 210. Any combination of Physics 122, 123, 210, 215, 220 carries max 5 cr toward graduation.
General Education Requirements: NS+
Current Offerings: http://uwm.edu/schedule

PHYSICS 265 Physics and the Energy Problem
3 cr. Undergraduate.
Study of how the laws of physics (particularly 1st and 2nd Laws of Thermodynamics) limit society’s options in dealing with scarcity of utilizable energy.
Prerequisites: H.S. algebra; Physics 107(P), 110(P), 120(P), or 209(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 270 Introduction to Computational Physics
3 cr. Undergraduate.
Use of computers to solve physics problems, including particle collisions, chaotic systems, planetary motion, and other topics related to relativity and quantum mechanics.
Prerequisites: Physics 209(P); Math 233(C).
Current Offerings: http://uwm.edu/schedule
PHYSICS 289 Internship in Physics, Lower Division
1-6 cr. Undergraduate.
Application of basic principles of physics in a research, business, organizational, educational, political, or other appropriate setting.
Prerequisites: intro course in physics; 2.25 gpa; cons supervising faculty member.
Course Rules: One cr earned for academic work based on 40 hours in internship. May be retaken to 6 cr max.
Current Offerings: http://uwm.edu/schedule

PHYSICS 296 UROP Apprenticeship
1-3 cr. Undergraduate.
Undergraduate research participation in a project developed with a supervising member of the faculty or staff.
Prerequisites: acceptance into UROP; prior or conc reg in UROP seminar.
Course Rules: One cr for 45 hrs research. May be retaken to 9 cr max in any combination of UROP apprenticeship courses.
Last Taught: Spring 2018, Spring 2017, Fall 2016, Fall 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 297 Study Abroad:
1-12 cr. Undergraduate.
Designed to enroll students in UWM sponsored program before course work level, content, and credits are determined and/or in specially prepared program course work.
Prerequisites: acceptance for Study Abroad Prog.
Course Rules: May be retaken w/chg in topic.
Last Taught: Spring 2015, Summer 2011, Spring 2010, Fall 2009.
Current Offerings: http://uwm.edu/schedule

PHYSICS 299 Ad Hoc:
1-6 cr. Undergraduate.
Course created expressly for offering in a specified enrollment period. Requires only dept & assoc dean approval. In exceptional circumstances, can be offered in one add'l sem.
Prerequisites: none; add'l prereqs may be assigned to specific topic.
Course Rules: May be retaken w/chg in topic.
Current Offerings: http://uwm.edu/schedule

PHYSICS 305 Medical Physics
3 cr. Undergraduate.
Applications of physics to living systems & medical diagnostics. 3 hrs lec.
Prerequisites: grade of B+ or better in Physics 209(P). (Conc reg in Physics 210 strongly recom).
Course Rules: Primarily for premed students and others in the medical & biological sciences. Approved for Premed Stds Cert Prog.
Current Offerings: http://uwm.edu/schedule

PHYSICS 306 Introduction to Biophysics
3 cr. Undergraduate.
Physical foundations of cellular phenomena; physical laws of complex biological systems; imaging and instrumentation for biophysics. 3 hrs lec.
Prerequisites: Physics 122(P) or 210(P); Chemistry 104(P) or 105(P).
Course Rules: Approved for Premed Stds Cert Prog.
Last Taught: Fall 2017, Fall 2015, Fall 2010, Spring 2009.
Current Offerings: http://uwm.edu/schedule

PHYSICS 309 Physics III: Modern Physics
3 cr. Undergraduate.
Elementary quantum physics, atomic and molecular physics, solid state and nuclear physics.
Prerequisites: Physics 210(NP); Math 234(C).
Course Rules: Not open for cr to students who have had Physics 341.
General Education Requirements: QLB
Last Taught: Spring 2018, Fall 2017, Spring 2017, Fall 2016.
Current Offerings: http://uwm.edu/schedule

PHYSICS 317 Thermodynamics
3 cr. Undergraduate.
Classical thermodynamics, including entropy, the use of thermodynamic potentials, and applications to pressure-volume and other systems. Some basic statistical physics may be included.
Prerequisites: Physics 210(NP).
Last Taught: Fall 2017, Fall 2016, Spring 2016, Spring 2015.
Current Offerings: http://uwm.edu/schedule

PHYSICS 325 Optics
4 cr. Undergraduate.
Geometric and physical optics, image formation, interference, diffraction, polarization, optical instruments, resolving power, coherence, lasers, holography. Selected experiments in optics. Studio-format course.
Prerequisites: Math 234(P) & Physics 309(C) or cons instr.
Course Rules: Counts as repeat of Physics 325 & 2 cr of Physics 410.
Current Offerings: http://uwm.edu/schedule

PHYSICS 351 Basics of Condensed Matter Physics
3 cr. Undergraduate.
Basic principles of condensed-matter physics. Crystals and amorphous materials; bonding; magnetic, thermal, and transport properties; band theory.
Prerequisites: Physics 309(P) or Chem 311(P).
Course Rules: Counts as repeat of Physics 499 w/same topic.
Current Offerings: http://uwm.edu/schedule

PHYSICS 370 Analytical and Numerical Methods in Physics
3 cr. Undergraduate.
Solutions to various physics problems. Applications (both analytical and numerical) from mechanics, electromagnetics, quantum mechanics, astrophysics, condensed matter physics.
Prerequisites: Physics 210(NP); Math 234(C) or ElecEng 234(C); or cons instr.
Last Taught: Spring 2018, Spring 2017, Fall 2015, Fall 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 381 Honors Seminar:
3 cr. Undergraduate.
Selected topics concerning history and the nature of physics as an intellectual discipline.
Prerequisites: soph st; Honors 200(P); cons Honors College dir.
Course Rules: May be retaken w/chg in topic to 9 cr max. No cr toward major.
General Education Requirements: NS
Last Taught: Fall 2017, Fall 2016, Fall 2013, Fall 2011.
Current Offerings: http://uwm.edu/schedule
PHYSICS 391 Undergraduate Research Participation
1-6 cr. Undergraduate.
Independent research for undergraduates on faculty-supervised research projects.
Prerequisites: Physics 309(P); 3.25 GPA in physics courses; cons instr.
Course Rules: May be retaken w/chg in topic to 6 cr max; non-repeatable for change of grade.
Current Offerings: http://uwm.edu/schedule

PHYSICS 406 Introduction to Infrared Microspectroscopy
3 cr. Undergraduate.
Microscopy and spectroscopy methods for identification of chemical composition introducing interdisciplinary opportunities in fundamental and industrial applications.
Prerequisites: Bio Sci 150(P) & 152(P); or Physics 209(P) & 210(P); or Chem 102(P) & 104(P); or Chem 105(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 408 Experiments in Linear Electronics
3 cr. Undergraduate/Graduate.
Transistor and integrated circuit characteristics; electronic measurement and control.
Prerequisites: jr st, Physics 210(P).
Course Rules: No cr for students w/cr in ElecEng 330(R).
Current Offerings: http://uwm.edu/schedule

PHYSICS 409 Modern Physics Laboratory
3 cr. Undergraduate.
Selected experiments in modern physics using advanced lab instrumentation.
Prerequisites: jr st; Physics 210(P) or cons instr.
Last Taught: Spring 2018, Fall 2017, Fall 2016, Fall 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 411 Mechanics
4 cr. Undergraduate/Graduate.
Kinematics, vector analysis, conservation laws, oscillations, variational methods, chaos, Lagrangian and Hamiltonian mechanics.
Prerequisites: jr st; Physics 210(NP).
Current Offerings: http://uwm.edu/schedule

PHYSICS 420 Electricity and Magnetism I
3 cr. Undergraduate/Graduate.
Conservation laws in electrodynamics, Maxwell’s stress tensor, electromagnetic waves, absorption, dispersion, reflection and transmission of plane electromagnetic waves, wave guides, retarded potentials, radiation, electrodynamics and relativity.
Prerequisites: jr st, Physics 420(P); or grad st.
Course Rules: Counts as repeat of 2 cr of Physics 421.
Current Offerings: http://uwm.edu/schedule

PHYSICS 422 Electricity and Magnetism II
3 cr. Undergraduate/Graduate.
Historical background and experimental basis, De Broglie waves, correspondence principle, uncertainty principle, Schroedinger equation; hydrogen atom, electron spin, Pauli Principle, applications of wave mechanics.
Prerequisites: jr st; Physics 309(NP); Math 321(C).
Last Taught: Fall 2017, Fall 2016, Fall 2015, Fall 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 441 Introduction to Quantum Mechanics I
4 cr. Undergraduate/Graduate.
Continuation of Physics 441, emphasizing perturbation theory and applications to multi-electron systems, including atoms, molecules, and solids.
Prerequisites: jr st; Physics 441(NP).
Current Offerings: http://uwm.edu/schedule

PHYSICS 442 Introduction to Quantum Mechanics II
3 cr. Undergraduate/Graduate.
Application of advanced principles of physics in a research, business, organizational, educational, political, or other appropriate setting.
Prerequisites: jr st; 300-level or above course in Physics; 2.25 gpa; cons supervising faculty member.
Course Rules: One cr earned for academic work based on 40 hrs in internship. May be retaken to 6 cr max.
Current Offerings: http://uwm.edu/schedule

PHYSICS 489 Internship in Physics, Upper Division
1-6 cr. Undergraduate.
Designed to enroll students in UWM sponsored program before course work level, content, and credits are determined and/or in specially prepared program course work.
Prerequisites: jr st; acceptance for Study Abroad Prog.
Course Rules: May be retaken w/chg in topic.
Current Offerings: http://uwm.edu/schedule

PHYSICS 497 Study Abroad:
1-12 cr. Undergraduate/Graduate.
Talks by faculty, visitors, and students on topics of current interest in physics, astronomy, and other science and engineering fields.
Prerequisites: sr st; Physics 411(C), 421(C), or 441(C).
Course Rules: Cr/no cr only.
Current Offerings: http://uwm.edu/schedule

PHYSICS 498 Undergraduate Physics Seminar
1 cr. Undergraduate.
Courses, talks by faculty, visitors, and students on topics of current interest in physics, astronomy, and other science and engineering fields.
Prerequisites: jr st; Physics 309(P); Math 321(C).
Course Rules: May be retaken to 6 cr max; non-repeatable for change of grade.
Current Offerings: http://uwm.edu/schedule
PHYSICS 499 Ad Hoc:
1-6 cr. Undergraduate.
Course created expressly for offering in a specified enrollment period.
Requires only dept & assoc dean approval. In exceptional circumstances, can be offered in one add'l sem.
Prerequisites: jr st; add'l prereqs may be assigned to specific topic.
Course Rules: May be retaken w/chg in topic.
Current Offerings: http://uwm.edu/schedule

PHYSICS 501 Special Topics: Mathematical Models of Physical Problems
I
3 cr. Undergraduate/Graduate.
Selected topics in mathematics for study of the techniques and procedures for stating physical problems in mathematical terms and the physical interpretation of mathematical solutions.
Prerequisites: jr st; Physics 210(P); Math 234(P).
Last Taught: Fall 2017, Fall 2016, Fall 2015, Fall 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 502 Special Topics: Mathematical Models of Physical Problems
II
3 cr. Undergraduate/Graduate.
More selected topics in mathematical models.
Prerequisites: jr st, Physics 210(P); Math 234(P). Physics 501(R).
Current Offerings: http://uwm.edu/schedule

PHYSICS 515 Statistical Mechanics
3 cr. Undergraduate/Graduate.
Brief survey of thermodynamics; statistical mechanics; classical and quantum gases.
Prerequisites: jr st; Physics 317(P) & 441(P).
Last Taught: Fall 2017, Fall 2016, Fall 2015, Fall 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 517 Special Relativity
3 cr. Undergraduate/Graduate.
Relativistic kinematics, the Lorentz transformation, tensor calculus, applications to motion of particles, electromagnetism.
Prerequisites: jr st; Physics 441(R) & 421(R).
Last Taught: Fall 2017, Fall 2014, Spring 2013, Fall 2010.
Current Offerings: http://uwm.edu/schedule

PHYSICS 531 Principles of Quantum Mechanics I
3 cr. Undergraduate/Graduate.
Vector and Hilbert spaces; Schroedinger equation in 1, 2, and 3 dimensions; systems of many particles; symmetries; angular momentum.
Prerequisites: jr st, Physics 441(P).
Last Taught: Fall 2017, Fall 2016, Fall 2015, Fall 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 532 Principles of Quantum Mechanics II
3 cr. Undergraduate/Graduate.
Continuation of 531. Spin; hydrogen atom; variational methods; WKB approximation; perturbation theory; scattering theory; Dirac equation.
Prerequisites: jr st, Physics 531(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 541 Elementary Particles
3 cr. Undergraduate/Graduate.
Accelerators and detectors; special unitary groups; quark model of hadrons; Feynman diagrams; electromagnetic, weak and strong interactions of quarks and leptons; Higgs boson.
Prerequisites: jr st; Physics 441(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 551 Introduction to Solid State Physics I
3 cr. Undergraduate/Graduate.
Crystal structure, reciprocal lattice; crystal binding; elastic waves; phonons, lattice vibrations; thermal properties of insulators; free electron Fermi gas. Band structure; semiconductor crystals; Fermi surface.
Prerequisites: jr st; Physics 441(P) or cons instr.
Last Taught: Fall 2016, Fall 2014, Fall 2012, Fall 2010.
Current Offerings: http://uwm.edu/schedule

PHYSICS 557 Vacuum Science and Technology
3 cr. Undergraduate/Graduate.
Viscous and molecular flow, vacuum materials and seals, metal-to-ceramic seals, evaporation and vapor pressures, vacuum pumps, vacuum gauges, mass spectrographs, chemical reactions at surfaces, outgassing.
Prerequisites: jr st, Physics 441(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 606 Molecular, Cellular, and System Biophysics
3 cr. Undergraduate.
Prerequisites: jr st, Physics 210(P), & writ cons instr; or grad st.
Current Offerings: http://uwm.edu/schedule

PHYSICS 610 The Art and Science of Teaching Physics
1 cr. Undergraduate/Graduate.
Participants critique lectures, videotapes of experienced teachers, each other; address conceptual problems facing beginning students; gain familiarity with demonstrations, classroom technology; discuss their own classes.
Prerequisites: appt as undergrad TA or grad st.
Last Taught: Fall 2017, Fall 2016, Fall 2015, Fall 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 651 Introduction to Solid State Physics II
3 cr. Undergraduate/Graduate.
Transport, superconductivity, dielectric properties, ferroelectric crystals, magnetism, magnetic resonance, optical phenomena in insulators, nanostructures, non-crystalline solids, point defects, alloys, dislocations.
Prerequisites: jr st; Physics 551(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 670 Electron Microscopy Laboratory
3 cr. Undergraduate/Graduate.
Diffraction, imaging, and spectroscopy methods for study of morphology, crystallinity, and composition of solids in a transmission electron microscope.
Prerequisites: sr st; Physics 551(P) or cons instr.
Current Offerings: http://uwm.edu/schedule
PHYSICS 698 Research Experience for Teachers
1-6 cr. Undergraduate/Graduate.
Enrichment of students' physics background. Work with faculty mentor to develop an innovative teaching program for use in students' own classroom.
Prerequisites: sr st; current teaching contract.
Course Rules: Open only to practicing science teachers with demonstrable expertise in physics. May be retaken to 9 cr max.
Current Offerings: http://uwm.edu/schedule

PHYSICS 699 Advanced Independent Reading
1-3 cr. Undergraduate.
Independent reading or research under supervision of faculty member. Study proposal required. For further information, consult dept chair or undergrad advising coord.
Prerequisites: jr st; 2.5 GPA; writ cons instr, dept chair, & asst dean for SAS.
Course Rules: May be retaken w/chg in topic to 6 cr max.
Current Offerings: http://uwm.edu/schedule

PHYSICS 705 Molecular, Cellular, and System Biophysics
3 cr. Graduate.
Prerequisites: grad st
Last Taught: Fall 2017, Fall 2015, Fall 2012, Spring 2010.
Current Offerings: http://uwm.edu/schedule

PHYSICS 706 Biophotonics
3 cr. Graduate.
Biophotonics and bioimaging; overview of application of optics in biology and medicine based on the understanding of basic optics, spectroscopy, and imaging theory.
Prerequisites: grad st
Current Offerings: http://uwm.edu/schedule

PHYSICS 707 Structural Molecular Biophysics
3 cr. Graduate.
Methods in molecular biophysics.
Prerequisites: grad st; major in science-based discipline & Physics 210(P), or writ cons instr.
Current Offerings: http://uwm.edu/schedule

PHYSICS 711 Theoretical Physics—Dynamics
3 cr. Graduate.
Lagrange equations, canonical formulation, principle of least action, normal coordinates, rigid bodies, special relativity, mathematical methods.
Prerequisites: grad st; Math 321(C) or 322(C); or 701(C) or 702(C).
Current Offerings: http://uwm.edu/schedule

PHYSICS 716 Advanced Topics in Statistical Physics
3 cr. Graduate.
Systems of interactr particles; critical phenomena; transport theory; irreversible processes and fluctuations; model calculations for interacting systems of particles.
Prerequisites: grad st; Physics 515(P), 532(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 717 Gravitation
3 cr. Graduate.
Prerequisites: grad st; Physics 717(P).
Last Taught: Spring 2018, Fall 2015, Fall 2014, Fall 2012.
Current Offerings: http://uwm.edu/schedule

PHYSICS 718 White Dwarfs, Neutron Stars, and Black Holes
3 cr. Graduate.
Physics of compact objects; newtonian and relativistic stellar structure and stability; pulsars, x-ray sources; accretion disks; gravitational collapse; stellar-size and supermassive black holes; quasars.
Prerequisites: grad st; Physics 717(P) or cons instr.
Current Offerings: http://uwm.edu/schedule

PHYSICS 720 Electrodynamics I
3 cr. Graduate.
Maxwell's equations; Helmholtz theorem; scalar and vector potentials; boundary value problems; plane wave solutions.
Prerequisites: grad st; Physics 711(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 721 Electrodynamics II
3 cr. Graduate.
Wave guides, radiation by charges; radiation reaction; radiation scattering, damping and dispersion; covariant formulation of electrodynamics.
Prerequisites: grad st; Physics 720(P).
Last Taught: Fall 2017, Fall 2016, Fall 2015, Spring 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 723 Quantum Mechanics
3 cr. Graduate.
Mathematical formalism of quantum mechanics. Observables and transformation theory, scattering perturbation, other approximation methods.
Prerequisites: grad st; Physics 720(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 735 High Energy Physics
3 cr. Graduate.
Special relativity applied to high energy collisions, experimental techniques, ionization and radiation at high energy, weak interactions theory, h-meson and strange particle interactions, ultra-high energy phenomena.
Prerequisites: grad st & Physics 732(P).
Last Taught: Fall 2011.
Current Offerings: http://uwm.edu/schedule

PHYSICS 736 Advanced Quantum Mechanics
3 cr. Graduate.
Spectral theory of operators; Hilbert space; second quantization; many-body theory; relativistic quantum mechanics.
Prerequisites: grad st; Physics 723(P).
Last Taught: Summer 2011.
Current Offerings: http://uwm.edu/schedule

PHYSICS 737 Advanced Nuclear Physics
3 cr. Graduate.
Theoretical nuclear physics and applications to atomic and condensed matter physics.
Prerequisites: grad st; Physics 723(P) & 735(P).
Last Taught: Fall 2011, Fall 2008.
Current Offerings: http://uwm.edu/schedule

PHYSICS 741 Relativistic Quantum Theory
3 cr. Graduate.
Dirac theory of electron, weak interactions, neutrinos, and photons.
Prerequisites: grad st; Physics 721(P) & 733(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 747 Elementary Particle Physics
3 cr. Graduate.
Quark and lepton models; perturbation theory; symmetries; supersymmetry.
Prerequisites: grad st; Physics 735(P) & 736(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 755 Astrophysics
3 cr. Graduate.
Astronomy and cosmology. Special emphasis on solar system and galactic structure.
Prerequisites: grad st; Physics 717(P) or cons instr.
Last Taught: Fall 2016, Fall 2013, Fall 2010, Fall 2007.
Current Offerings: http://uwm.edu/schedule

PHYSICS 787 Independent Study
1-6 cr. Undergraduate/Graduate.
Independent study in areas not covered in current course offerings.
Prerequisites: grad st & Physics 732(P).
Last Taught: Fall 2016, Fall 2013.
Current Offerings: http://uwm.edu/schedule

http://uwm.edu/schedule
PHYSICS 751 Solid State Theory I
3 cr. Graduate.
Phonons, plasmons, magnons, fermion fields and the hartree-fock approximation, and electron many-body techniques and the electron gas.
Prerequisites: grad st; Physics 531(P) & Physics 651(P).
Last Taught: Spring 2018, Fall 2015, Fall 2013, Fall 2011.
Current Offerings: http://uwm.edu/schedule

PHYSICS 752 Solid State Theory II
3 cr. Graduate.
Dynamics of electrons in a magnetic field: energy bands, cyclotron resonance, impurity states, optical absorption and excitons in semiconductor crystals; electrodynamics of metals; green’s functions.
Prerequisites: grad st & Physics 532(P) & 751(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 770 Electron Microscopy
3 cr. Graduate.
Prerequisites: grad st; Physics 551(P) or cons instr.
Last Taught: Fall 2011, Spring 2002.
Current Offerings: http://uwm.edu/schedule

PHYSICS 775 Surface Physics I
3 cr. Graduate.
Survey of experimental techniques in surface physics research.
Prerequisites: grad st; Physics 515(P) & 575(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 781 Medical Radiation Physics
3 cr. Graduate.
Physical principles of the generation, interaction, detection, and measurement of radiation in medical applications; basics of radiation protection.
Prerequisites: grad st
Current Offerings: http://uwm.edu/schedule

PHYSICS 782 Physics of Medical Imaging
3 cr. Graduate.
Basic theoretical knowledge of the physics of diagnostic radiology using x-rays, magnetic resonance, nuclear medicine, and ultrasounds.
Prerequisites: grad st
Current Offerings: http://uwm.edu/schedule

PHYSICS 784 Radiotherapy Physics
3 cr. Graduate.
Radiation physics for work as a hospital physicist, including accelerators for radiation therapy, quality characteristics of treatment beams, treatment planning, treatment techniques, quality assurance, oncology.
Prerequisites: grad st
Current Offerings: http://uwm.edu/schedule

PHYSICS 786 Medical Physics Practicum
3 cr. Graduate.
Training with clinical medical imaging and therapy equipment, and dosimetry instrumentation.
Prerequisites: grad st; Physics 781(P)
Current Offerings: http://uwm.edu/schedule

PHYSICS 801 Special Topics in Theoretical Physics:
2-3 cr. Graduate.
Discussion of recent research or advanced special topics.
Prerequisites: grad st & cons instr.
Course Rules: Retakable w/chg in topic to 9 cr max.
Current Offerings: http://uwm.edu/schedule

PHYSICS 807 Group Theory and Its Applications to Physics
3 cr. Graduate.
Representations of discrete and continuous groups, including rotation groups, unitary groups and crystal point and space groups. Symmetries of elementary particles. Molecular orbitals, energy bands.
Prerequisites: grad st; Physics 532(P).
Course Rules: Counts as repeat of Math 807.
Current Offerings: http://uwm.edu/schedule

PHYSICS 811 Nonlinear Dynamics and Chaos
3 cr. Graduate.
Iteration of maps, numerical integration, strange attractors in dissipative systems, fractal dimensions, multifractals, entropy. Chaos in hamiltonian systems, perturbation theory, kam theorem. Quantum chaos.
Prerequisites: grad st; Physics 711(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 817 Gravitation and Cosmology II
3 cr. Graduate.
Experimental tests in gravitation. Gravitational waves: generation, detection. Spinning black holes. Cosmology: idealised cosmologies; present state of the universe; nucleosynthesis; inflation; recent developments.
Prerequisites: grad st; Physics 717(P) or cons instr.
Current Offerings: http://uwm.edu/schedule

PHYSICS 818 Advanced Topics in Gravitational Physics
3 cr. Graduate.
Prerequisites: grad st; Physics 717(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 831 Quantum Field Theory I
3 cr. Graduate.
Group theory, canonical and path integral quantization, feynman rules, quantum electrodynamics, renormalization, quantum chromodynamics, electroweak theory, spontaneous symmetry breaking.
Prerequisites: grad st; Physics 732(P).
Last Taught: Fall 2017, Fall 2013, Spring 2000, Fall 1994.
Current Offerings: http://uwm.edu/schedule

PHYSICS 852 Superconductivity
3 cr. Graduate.
Properties of type I and type II superconductors, bcs and ginzburg-landau theory, vortices, and flux dynamics.
Prerequisites: grad st; Physics 532(P) & 651(P).
Last Taught: Spring 2007.
Current Offerings: http://uwm.edu/schedule
PHYSICS 853 Superfluidity
3 cr. Graduate.
Prerequisites: grad st; Physics 551(P) & 651(P) or physics 515(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 854 Electron Phonon Interaction
3 cr. Graduate.
Wave propagation in metals. Interaction of electrons with the lattice in normal metals, superconductors, and magnetic materials.
Prerequisites: grad st; Physics 532(P) & 651(P).
Current Offerings: http://uwm.edu/schedule

PHYSICS 900 Colloquium
1 cr. Graduate.
Lectures by staff and visitors on research in various areas of physics.
Prerequisites: grad st.
Last Taught: Fall 2017, Fall 2014, Spring 2013, Spring 2012.
Current Offerings: http://uwm.edu/schedule

PHYSICS 903 Seminar in Theoretical Physics:
1-3 cr. Graduate.
Discussion of special topics of interest to research students in theoretical physics. Retakable w/chg in topic to 9 cr max. Prereq: grad st & cons instr.
Prerequisites:
Last Taught: Spring 2017, Fall 2016, Spring 2015, Fall 2014.
Current Offerings: http://uwm.edu/schedule

PHYSICS 904 Seminar in Surface Studies:
1-3 cr. Graduate.
Special topics in the chemistry and physics of surface studies. Specific topics and any additional prerequisites announced in Timetable each time course is offered.
Prerequisites: grad st; cons instr.
Course Rules: Retakable w/chg in topic to 9 cr max.
Current Offerings: http://uwm.edu/schedule

PHYSICS 906 Seminar in Biophysics:
1-3 cr. Graduate.
Special topics in experimental biophysics. Retakable with change in topic to 9 cr max.
Prerequisites: grad st; cons instr.
Last Taught: Spring 2017.
Current Offerings: http://uwm.edu/schedule

PHYSICS 990 Research
1-9 cr. Graduate.
Prerequisites: grad st & cons instr.
Current Offerings: http://uwm.edu/schedule

PHYSICS 999 Independent Reading
1-3 cr. Graduate.
For the benefit of graduate students unable to secure needed content in regular courses.
Prerequisites: grad st, cons instr.
Current Offerings: http://uwm.edu/schedule

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### Faculty

<table>
<thead>
<tr>
<th>Name</th>
<th>Rank</th>
<th>Degree</th>
<th>School</th>
<th>Graduate Faculty</th>
<th>Emeritus Faculty</th>
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<tbody>
<tr>
<td>Daniel Agterberg</td>
<td>Professor</td>
<td>PhD</td>
<td>University of Toronto</td>
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<td>Donald E. Beck</td>
<td>Professor Emeritus</td>
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<td>Patrick Brady</td>
<td>Professor</td>
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<td>Philip Chang</td>
<td>Associate Professor</td>
<td>PhD</td>
<td>University of California-Santa Barbara</td>
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<td>Yutze Chow</td>
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<td>Jolien Creighton</td>
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<td>Richard H. Dittman</td>
<td>Professor Emeritus</td>
<td>PhD</td>
<td>California Institute of Technology</td>
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<td>Dawn Erb</td>
<td>Associate Professor</td>
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<td>John L. Friedman</td>
<td>Distinguished Professor Emeritus</td>
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<td>Arizona State University</td>
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<td>Marija Gajardziska-Josifovska</td>
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<td>Robert G. Greenler</td>
<td>Professor Emeritus</td>
<td>PhD</td>
<td>University of Bombay, India</td>
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<tr>
<td>Prasenjit Guptasarma</td>
<td>Professor, Chair</td>
<td>PhD</td>
<td>Yale University</td>
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<tr>
<td>Carol Hirschmugl</td>
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<td>David Kaplan</td>
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<td>Moises Levy</td>
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<td>Paul Lyman</td>
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<td>Abbas Ourmazd</td>
<td>Distinguished Professor</td>
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<td>Wolfson College, Oxford</td>
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<td>Leonard E. Parker</td>
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<td>Sarah Patch</td>
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<td>PhD</td>
<td>University of California-Berkeley</td>
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*Nota: El contenido del documento se ha resumido para facilitar su lectura.*
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<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Ionel Popa</td>
<td>Assistant Professor</td>
<td>PhD</td>
<td>University of Geneva, Switzerland</td>
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<tr>
<td>Valerica Raicu</td>
<td>Professor</td>
<td>PhD</td>
<td>University of Bucharest, Romania</td>
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<td>Dilano K. Saladin</td>
<td>Distinguished Professor</td>
<td>PhD</td>
<td>Oxford University</td>
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<td>Bimal K. Sarma</td>
<td>Professor Emeritus</td>
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<td>Glenn Schmieg</td>
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<tr>
<td>Peter Schwander</td>
<td>Associate Professor</td>
<td>PhD</td>
<td>Swiss Federal Institute of Technology Zürich (ETHZ)</td>
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<td>Xavier Siemens</td>
<td>Associate Professor</td>
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<td>Tufts University</td>
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<td>Dale R. Snider</td>
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<td>Richard S. Sorbello</td>
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<td>Michael Weinert</td>
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<td>Northwestern University</td>
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<td>Alan Wiseman</td>
<td>Associate Professor</td>
<td>PhD</td>
<td>Washington University</td>
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<tr>
<td>Robert Wood</td>
<td>Senior Lecturer, Adjunct Associate Professor, Associate Chair</td>
<td>PhD</td>
<td>Oxford University</td>
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