

The Department of Mechanical Engineering & Materials Science

PhD Student Handbook

2016-2017



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Research

The Department of Mechanical Engineering & Materials Science in the School of Engineering & Applied Science at Washington University in St. Louis is generating new knowledge and preparing students to achieve great impact through research and teaching. As new technologically advanced materials are critical to addressing the most pressing challenges of the 21st century (energy, sustainability, health care, security and information management), our department has recently expanded in the area of advanced materials. Degrees granted by the department include: the ABET-accredited bachelor's degree in mechanical engineering; master's degrees in mechanical engineering, aerospace engineering and materials science; and doctoral degrees in mechanical engineering, aerospace engineering and materials science.

Research activities take place in multiple laboratories:

- Biomechanics — the mechanics of cells, tissues and biomaterials. Research projects involve the mechanics of brain injury, cell motility, bones and tendons, blood vessels, embryonic development and imaging
- Computational Fluid Mechanics — the modeling and simulation of flow physics, flow control, air vehicles and fluid energy systems
- Design & Optimization — design theory and numerical methods for optimization
- Computational Mechanics & Rotorcraft Dynamics — finite state models of rotorcraft inflow and wake, aeroelasticity and numerical methods for mechanics
- Advanced Materials — structural, electronic, optical, photovoltaic and multifunctional materials. Specific research areas include bulk metallic glasses, atomic layer deposition and plasmonic nanostructures

Recent major research awards:

- » **\$25,000** from the NSF: “Multiscale Mechanisms of Force Transfer in Tendon”
- » **\$299,999** from NSF with the goal of unraveling the mechanism of diamond coated wire sawing of silicon ingots
- » **\$196,452** from the NIH: “Point of care acute kidney injury detection using molecularly imprinted gold nanocages
- » **\$173,299** from the Navy: “High-resolution anatomical imaging, MR elastography and diffusion tensor imaging of the brain

Research Themes:

AEROSPACE SYSTEMS:

- » Computational fluid dynamics
- » Flow physics & flow control
- » Rotorcraft modeling & analysis
- » Aeroelasticity
- » Design & optimization

ENERGY & SUSTAINABILITY:

- » Renewable energy
- » Efficient vehicles & buildings
- » Sustainable materials & devices
- » Energy harvesting
- » Energy conversion & storage

ADVANCED MATERIALS:

- » Nanostructured materials
- » Metallic glasses
- » Polymers & nanocomposites
- » Biomaterials
- » Adaptive multifunctional materials
- » Organic/inorganic hybrid materials

BIOMECHANICS & BIOTECHNOLOGY:

- » Subcellular & cellular mechanics
- » Tissue biomechanics
- » Biomaterials
- » Medical devices

Policies & Regulations

A key objective of the doctoral program is to promote cutting-edge multidisciplinary research and education in the areas of mechanical engineering and materials science. The doctoral student learns in conjunction with his or her adviser to design a program of study and research project. Students are selected for admission to the program by a competitive process, and they typically start in the fall semester. Upon arrival at WashU, the student will be advised by the temporary adviser on all procedural issues. The student should choose a permanent adviser by the end of the first year of residency in the program.

The following is a brief summary of the requirements for doctoral students:

- 1) Pass the qualifying exams. Qualifying exams should be taken by the end of the third semester.
- 2) Prepare and defend a research proposal. The research proposal should be defended by the end of the fifth semester.
- 3) Write and successfully defend the doctoral dissertation.
- 4) Minimum of **36** credits for coursework and a minimum of **24** credits for doctoral research; total of **72** credits to earn the PhD degree.
- 5) Satisfy the applicable teaching assistant requirements of the Graduate School.

The purposes of this handbook are to provide guidance to PhD students in MEMS and to inform students of department-specific policies.

Registration

Registration takes place each semester on dates announced by WashU. Detailed instructions for registration plus necessary materials are mailed directly to all graduate students enrolled during the previous semester.

All graduate students in the department must register each semester until all degree requirements are completed. The maximum time period for completing all PhD degree requirements is seven years.

Three categories of registration:

Active: Normally, students register in this category until they have earned the total number of credit hours required for their degree. Registration for a minimum of three units each semester is required with one exception: if a student has already acquired 72 units of graduate credit, the student should register for “special” status.

Inactive: Students who have not completed their course requirements but who, because of personal reasons, must suspend their studies temporarily, may register as inactive students with the approval of their adviser and the department chair.

Special: Students who have earned the required number of credit hours and who have only to complete the writing of a dissertation may register as special students. This status is not appropriate for students who are still actively engaged in the performance of research. In the latter case, regardless of the number of credit hours earned, the student must retain active status and register for at least three credits of research (MEMS 599 or 600) each semester until the research is completed.

Students who fail to register in one of the previously mentioned categories will automatically have their graduate standing revoked. Students whose graduate standing has been revoked may apply for reinstatement. There is an application fee for reinstatement (\$100). Students seeking reinstatement may be required to take a special reinstatement examination and to repeat any previously taken requirements that fails to meet contemporary standards. Candidates for the PhD degree who apply for reinstatement may be required to repeat the qualifying examination and must pay tuition for three credit hours in each missed semester.

Helpful website — Graduate School:
graduateschool.wustl.edu

Advising

The Director of PhD Studies will serve as a temporary adviser to PhD students enrolling for the first time. Full-time students should choose a research project and adviser for their thesis or dissertation within the first year of residency. The thesis adviser will then be the primary adviser for the student. The thesis adviser must be a primary or joint faculty member in MEMS or within the MEMS Graduate Faculty Group with the title of Professor, Associate Professor, or Assistant Professor. It is the joint responsibility of the student and his or her adviser to plan a coherent, complementary program of coursework and research and to ensure that satisfactory progress is made toward fulfillment of the appropriate degree requirements.

MEMS Graduate Faculty group:

Faculty members that do not have a primary or joint appointment in MEMS may be a thesis adviser for a MEMS student if they are members of the MEMS Graduate Faculty Group. To apply to the MEMS Graduate Faculty Group, the faculty member must send by email in one PDF to the Director of PhD Studies:

1. Recommendation letter or supporting statement from the applicant's department head/chair that includes a statement of recognition that the student stipend support is the responsibility of the department/division if the applicant is unable to provide full support.
2. Biosketch of the applicant (standard NIH or NSF format is fine).
3. Current and pending support of the applicant.
4. One page research statement highlighting connections to MEMS.

The graduate faculty committee in MEMS will evaluate the application packet and let the applicant know if they are accepted into the MEMS Graduate Faculty Group.

Research Rotations

All PhD students admitted as teaching assistants must complete at least two research rotations during their first year of residency. PhD students admitted as research assistants do not need to do rotations. For each rotation, students will register for 3 units of MEMS 597 Research Rotation under the chosen rotation adviser's section number. Rotations can be performed in the laboratory of any MEMS primary or joint faculty or in the MEMS Graduate Faculty Group. If a student is interested in doing a rotation with a faculty member not in these groups, the student should discuss their options with the Director of PhD studies.

The research rotations allow the student and the faculty member to determine if they are a suitable match for a dissertation or thesis project. Research rotations may be repeated in the same laboratory, if no additional exploration is necessary for the student to find a thesis adviser. A third rotation during the summer is possible for students that enter in the fall semester and do not find a thesis adviser through the first two rotations. For students entering in the spring semester, the second rotation will be performed during the summer. Because PhD students do not register for courses in the summer, any rotation performed outside of the fall or spring semester is not taken for credit or as a course.

A rotation report is due at the end of each research rotation to the rotation mentor for review and signature, and then to the Director of PhD studies on the last day of finals for each semester or August 1 for a summer rotation. The student's performance in the laboratory and the report are the primary basis for the course grade assigned by the rotation mentor. This report is a 3-6 page document (including

figures, excluding references) with at least 11 font size, single-spaced paragraphs, and one inch page margins. The report should be organized around these sections — Abstract, Introduction, Materials & Methods, Results, Discussion, and Future Directions.

Qualifying Examination

The qualifying examination should be taken no later than end of the first year of the doctoral program. The examining committee consists of three members of the MEMS Faculty (including joint faculty). Committee members will be suggested by the student, but will be chosen based on input from the Director of PhD studies for the chosen topic areas. The student's prospective PhD thesis adviser may attend the exam, but may not be a member of the examining committee. The scope and purpose of the oral exam is to ensure knowledge of fundamental concepts essential to perform research in the selected areas and to focus on a thorough understanding of relevant undergraduate material. The exam consists of three parts:

1. A written report describing the background, methods, and results obtained from one research rotation experience.
 - a. Note that this research report will likely be based on, but may be different, from the semester-end research rotation reports.
 - b. This research report should be 5-8 pages (including figures, excluding references) with a font size of at least 11 points, single-spaced paragraphs, and at least one-inch page margins in all directions.
 - c. The report must be approved by the PhD thesis adviser and sent to the qualifying exam committee at least 2 weeks before the exam.
2. 20 minute oral presentation on the research report.
 - a. Students are encouraged to consult with their PhD thesis adviser in preparing the research report and the presentation.
3. An oral examination (approximately one hour) covering the presented research as well as the student's knowledge in two fundamental areas of MEMS (see below) of the student's choice.

Qualifying Exam Topics

Fundamental areas that can be chosen for qualifying exam topics are listed below. The numbers in parentheses are undergraduate or graduate courses in MEMS that correspond with these topics. The course numbers are meant to show students what possible material may be covered on the exam, but do not guarantee that everything on the exam will be covered in that course, or that they need to take all of these courses to pass the qualifying exam.

- » Vibrations (405, 4310, 5301, 5302)
- » Heat transfer (305, 3420, 5402, 5403, 5422)

- » Thermodynamics and energy (301, 412, 5401, 5422, 5423, 5424, 5705)
- » Fluid dynamics (305, 3410, 3411, 5410, 5411, 5412, 5413)
- » Solid mechanics (350, 5500, 5501, 5502, 5504, 5515)
- » Biomechanics (350, 5506, 5560, 5564)
- » Mechanics of materials (205, 253, 5601, 5602, 5605)
- » Materials characterization (205, 3610, 5603, 5604)
- » Polymers and nanomaterials (463, 5606, 5607, 5608)
- » Aerodynamics (4302, 5700, 5701, 5703, 5704, 5705)

At the end of the exam, a "Pass", "Retake", "Provisional pass" grade may be awarded. The students with "Retake" grade have one more chance to take the exam, which must be completed within one semester. The requirements of the "Provisional pass" must be completed within one semester as well. If a student fails the exam after the second attempt, the case should be referred to the Doctoral Progress Assessment Committee (DPAC) for a final decision.

Examinees should provide the following information to the Director of PhD Studies by email:

1. Thesis adviser;
2. Research report topic
3. Two fundamental areas for examination
4. Three proposed MEMS faculty members for the committee (may be subject to change by the Director of PhD studies).

The Director of PhD Studies, in consultation with the department chair, will appoint the examining committee. The student will then schedule the exam date, time, and location with the committee.

Thesis Committee and Proposal

The thesis proposal should be completed within two years of the qualifying exam. The student will choose a thesis committee that consists of five members, including the thesis mentor, all with doctoral degrees:

- » 4 from WashU
- » 3 from MEMS
- » 1 from outside MEMS

The student will submit a comprehensive written research proposal to his or her thesis committee at least two weeks before a presentation of the proposal to the committee. The proposal and presentation will include a thorough survey of the field, a discussion of those areas in need of further research and a tentative but clear definition of the problem on which the student intends to focus the dissertation. Following the presentation, the committee will examine the student on his or her understanding of the foundation of the particular field of research and will evaluate the scope and merit of the proposed research.

After the thesis proposal, the student will meet with the thesis committee at least once per year to update them on their progress toward the doctoral degree. More frequent meetings may be appropriate in some cases. Every year, or more often in the case of unsatisfactory progress, the committee will send a report on the student's progress to the Director of PhD Studies.

DSc and PhD Comparison

Area	DSc	PhD
Minimum Academic Requirements:	<ul style="list-style-type: none"> 72 approved graduate units minimum Course distribution may vary by department 36 course units + 24 research + 12 additional from either (departments have the right to require additional units for some programs) Two 400-level courses are acceptable on a DSc “final program” provided they are approved by the chair Three to nine maximum credit hours of independent study 500-level courses can count toward overall required coursework Qualifying exam (as approved by department) No teaching requirement Dissertation Final oral exam/defense & dissertation acceptance 	<ul style="list-style-type: none"> 72 approved graduate units Course distribution may vary by department SEAS general distribution requirements will apply Two 400-level courses are acceptable provided they are approved by the department chair A maximum of three credit hours of independent study 500-level courses can count toward overall required coursework Qualifying exam (as approved by department) Teaching requirement Dissertation Dissertation examination
Teaching Requirement:	No formal teaching requirement	14 hours of teaching experience at the basic level and four hours of teaching experience at the advanced level.
Transfer Credits:	<ul style="list-style-type: none"> 30 maximum transfer coursework units (599 MS research units can count as coursework units) 18 maximum transfer research units (six of which can be MS research study if approved) 	<ul style="list-style-type: none"> 30 maximum transfer coursework units (599 MS research units can count as coursework units) 18 maximum transfer research units (6 of which can be MS research study if approved)
Residence Requirement:	<ul style="list-style-type: none"> Seven years maximum to complete program (An extension is possible if recommended by the department and if approved by the SEAS Graduate Board.) Two consecutive full-time semesters of 9 or more credit hours of academically relevant activities. Minimum of 24 units completed at WashU 	<ul style="list-style-type: none"> Seven years maximum to complete program (An extension is possible if recommended by the department and if approved by the Engineering Graduate Board.) Two consecutive full-time semesters of 9 or more credit hours of academically relevant activities. Minimum of 48 units completed at WashU
Continuous Registration Requirement:	Registration is required every semester. Students needing a leave of absence may file an “inactive status” declaration.	Students admitted to a PhD program in the Graduate school must maintain full-time continuous enrollment throughout the published length of their programs.
Full-time vs. Part-time Status:	SEAS DSc students enrolled for 9 or more units per semester are considered full-time students. (They must enroll in two consecutive semesters to meet the residence requirement.)	<p>Students enrolled for 9 or more units per semester are full-time students. Students enrolled in LGS 9000 Full-time Graduate Research/Study or LGS 9001 Full-time Graduate Research/Study in Absentia also have full-time status.</p> <p>Students taking between 1 and 8 units of coursework who are not registered for Full-time Graduate Research/Study do not qualify for full-time student status.</p>

Requirements for PhD Degree

Academic Requirements

Candidates for this degree must complete a total of 72 credits beyond the bachelor’s degree. Of these, a minimum of 36 must be graduate coursework, and a minimum of 24 must be doctoral thesis research units. To be admitted to candidacy, students must have an overall GPA greater than 3.0 and pass the Qualifying Examination as described on page 3.

The normal load for full-time graduate students in engineering is nine to 12 units per semester, including research credits. The course content and load must be discussed with and approved by the student’s adviser.

Transfer Credits: At most, 24 graduate credits in a master’s program from another university may be counted as transfer credits toward the required 36 units of coursework. All transferred credit must be approved by the department chair as appropriate engineering or science courses, not used to complete the BS degree of the student, and be completed with a grade B or better.

Maximum Research Units per Semester: At most, nine units of research units may be taken in a semester.

Seminar Credits: The zero-unit MEMS 501 seminar course must be taken every semester.

Independent Study Credits: At most, three units of coursework may be taken as graduate independent study. An independent study must be entirely separate from research done as part of the graduate thesis research. The student should prepare a proposed plan of study to be completed, and this plan must be described on the Independent Study Petition form approved by the independent study instructor, student’s adviser, Director of Graduate Studies, and department chair for the independent study credits to count toward the 36 required units of coursework.

400-level Courses: A maximum of six units of 400-level courses are allowed, and these must be from courses not required for the BS degree.

Residency

The residency requirements for the PhD are:

- 1) that each student must earn at least 48 semester hours of the required 72 at Washington University, and
- 2) that each student must spend at least one academic year registered for full-time credits (nine to 12 in the fall followed by nine to 12 in the spring) at Washington University. Any exceptions to these requirements must be approved by the dean of the Graduate School. All PhD programs prefer that students remain full time and in residence throughout their progress toward the degree.

Teaching Requirement

All PhD students must meet the Graduate School-wide Teaching Requirement for PhD Candidates (graduateschool.wustl.edu). 14 hours of teaching experience at the basic level are required. This can be accomplished in many ways, including giving a lecture in an undergraduate class; conducting discussion sections; introducing/interpreting laboratory exercises; or conducting formal help sessions. Students also need to accumulate 4 hours of teaching experience at the advanced level. An example of this would be presenting a paper at a conference or teaching one’s research at a regularly scheduled colloquium or seminar that is attended by other graduate students and faculty.

Dissertation

The candidate must submit a satisfactory dissertation that involves independent, creative study in an area of specialization and that demonstrates ability for critical and constructive thinking. It must constitute a definite contribution to knowledge in some field of engineering or applied science. The research used as the subject of the dissertation must have been performed under the supervision of a member of the faculty of the School of Engineering & Applied Science. A copy of the rules governing off-campus research may be obtained from the student’s adviser.

The student must deliver to the chair of the doctoral committee five copies of the dissertation. The copies must be prepared according to the , which may be secured from the office of the associate dean and Engineering Student Services. Each student must have his or her dissertation approved for format by the associate dean’s office. The first two copies, duly corrected and approved, must be forwarded to the associate dean and Engineering Student Services office no later than the deadline stated in the current, together with a statement from the chair of the doctoral committee and two additional faculty members that the dissertation has been tentatively accepted. The third copy is presented to the candidate’s adviser, and the fourth copy is given to the department.

Each candidate for the doctorate shall submit with the dissertation an abstract of 350 words or less, embodying the principal findings of the research and approved by the doctoral committee as ready for publication. Such abstracts will be published in , which announces the availability of the dissertation for distribution.

The School of Engineering & Applied Science will arrange to bind and microfilm the dissertation. Of the two copies submitted, one copy will be deposited in Olin Library, and the second copy will be returned to the author. The dissertation must be put into condition for microfilming with care similar to that which would be required if the manuscript were to be printed.

The candidate must defend the dissertation during a final oral examination by an examining committee to be nominated by the adviser and approved by the Director of Graduate Studies. The committee will consist of five members all with doctoral degrees:

- » 4 from WashU
- » 3 from MEMS
- » 1 from outside MEMS

Financial Assistance

All full-time doctoral students in good standing are guaranteed financial assistance, including full tuition, a stipend and health insurance stipend, as long as they are making satisfactory progress towards completion of their degree. Students who are placed on academic suspension will automatically have their financial assistance canceled, effective with the date of suspension.

Year one

Fall admission	Spring admission	Task	Submit to
End of 1st week of classes, fall semester	End of 1st week of classes, spring semester	Determine 1st research rotation	Register on Webstac.
Last day of finals, fall semester	Last day of finals, spring semester	1st research rotation report	Rotation mentor for review and signature, then hard copy to Director of PhD studies
End of 1st week of classes, spring semester	Last day of finals, spring semester	Determine 2nd research rotation	Determine 2nd research rotation Register on Webstac (fall admission) or email Director of PhD studies for spring admission
Last day of finals, spring semester	August 1	Determine 2nd research rotation	Rotation mentor for review and signature, then hard copy to Director of PhD studies
2 weeks before the end of spring semester	N/A	Determine 3rd research rotation (if necessary to find a thesis adviser)	Director of PhD studies by email
August 1		3rd research rotation report (if applicable)	Rotation mentor for review and signature, then hard copy to Director of PhD studies
June 1 (2 rotations) or August 1 (3 rotations)	August 1	Determine thesis mentor	Director of PhD studies by email
2 weeks before exam		Research report to exam committee	Qualifying exam committee by email
August 31	January 31	Complete qualifying exam	Signed qualifying exam form to Director of PhD Studies

Year two and beyond

Fall admission	Task	Submit to
End of 3rd year of residency	Complete and present thesis proposal	Signed proposal form to Director of PhD Studies
Annual review	Meet with thesis committee and update them on progress	Signed summary of progress to Director of PhD studies
Dissertation	Complete and present thesis dissertation	Signed dissertation form to Director of PhD Studies

Fellowships

Fellowships are grants to the student generally providing full tuition plus a stipend. Usually no duties are required in return for the duration of the fellowship. Fellowships may be awarded for one to three years with renewability contingent upon performance.

Fellowship funds may derive from government or private sources and be administered by the department, or they may be awarded to the student by an external agency, e.g., the National Science Foundation. (In the case of NSF fellowships, students must apply directly to the Foundation and take a written examination.)

Teaching Assistant

All students must be a teaching assistant or assist in some teaching activity in the Department for at least two semesters prior to graduation; in some cases, a student may be required to serve as a teaching assistant in more than two semesters. The Department has in place a fair process to assign students as teaching assistants. This will normally be done after the first year and after having passed

the Qualifying Examination. In being a teaching assistant, students should meet the Graduate School-wide Teaching Requirement for PhD Candidates; details of fulfilling teaching requirements are described in the Teaching Requirement Form with Policy Statement on graduateschool.wustl.edu.

The TA experience may include, but is not limited to: giving an actual lecture in an undergraduate class with the instructor in attendance, introducing/interpreting laboratory exercises, or conducting formal help sessions before exams. TAs will also be expected to hold one-on-one office hours and participate in grading homework assignments and exams. Both the students and the instructor will evaluate each TA's performance, and the Graduate Studies Committee will use these evaluations to determine whether the teaching requirement has been fulfilled for that semester.

PhD candidates shall also accumulate teaching experience at the advanced level. Presenting one's research in formal settings to other graduate students and faculty is the best way to fulfill the requirement at this level. Therefore, all PhD candidates who entered the program since Fall 2011 shall give at least two formal presentations at the departmental or university-wide, or local level or at a national or international conference. For students entered before Fall 2011, four formal presentations are required. Among the presentations, at least one presentation should be oral at a national or international conference (this last requirement may be waived upon approval of the Graduate Studies Committee).

During the semester, PhD students will be a teaching assistant in addition to the normal coursework and research that are expected by the research adviser.

Tax Liability

The taxability of the various types of awards described above is determined by current policy of the U.S. Internal Revenue Service (IRS). It is prudent to assume that all stipends are fully taxable and that tax will be withheld. Questions concerning any individual's tax liability must be referred to the IRS.

Outside Employment

Holders of fellowships, traineeships and assistantships are required to devote full-time effort to graduate studies. They are not permitted to engage in any outside employment without permission of the adviser and department chair.

Time Off

Graduate students receiving financial support are expected to commit themselves fully to their studies and research. Intersession periods listed in the University Academic Calendar denote times when classes are not in session, and graduate students are expected to devote themselves full-time to their research during these periods.

Students on full support are permitted to take off a **maximum of two weeks** during the calendar year for holidays, interview trips,

etc. Additional time off that interrupts the making of satisfactory progress towards the completion of the degree can be arranged in discussion with the research adviser, but it may result in a reduction of the student's stipend. During the first year in the program when students do not have a permanent adviser, they should consult their first-year adviser to schedule any time off. Absence of research assistants must be scheduled so as not to impede the progress of an ongoing research project and should be approved by the research adviser.

Full-time summer appointments do not include paid time off. An appointment may be prepared for periods of less than three months to allow for planned time off from study.

Other Policies

Seminars

Each year the department sponsors or participates in a series of seminars by visiting lecturers and WashU faculty and students. All full-time graduate students are required to enroll in MEMS 501 - Graduate Seminar, which is a pass/fail course carrying 0 units. A passing grade is required for each semester for all full-time students and is earned by regular attendance at these events.

Secretarial Service

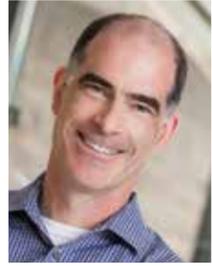
Department staff will help students with payroll, purchases, keys and allocation of space issues. They do not generally provide clerical services to graduate students except in connection with scheduled courses and sponsored research projects.

Copying Service

Graduate students may not charge copying coursework to the department or a research project without prior authorization. Requests for copying service are normally channeled through the department staff who are instructed to verify authorization with the department chair.

The cost of copying dissertations is considered to be a personal obligation. It is, however, permissible for students to make private arrangements to have the copying work done on the department copier and then to reimburse the department on a per-page basis.

Faculty



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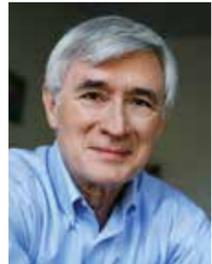
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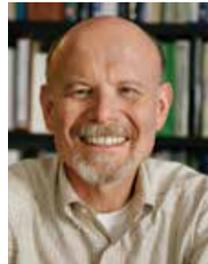
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Contact for:

- Meetings with the chair
- Website management
- Department seminars



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Contact for:

- Graduate student administration
- Visa & visiting scholar administration
- Urbauer Hall keys
- Parking passes



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Contact for:

- General laboratory, equipment, and software questions



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Contact for:

- Grant submissions & management
- Misc. budget/financial inquiries



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Contact for:

- Travel reimbursements
- Check requests
- Travel advances
- Payment of interdepartmental invoices (IDs)



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