The Physics Department exhibits exceptional strength in several areas. We invite applications from able students interested in experimental and theoretical surface physics and condensed matter physics; in structural biophysics and protein dynamics and function; in quantum field theory, cosmology, relativistic astrophysics, and gravitational-wave/multimessenger astronomy, in medical imaging. The primary goal of our graduate education is the training of creative research scientists.

Our research in gravitational physics is in several areas: In gravitational-wave astronomy, we play a leading role in LIGO, extracting signals of gravitational-waves from the coalescence of binary neutron stars and black holes, as well as searching for electromagnetic counterparts. We play a leading role in the use of pulsars to measure gravitation waves from supermassive black holes. In relativistic astrophysics we have established limits on the spin and mass of rotating neutron stars, and develop computational techniques to model merging stars. Astronomy efforts include studying early galaxy formation and evolution, and phenomenology of neutron stars and white dwarfs.

Experimental work in condensed matter and surface physics includes electron microscopy, electron and x-ray diffraction, atomic force microscopy, infrared spectroscopy, synchrotron radiation, molecular beam epitaxy, and atomic layer deposition. Experimental work is also being done in the areas of low-temperature physics, unconventional superconductivity (including high Tc), heavy fermions, topological insulators, materials synthesis and floating zone single crystal growth, oxides, magnetism, ultrasonics, and neutron diffraction. These efforts are all aimed at creating and analyzing novel materials.

Theoretical work in condensed matter physics and surface physics includes research in quantum transport phenomena, superconductivity, magnetism, novel states of matter, and first-principles electronic structure calculations.

Experimental work in biophysics includes advanced optical and electrical methods for probing protein-protein interactions and protein complex structure and dynamics in vivo. Other efforts are in structural biophysics, static and time-resolved macromolecular crystallography, and XFEL-based femtosecond crystallography. Molecular biophysics studies include protein mechano-chemistry and single-molecule force spectroscopy.

Theoretical and computational work in biophysics includes advanced algorithms for signal extraction in the presence of extreme noise and timing uncertainty (XFEL and cryo-electron microscopy data) for protein crystallography, biostructure, dynamics, and function.

Experimental and theoretical efforts in medical imaging revolve around image reconstruction using Radon transformations, and novel imaging modalities such as thermo/opto-acoustic tomography.

Graduate Minor in Physics
A doctoral student in another department wishing to minor in Physics must choose a minor professor from among the Physics Graduate Faculty. The student and the minor professor plan a program of study consisting of 9 to 12 graduate credits in Physics and complete a Graduate Minor Program Plan for the Physics Department files.

Admission Requirements
Application Deadlines
Application deadlines vary by program, please review the application deadline chart (http://uwm.edu/graduateschool/program-deadlines) for specific programs. Other important dates and deadlines can be found by using the One Stop calendars (https://uwm.edu/onestop/dates-and-deadlines).

Admission
Applicant must meet Graduate School requirements plus departmental requirements as given for admission to the master’s program. A master’s degree is not a prerequisite for this PhD program.

Reapplication
A student who receives the master’s degree must formally reapply for admission to the Graduate School before continuing studies toward the PhD.

Credits and Courses
Minimum degree requirement is 54 graduate credits beyond the bachelor’s degree, at least 27 of which must be earned in residence at UWM. The student plans an individual program of studies in consultation with the major professor.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Physics core courses</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Additional credits numbered 700-999 *</td>
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<tr>
<td></td>
<td>Other courses and PHYSICS 990</td>
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</tr>
<tr>
<td></td>
<td>Total Credits</td>
<td>54</td>
</tr>
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</table>

* Not including courses 711, 720, 721, or 990. Physics 651 is included.

A student may elect to complete one of the following minor programs: a minor of 9 to 12 credits in a single department; a minor of 12 credits in two or more departments. Traditional fields for the minor are mathematics, other natural sciences, computer sciences and engineering. In planning a minor in a single department, the student is advised by the minor professor; in planning a minor in two or more departments, the student is advised by the major professor. The program of study is to be chosen with the major professor and the departmental academic graduate committee.

Program Requirements
Residence
The student must meet minimum Graduate School residence requirements.

Written Qualifying Examination
Prior to taking the oral doctoral preliminary examination, the student must pass a written qualifying examination. The exam is designed to test a student’s physics problem solving capabilities assuming a knowledge of physics equivalent to an advanced undergraduate at a premier institution. The exam is given at the start of the Fall and Spring semesters. Students have a maximum of 3 attempts to pass the exam and must take the exam each time that it is offered until passing the exam or exhaust the 3 allowed attempts.

Doctoral Preliminary Examination and Doctoral Proposal Hearing
The student must prepare a written proposal and pass an oral examination to qualify for formal admission to candidacy for the degree. The oral examination primarily seeks to determine the student’s
preparation for independent research and the suitability of the proposed dissertation program. The Examination must be taken within four years of enrollment into the physics doctoral program and must be passed within five years of enrollment into the program.

**Dissertation**
The candidate must present a dissertation reporting the results of an original and independent research investigation representing substantive creative contribution.

**Dissertation Defense**
The candidate must, as the final step toward the degree, pass an oral examination in defense of the dissertation.

**Time Limit**
All degree requirements must be completed within ten years from the date of initial enrollment in the doctoral program.