PHYSICS: QUANTUM COMPUTING, M.S.

This is a named option in the Physics M.S. (http://guide.wisc.edu/graduate/physics/physics-ms/)

The M.S. in Physics–Quantum Computing (MSPQC) is an intensive professional master's degree and is designed to be completed in one calendar year. The program provides students with a thorough grounding in the new discipline of quantum information and quantum computing. This begins with a study of the relevant parts of quantum theory, and proceeds to quantum gates, measurements, algorithms, quantum error correction and decoherence. Quantum communication theory and the secure transmission of information are also covered. The supporting areas of statistical mechanics, solid-state physics and atomic physics form part of the classroom training. Just as important, the program gives students a mastery of the advanced lab skills involved in quantum computation. Students who graduate from this program will have the tools to succeed as researchers or program managers in a quantum computing or quantum technologies enterprise. They may also use the program as a springboard to Ph.D. programs in physics or related areas. MSPQC students interested in applying to the Ph.D. at UW–Madison must adhere to all Ph.D. admission requirements and deadlines.

The tuition for this program is $1,600 per credit hour. Students in this program cannot accept research assistantships, teaching assistantships, project assistantships, or other university appointments that grant waivers of tuition.

ADMISSIONS

Please consult the table below for key information about this degree program’s admissions requirements. The program may have more detailed admissions requirements, which can be found below the table or on the program’s website. Graduate admissions is a two-step process between academic programs and the Graduate School. Applicants must meet the minimum requirements (https://grad.wisc.edu/apply/requirements/) of the Graduate School as well as the program(s).

Once you have researched the graduate program(s) you are interested in, apply online (https://grad.wisc.edu/apply/).

FUNDING

The tuition for this program is $1,600 per credit hour. Students in this program cannot accept research assistantships, teaching assistantships, project assistantships, or other university appointments that grant waivers of tuition.

GRADUATE SCHOOL RESOURCES

Resources to help you afford graduate study might include assistantships, fellowships, traineeships, and financial aid. Further funding information (https://grad.wisc.edu/funding/) is available from the Graduate School. Be sure to check with your program for individual policies and restrictions related to funding.

REQUIREMENTS

MINIMUM GRADUATE SCHOOL REQUIREMENTS

Review the Graduate School minimum academic progress and degree requirements (http://guide.wisc.edu/graduate/#policiesandrequirementstext), in addition to the program requirements listed below.

NAMED OPTION REQUIREMENTS

MODE OF INSTRUCTION

<table>
<thead>
<tr>
<th>Mode of Instruction Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accelerated:</strong> Accelerated programs are offered at a fast pace that condenses the time to completion. Students are able to complete a program with minimal disruptions to careers and other commitments.</td>
</tr>
<tr>
<td><strong>Evening/Weekend:</strong> Courses meet on the UW–Madison campus only in evenings and/or on weekends to accommodate typical business schedules. Students have the advantages of face-to-face courses with the flexibility to keep work and other life commitments.</td>
</tr>
<tr>
<td><strong>Face-to-Face:</strong> Courses typically meet during weekdays on the UW-Madison Campus.</td>
</tr>
<tr>
<td><strong>Hybrid:</strong> These programs combine face-to-face and online learning formats. Contact the program for more specific information.</td>
</tr>
<tr>
<td><strong>Online:</strong> These programs are offered 100% online. Some programs may require an on-campus orientation or residency experience, but the courses will be facilitated in an online format.</td>
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CURRICULAR REQUIREMENTS

<table>
<thead>
<tr>
<th>Requirements Detail</th>
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<tbody>
<tr>
<td>Minimum Credit Requirement</td>
<td>30 credits</td>
</tr>
<tr>
<td>Minimum Residence Credit Requirement</td>
<td>16 credits</td>
</tr>
</tbody>
</table>

Minimum Graduate Coursework Requirement: Half of degree coursework (15 credits out of 30 total credits) must be completed graduate-level coursework; courses with the Graduate Level Coursework attribute are identified and searchable in the university's Course Guide (https://registrar.wisc.edu/course-guide/). No 300-level courses will be counted toward the 30 credit minimum.

Overall Graduate GPA Requirement: 3.00 GPA required.

Other Grade Requirements: The Graduate School requires an average grade of B or better in all coursework (300 or above, not including research credits) taken as a graduate student unless conditions for probationary status require higher grades. Grades of Incomplete are considered to be unsatisfactory if they are not removed during the next enrolled semester.

REQUIRED COURSES

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICS 531</td>
<td>Introduction to Quantum Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>or PHYSICS 731</td>
<td>Quantum Mechanics</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 415</td>
<td>Thermal Physics</td>
<td>3</td>
</tr>
<tr>
<td>or PHYSICS 715</td>
<td>Statistical Mechanics</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 709</td>
<td>Introduction to Quantum Computing</td>
<td>3</td>
</tr>
<tr>
<td>PHYSICS elective</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Fall

Spring

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>PHYSICS 551</td>
<td>Solid State Physics</td>
<td>3</td>
</tr>
<tr>
<td>or PHYSICS 751</td>
<td>Advanced Solid State Physics</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 449</td>
<td>Atomic and Quantum Physics</td>
<td>3</td>
</tr>
<tr>
<td>or PHYSICS 545</td>
<td>Introduction to Atomic Structure</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 779</td>
<td>Advanced Quantum Computing</td>
<td>3</td>
</tr>
<tr>
<td>PHYSICS elective</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Summer

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICS 707</td>
<td>Quantum Computing Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 799</td>
<td>Independent Study</td>
<td>2</td>
</tr>
</tbody>
</table>

Total Credits: 30

POLICIES

GRADUATE SCHOOL POLICIES

The Graduate School's Academic Policies and Procedures (https://grad.wisc.edu/acadpolicy/) provide essential information regarding general university policies. Program authority to set degree policies beyond the minimum required by the Graduate School lies with the degree program faculty. Policies set by the academic degree program can be found below.

NAMED OPTION-SPECIFIC POLICIES

PRIOR COURSEWORK

Graduate Work from Other Institutions

Prior coursework from other institution may count toward any graduate degree in physics as allowed by the Graduate School policy on prior coursework.

UW–Madison Undergraduate

Up to 7 credits in courses numbered 500 or above may be used to satisfy minimum degree requirements.

UW–Madison University Special

With program approval and payment of difference in tuition (between Special and graduate tuition), students are allowed to count no more than 9 credits of coursework numbered 500 or above taken as a UW–Madison University Special student. Coursework earned five or more years prior to admission to a master’s degree is not allowed to satisfy requirements.

PROBATION

Grade of B or better in all coursework and a minimum cumulative graduate GPA of 3.0 are required.

ADVISOR / COMMITTEE

All students will be assigned a faculty advisor upon matriculation.

CREDITS PER TERM ALLOWED

15 credits

TIME CONSTRAINTS

n/a

GRIEVANCES AND APPEALS

These resources may be helpful in addressing your concerns:

- Bias or Hate Reporting (https://doso.students.wisc.edu/bias-or-hate-reporting/)
- Graduate Assistantship Policies and Procedures (https://hr.wisc.edu/policies/gapp/#grievance-procedure)
- Hostile and Intimidating Behavior Policies and Procedures (https://hr.wisc.edu/hib/)
- Office of the Provost for Faculty and Staff Affairs (https://facstaff.provost.wisc.edu/)
- Dean of Students Office (https://doso.students.wisc.edu/) (for all students to seek grievance assistance and support)
- Employee Assistance (http://www.eao.wisc.edu/) (for personal counseling and workplace consultation around communication and conflict involving graduate assistants and other employees, post-doctoral students, faculty and staff)
Employee Disability Resource Office (https://employeedisabilities.wisc.edu/) (for qualified employees or applicants with disabilities to have equal employment opportunities)

Graduate School (https://grad.wisc.edu/) (for informal advice at any level of review and for official appeals of program/departmental or school/college grievance decisions)

Office of Compliance (https://compliance.wisc.edu/) (for class harassment and discrimination, including sexual harassment and sexual violence)

Office of Student Conduct and Community Standards (https://conduct.students.wisc.edu/) (for conflicts involving students)

Ombuds Office for Faculty and Staff (http://www.ombuds.wisc.edu/) (for employed graduate students and post-docs, as well as faculty and staff)

Title IX (https://compliance.wisc.edu/titleix/) (for concerns about discrimination)

Students should contact the department chair or program director with questions about grievances.

OTHER

Students enrolled in this program are not permitted to accept teaching assistantships, project assistantships, research assistantships or other appointments that would result in a tuition waiver. Students in this program cannot enroll in other graduate programs nor take courses outside the prescribed curriculum.

PROFESSIONAL DEVELOPMENT

GRADUATE SCHOOL RESOURCES

Resources to help you afford graduate study might include assistantships, fellowships, traineeships, and financial aid. Further funding information (https://grad.wisc.edu/funding/) is available from the Graduate School. Be sure to check with your program for individual policies and restrictions related to funding.

PROGRAM RESOURCES

Students are encouraged to attend Graduate School sponsored Professional Development events and participate in Graduate School Professional Development resources, such as the Individual Development Plan (IDP).

PEOPLE

M.S. IN PHYSICS - QUANTUM COMPUTING

More detail about each faculty member (https://www.physics.wisc.edu/people/faculty/) and the research areas (https://www.physics.wisc.edu/research/areas/) can be found on the Physics website.

QUANTUM COMPUTING FACULTY

Susan Coppersmith, Robert E. Fassnacht Professor and Vilas Professor
Mark Eriksson, Vilas Distinguished Achievement Professor
Lev Ioffe, Professor
Robert Joynt, Professor
Shimon Kolkowitz, Assistant Professor
Alex Levchenko, Associate Professor

Robert McDermott, Professor
Mark Saffman, Professor
Maxim Vavilov, Professor
Thad Walker, Professor
Deniz Yavuz, Professor

QUANTUM COMPUTING ADMINISTRATION

The MSPQC Program Director is Professor Robert Joynt. The MSPQC Committee Members are Robert Joynt (Chair), Mark Saffman, Mark Eriksson, Robert McDermott, Deniz Yavuz, Stas Boldyrev, Michelle Holland.