

# AGRICULTURAL AND BIOSYSTEMS ENGINEERING

## GRADUATE STUDENT HANDBOOK



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# **AGRICULTURAL & BIOSYSTEMS ENGINEERING MISSION, PURPOSE, VISION, VALUES**

## **Mission**

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Our mission is to improve the quality of life in the Southwest through excellence in instruction, research, and extension programs. To achieve this, ABE will provide technologies and information systems for safe and secure food, water, energy, and biological products to adapt to a changing world.

## **Purpose**

ABE develops and facilitates use of innovative technologies for generation of food, bioenergy, and bioproducts, with smart utilization of water, resources, and information, suitable for arid and semi-arid environments. Our faculty, staff, and students work across interfaces between science and engineering.

## **Vision**

ABE will be a world leader known for developing technologies and systems for the safe production of food, bioenergy, bioproducts, and biological information for sustainable use of arid and semi-arid environments. Students, constituents, and professionals will come from across the world to participate with our programs.

## **Shared Values**

### ***Excellence***

Faculty, staff, and students will have academic freedom and our research and educational programs will be of the highest quality.

### ***Openness***

We will communicate openly and treat people fairly because we value the opinions and respect the needs of all.

### ***Ethics***

High ethical standards and sound decision-making will be at the heart of our business and financial practices.

### ***Diversity***

Diverse people, ideas, backgrounds and perspectives produce lasting solutions. We will make it our duty to encourage and help all to be successful.

### ***Cooperation***

We will forge partnerships on and off campus in our drive to solve society's complex problems and improve the quality of life.

## **INTRODUCTION**

Departmental Graduate Programs focus on biological systems and water related issues such as irrigation and water quality; biosystems applications, including computer modeling, sensors and controls, and systems design and evaluation. However, students will find that this program can be designed to fit almost any need in the general field of the application of engineering principles to the solution of agricultural and biological engineering problems. The flexibility of the program allows foreign and domestic students, in consultation with their advisors, to develop programs specifically suited to their needs. The University of Arizona is a diverse institution and therefore provides courses in many different areas to support specific and general programs. The Department interdisciplinary desires are met by students taking courses across the broad spectrum available in the College of Engineering and the College of Agriculture and Life Sciences as well as other departments on campus.

## **APPLICATION INFORMATION FOR THE MS AND PHD PROGRAMS**

The Department offers graduate work leading to the Master of Science Degree (MS) and the Doctor of Philosophy Degree (PhD) in Agricultural and Biosystems Engineering. There is opportunity for study and research in many fields, including the following:

**Bioproducts; Controlled Environment; Food Safety; Mechanization & Automation; Remote Sensing & Precision Agriculture; Sensors & Controls; Renewable Energy; Water Resources & Irrigation systems.**

All Candidates must apply on line through the Graduate College application site located at:

<https://apply.grad.arizona.edu>.

Qualified candidates must meet the minimum criteria to qualify for the ABE Graduate Programs:

**GPA:** MS 3.0; PhD 3.3

**GRE:** Quantitative minimum 151, Verbal minimum 138, Analytical minimum 3.0.

**TOEFL:** IBT– 79; CBT - 213R; PBT- 550

**Note:** Candidates from non-engineering program may be required to take additional undergraduate courses such as: Statics, Fluid Mechanics, Mechanics of materials, and/or Thermodynamics.

**Additional requirements** can be found on <http://grad.arizona.edu/admissions-requirements>.

## **PROGRAM REQUIREMENTS FOR MS AND PHD STUDENTS:**

All ABE Graduate Students (MS and PhD) are responsible for meeting the ABE Department requirements, and the Graduate College requirements located at <http://grad.arizona.edu>.

**ORIENTATIONS:** Every incoming graduate student must attend departmental orientation available for graduate students and post-docs every semester. This will be administered by the department's Director of Graduate Studies and the Graduate Program Coordinator.

New students and students who are hired as Graduate Assistants are required to attend all of the Graduate College orientations that may apply <http://grad.arizona.edu/search/node/orientation>.

**ADVISOR MEETINGS:** The student must meet with his/her Advisor once every semester to review their academic progress.

**COMMITTEE MEETINGS:** The student must meet with his/her committee members at least once in an academic year.

**GRADUATE STUDENT ACADEMIC PROGRESS REPORTS:** All ABE graduates students are required to submit a Graduate Student Academic Progress Report (GSAPR) ONCE in an academic year either by April 15<sup>th</sup> during the spring semester or November 15<sup>th</sup> during the fall semester.

**THESIS/DISSERTATION PUBLICATION REQUIREMENTS:** All MS and PhD Students are required to submit papers or receive committee approval meeting the standard for publication in a refereed scientific journal by the time of their final Thesis/Dissertation Defense. Details about the Thesis and Dissertation paper submission requirements and forms can be found on pages 18-20.

**CONTINUOUS ENROLLMENT POLICY:** Graduate students must meet the Graduate College requirements for continuous enrollment found on: <http://grad.arizona.edu/academics/program-requirements/doctor-of-philosophy/continuous-enrollment-PhD>. Auditing a class does not count toward meeting the unit requirement. MS students who are graduating in summer are required to enroll during Summer II Session. PhD students who have completed their course work and are graduating in summer do not need to enroll in a Summer Session. If you are unable to enroll in fall or spring semester, to maintain your student status, you should submit a Leave of Absence. If you fail to meet the continuous enrollment policy and do not register, you will need to reapply to the Graduate College and be approved for readmissions by the Associate Dean of Academic Programs Domestic students with scholarships/Graduate Assistantships or financial aid may be required to be enrolled in more than 6 units.

**INTERNATIONAL GRADUATE ENROLLMENT POLICY:** International students who are not funded as Research Assistants (RA) / Teaching Assistants (TA) must be enrolled full-time, 9 units, each fall and spring semester. <http://global.arizona.edu/international-students/maintaining-status>

**ENROLLMENT POLICY FOR GRADUATE ASSISTANTSHIPS:** Graduate students hired on an assistantship must be enrolled in at least **12 units**.

**ENROLLMENT POLICY FOR GRADUATE SCHOLARSHIPS:** Students on RA/TA or those who have been awarded Graduate Registration Scholarships or Graduate Tuition Scholarships are required to register for 12 units during all regular sessions. International students should review the requirements located at: <http://global.arizona.edu/international-students>.

**GRADUATE COLLEGE THESES/DISSERTATION SCHOLARSHIP:** International students who are within 2 years of completing their degree and only working on their thesis or dissertation research may qualify for a Thesis/Dissertation Scholarship.

This award excludes the mandatory registration fees and any additional tuition charged by the individual programs. Students on appointment as a Graduate Research Assistant/Associate do not qualify for this waiver.

To be eligible for a Graduate College Theses/Dissertation scholarship, students must be enrolled at the University of Arizona for not less than one (1) and not more than six (6) units of 910/920 level units only. Generally, waivers for students enrolling in 1 unit will be approved. Students must have met all course and unit requirements and be finishing up his/her Thesis/Dissertation.

International students who qualify should request for Scholarship through the Program Coordinator, at least two months prior to the beginning of the semester that they qualify for the scholarship.

<http://grad.arizona.edu/financial-resources/ua-resources/meritorious-awards> .

## **GRADUATE RESEARCH AND TEACHING ASSISTANTSHIPS**

Depending on funding allocations, Graduate Research Assistantships and Graduate Teaching Assistantships may be available. Department policy provides that MS students will be supported for no more than four (4) semesters (2 years) and PhD students for no more than eight (8) semesters (4 years). The non-resident tuition fee is waived for students on assistantships of 25% time or more; the registration fee is not waived. There is a tuition remission of 50% or more of the registration fee depending on the level of appointment (1/2, 1/3 or 1/4). Graduate assistants and associates, on half-time assistantships, are expected to work 20 hours per week. This may be increased to 40 hours during the summer months in order to increase annual income and professional experience.

Students hired on Graduate Teaching Assistantships need to review policies, and complete training and orientations required by the Graduate College. <http://grad.arizona.edu/financial-resources/ua-resources/employment/ga-manual/requirements>

## ABE 696A REQUIREMENTS FOR MS AND PHD STUDENTS:

- MS and PhD students are required to enroll in 696A-001, each semester if they are not presenting.
- MS students, and PhD students who received an ABE MS degree are required to enroll in **ABE696A-002** and make 2 presentations to earn 2 units of seminar that will count towards their degree.
- PhD students who did not receive an ABE MS degree, are required to enroll in ABE 696A-002 and make 4 presentations to earn 4 units towards their degree.
- Graduate students, who are seeking an ABE minor in the department, are required to 1 unit of ABE 696A-002 (presentation).

**REQUIREMENTS FOR ABE MINORS (MS OR PhD):** Complete **10 units** consisting of **9 units of ABE courses** (determined by the student and his/her minor advisor) and **1 unit of 696A-002**. Students should select their Minor Advisor, and receive approval from their Major advisor, prior to completing the Graduate College Minor application and filing his/her POS. The Minor Advisor will serve on the Graduate Committees.

## **COMMENCEMENT AND DIPLOMA INFORMATION:**

The University of Arizona, the College of Agriculture and Life Sciences, the Department of Agricultural and Biosystems Engineering celebrates graduate degree completion twice a year, in December and May. Students completing degree requirements in August have the option of attending either the May or December events.

**University Commencement information:** <http://grad.arizona.edu/academics/degree-certification/commencement>. Diplomas are not given out at Commencement. Diplomas are ordered individually for each student after the final degree audit of their academic record is completed. The diploma will be mailed to the address you have listed on student link as your 'permanent' address. If you do not want it sent to your 'permanent' address you should create a 'diploma' address and it will be mailed there instead. If you complete your degree requirements early in the semester and need to provide proof of your degree, please contact the Graduate College Degree Auditor.

**The ABE Department Pre-Commencement Ceremony/Dinner** will be held prior to the U of A Commencement Ceremony. Graduating students will be asked to complete a PowerPoint slide that will be displayed at the ABE Pre-Commencement ceremony.

**The College of Agriculture and Life Sciences Pre-Commencement lunch** held prior to the U of A Commencement Ceremony. The College of Agriculture and Life Sciences Commencement Ceremony is held prior to the U of A Commencement Ceremony. The Graduate Hooding Ceremony will be performed during the CALS Commencement; Graduate students will be expected to select a Faculty Member to perform the Hooding ceremony.



**INTERNATIONAL STUDENT RESOURCES:** International student should familiarize themselves with the Office of Global Initiatives for International Student <http://global.arizona.edu/>, as well as review the Student Resource Manual at <http://global.arizona.edu/international-students/student-resource-manual>.

Please check with the Office of International Student Programs to be sure you are in compliance with your visa status obligation, since you may be required to be enrolled in additional units to maintain your full-time student status. You should also check your I-20 expiration date and if necessary begin the renewal process giving yourself plenty of time to maintain your status, the process may take up to 6 months or more.

### **UACCESS GRADPATH FORMS:**

Graduate Students are required to use GRADPATH located in the UAccess Student system, <http://uaccess.arizona.edu/>, to complete their Graduate College degree certification forms. The forms can only be submitted in a controlled sequence. You cannot create a new form if there are prior forms in the sequence of events that have not been submitted and approved. Form modifications can only be performed on forms that have been approved by the Graduate College.

**Grad Path** can be found by selecting the drop down box located on the Academics section in **UAccess**. Once the student completes the required form in GradPath, the form automatically routes to everyone who needs to see or approve the form. This information is visible in the **Workflow Approval Path**, which displays at the bottom of the form as soon as you submit. You can also go to any form and **View Current** to see the path.

**The Workflow Approval Path** shows you where the form has been, the action taken, and where it's going. Forms will progress through the approval chain at different routing sections and each section has at least one approval group. The approval group may contain a single name or may have multiple approvers. Click on the blue link in any approval group to see more details regarding the person/people in the group.

**Students who have paper-forms on file**, approved prior to August of 2012, will not need to reenter the form in UAccess, unless they are making changes.

Students will need to complete forms in UAccess that were not completed via paper format.

Completed/ approved paper forms are not visible in GradPath; students and/or major advisors should contact the Department Program Coordinator, if they need a copy.

## **MASTERS STUDENT DEGREE CERTIFICATION REQUIREMENTS**

### **MASTERS STUDENT COURSE REQUIREMENTS:**

All course work and requirements for MS degree must be completed prior to the date the degree is awarded. The Department recommends that students should review their Plan of Study and Program requirements throughout their academic career to ensure that they are on track for graduation.

The following ABE requirements, must meet in addition to all of the University or the Graduate College requirements for the MS degree.

### **Additional units will be required to complete this degree if a student:**

- A) Is admitted to the UA with deficiencies;
- B) Changes his/her academic plan(s);
- C) Fails to meet minimum course/plan requirements;
- D) Ineffectively plans or fails to execute a course of study;
- E) Is completing more than one degree.

### **THE FOLLOWING REQUIREMENTS MUST BE MET FOR GRADUATION:**

**Cumulative GPA: 3.0**

**Completed Units: 30 units minimum which consist of at least 25 non-Thesis units, and 5 (ABE 910) Thesis units:**

#### **Minimum Requirements are:**

- 3 units STAT 571B
- 3 units of either a Statistics , Numerical Analysis, Mathematics/Modeling course.
- 16 units of ABE courses including:
  - 2 units of ABE 601
  - 2 units of ABE696A-002, (students who are presenting)
- 5 units of ABE (910) Thesis (under his/her faculty advisor's section number).
- 3 units of an Elective course (per faculty advisor's approval)
- In addition, every Graduate student is required to take ABE696A-001 each semester they are not presenting.

## MASTERS STUDENT PROCEDURES AND FORMS:

MS students are responsible for knowing the ABE program and Graduate College requirements.

MS students also need to review through the Graduate College Policies and Procedures located at <http://grad.arizona.edu/degrecert> and the degree requirements for Master's degrees located at <http://grad.arizona.edu/academics/program-requirements/masters-degrees>.

Each of these steps requires completion and should be taken at the appropriate time during the student tenure at the department. To keep your graduation on schedule, please refer to the dates and deadlines posted on <http://grad.arizona.edu/academics/degree-certification/deadlines-for-graduation>. The appropriate student forms may be accessed through UAccess, <http://uaccess.arizona.edu/>, by clicking on the drop-down menu under the Academics section and selecting "GradPath Forms"

**THE RESPONSIBLE CONDUCT OF RESEARCH STATEMENT.** This is the first form you must complete in order to go forward in GradPath. You cannot open the next form until this form is completed. To see the form, click **Create New**. Make sure you've read the General Information section. Then, in the **Certified Section**, read the statement and check the box. This form does not require any approval. Once submitted you are immediately able to access the Plan of Study (POS) form. To return to your forms page, click the **Return** button.

**RESEARCH TOPICS:** Students should select and submit their research topic to their Committee Chair and the Graduate Program Coordinator by the end of the second semester of their first year in the program.

**PLAN OF STUDY (POS):** In conjunction with his/her major professor or advisor, each student is responsible for developing a Plan of Study during their first year in residence, ABE Master students are required to submit their POS in Gradpath by the end of their 2<sup>nd</sup> semester in the program. <http://grad.arizona.edu/academics/program-requirements/doctor-of-philosophy/plan-of-study>. Thesis (910) units are not entered on the Gradpath POS form. (The 910 units need to be completed to meet degree requirements).

**Transfer credits** may apply towards the ABE MS degree. Students who wish to have Transfer units apply towards their ABE degree need to file a petition with the Program Coordinator. The Graduate Committee will review petition and determine if the transfer course is equivalent, if approved granted, the Course may be listed on the POS. For more information on Graduate College Transfer Credit policies students should review the following link: <http://grad.arizona.edu/academics/program-requirements/doctor-of-philosophy/credit-requirements-and-transfer-credit> , or contact the ABE Program Coordinator, and/or their Graduate College Degree Auditor.

**MASTER'S/SPECIALIST PROGRAM FEES:** Your bursar account will be billed candidacy fees of \$35.00 at the time you submit your Masters/Specialist Plan of Study to the Graduate Student Academic Services Office. This is a one-time fee, and you will not be billed again if you change your anticipated graduation date. <http://grad.arizona.edu/financial-resources/costs/degree-audit-processing-fee>

**MASTER'S/SPECIALIST COMMITTEE APPOINTMENT FORM:** Students should complete this Gradpath form no later than the last day of class during their second semester. Students will be required to enter their Committee Members, expected graduation term and year, title of their Thesis, as well as, confirm if they are archiving the Thesis with the University: <http://grad.arizona.edu/academics/degree-certification/diss-theses/format-check-process>

Master's thesis committees must consist of three members; at least two must be tenure-track UA ABE faculty members. If the third member is not a tenure-track UA faculty member, he or she must be approved by the Graduate College as a Special Member. Contact the Program Coordinator if you need to request a Special Member.

The chair of the committee must be an ABE Faculty member. A member who is not tenure-track will not be eligible to serve as sole chair of the committee but can serve as co-chair if approved to do so by the Graduate College.

**THESIS REQUIREMENT:** Students are required to submit a minimum of one paper for publication. Student must submit the paper along with their Thesis to their Committee for review three weeks prior to the defense. Student needs to:

- Receive approval for submission to a refereed journal from their major committee and major advisor.
- To be listed as the first author in at least one paper approved for submission.

Archiving your master's thesis is optional. If you are uncertain about archiving your thesis, please discuss the matter with your Major Advisor. Students who choose to Archive their Thesis will be charged a fee see <http://grad.arizona.edu/financial-resources/costs/degree-audit-processing-fee>.

An ABE Student should review the Graduate College manual to ensure that the Thesis is set up in the proper format. <https://grad.arizona.edu/degrecert/dissertations-theses>. Copies of filed Thesis papers are available for check out with the Department Program Coordinator or via the University Libraries: <http://arizona.openrepository.com/arizona/handle/10150/129649/>

**THESIS DEFENSE EXAMINATION:** Upon the completion and approval by the committee of the Thesis, the candidate is to defend his/her Thesis. A student must be in good academic standing to schedule the defense. The Committee Chair presides over the defense examination. The examination is closed to the public, except for an initial seminar portion during which the student presents the dissertation and entertains questions. There is no minimum time limit for the Final Defense, but the entire proceedings may not exceed three hours.

**THESIS DEFENSE REQUIREMENTS:** A student should notify the Program Coordinator, once his/her committee has agreed on a time and date for the final defense. All members must be present/participate during the entire examination.

- The Department recommends that the student submit the Thesis to the committee at least three weeks prior to the date of the defense.
- Student should make arrangements for his/her defense with the committee and notify the Program Coordinator and the committee of the final date and time for the defense.
- The student should send an Announcement Flyer to the Program Coordinator, via email to be sent to the Department Faculty and Students as well as posted.

**Members of the committee must be present for the entire examination.** Per Graduate College policies a member may participate in the Defense via Skype. If a member is requesting to participate via Skype, the student will need to receive permission from Graduate Director and Department Head. Student should send an email request to the Director of Graduate Studies, Department Head and the Program Coordinator at least 5 days in advance of the Defense date. If a member is not able to participate in person or via Skype, the student will need to find another Tenured Track Faculty member and update their Committee Appointment form.

**REPORTING RESULTS:** After the Defense the Committee will determine if the student passed or passed with revisions, or failed the exam. The Committee Chair will submit the results to the Program Coordinator via email.

- If the Student passed without revisions, the student may proceed with submission process. The Chair should submit a **Change of Grade Form**.
- If the student passed with revisions:
  - The committee must determine the date that the student needs to resubmit the corrections to the committee.
  - The Chair will have to make sure that the student makes the committee's recommendations are made and notify the Program Coordinator that the revisions are completed and the student met the degree requirements. The Chair should submit a **Change of Grade Form**.
- If the Student fails the Defense see the Department Head and the Director of Graduate Studies and the Program Coordinator.

**MASTER'S/SPECIALIST COMPLETION FORM:** This Gradpath form is completed by the Graduate Coordinator, after receiving the results of the exam from the Committee Chair.

<http://grad.arizona.edu/academics/program-requirements/masters-degrees/completion-of-masters-requirements>

**CHANGE OF DEGREE FROM ABE MS TO ABE PhD:** Students who wish to change degree objective from ABE Master's to ABE PhD, can file a Change of Degree form at any time they are in the program. Students must complete the Change form and submit to the Program Coordinator <https://grad.arizona.edu/gcforms/degree-certification-forms>.

Students who are completing their ABE Masters degree and wish to apply for the ABE PhD Program will receive a fee waiver for the PhD Candidate Application. The Official Transcript requirement is also waived for students who graduated with a BS and/MS from the University of Arizona. Interested students should turn in a Change of Program form with the ABE the Program Coordinator, as well as, complete the on-line application for the ABE PhD Program.

### **MASTER OF ENGINEERING PROGRAM:**

The Master of Engineering (ME) program in Agricultural and Biosystems Engineering is designed primarily for part- and full-time students seeking a Master's degree who are employed. The goal of the program is to provide a graduate-level educational opportunity (ME) to individuals whose primary interests are the enhancement of their existing skills and the development of new skills pertinent to their industrial positions. The Master of Engineering program emphasizes several areas, including: Biological and/or Biosystems Engineering; Bio-Energy and Bio-Products Engineering; Biological Information and Sensors; Controlled Environment Engineering; Safe Food, Feed and Fiber; Water Resources and/or Irrigation Engineering

The ME program does not require a research project leading to the completion of a master's thesis, but rather the completion of a design project report. Students should apply and be admitted to the University of Arizona. Appropriate graduate level courses satisfactorily completed at any of the cooperative institutions (i.e., Arizona State University and Northern Arizona University) will be applicable to the degree program, so long as these courses meet the program of study guidelines. However, at least one-half of the course requirements must be completed at the University of Arizona.

### **DUAL MASTERS PROGRAM WITH ELLER COLLEGE OF MANAGEMENT:**

Interested graduate students have the option of receiving two graduate degrees on a concurrent basis. One of these degrees will be an MBA degree from the Eller College of Management. The other will be a graduate degree from ABE. Students should apply on-line through the University of Arizona Graduate College website link: <https://apply.grad.arizona.edu>. For more information regarding this program go to: <http://mba.eller.arizona.edu/dual/>.

## **PHD STUDENT DEGREE CERTIFICATION REQUIREMENTS AND FORMS**

**PHD COURSE REQUIREMENTS:** All course work and requirements for this degree must be completed prior to the date the degree is awarded. The Department recommends that students should review their Plan of Study and Program requirements throughout their academic career to ensure that they are on track for graduation.

The following ABE requirements, must meet in addition to all of the University or the Graduate College requirements for the PhD degree.

**Additional units will be required to complete this degree if a student:**

- A) Is admitted to the UA with deficiencies;
- B) Changes his/her academic plan(s);
- C) Fails to meet minimum course/plan requirements;
- D) Ineffectively plans or fails to execute a course of study;
- E) Is completing more than one degree.

**THE FOLLOWING REQUIREMENTS MUST BE MET FOR GRADUATION:**

**Cumulative GPA: 3.0**

**Completed Units: 63 units minimum**, which consist of at least 45 non-Dissertation units and 18 (ABE920) Dissertation units:

**Minimum Requirements are:**

- 3 units of STAT 571B
- 9 units of either Statistics, Numerical Analysis, Mathematics/Modeling course work.
- 18 units of ABE courses including:
  - 2 units of ABE 601
  - 4 units of ABE696A-002 (students who are presenting).
    - For ABE MS Graduates are required to take 2 units as the other 2 units are earned from their MS program.
    - For Non ABE MS Graduates or Graduates from other Institutions, the 4 units apply.
  - 1 unit of ABE693 (section # under faculty sponsor)
- 18 units (minimum) of Dissertation units: ABE 920.
- 3~6 units minimum of an Elective course per approval of Faculty advisor and depending on the minor requirements.
- In addition, every Graduate student is required to take ABE696A-001 each semester he/she is not presenting.

**ABE PhD MINOR REQUIREMENTS:** ABE PhD Students are required to complete a Minor. The following are some possible minors for ABE students: Soil, Water and Environmental Science, Plant Sciences, Chemical and Environmental Engineering, Civil Engineering & Engineering Mechanics, Electrical and Computer Engineering, Hydrology and Water Resources, Agricultural & Resource Economics, Mathematics, Renewable Natural Resources, Systems and Industrial Engineering, Aerospace and Mechanical Engineering, Biomedical Engineering, Optical Science.

## PHD PROCEDURES AND FORMS:

PhD students are responsible for knowing the ABE program and Graduate College requirements. PhD students also need to review the Graduate College Policies and Procedures located at <http://grad.arizona.edu/degrecert> and the Degree requirements for PhD students at <http://grad.arizona.edu/academics/program-requirements/doctor-of-philosophy>.

Each of these steps requires completion and should be taken at the appropriate time in during the academic career. Students should review the Graduate College dates and deadlines located at <http://grad.arizona.edu/academics/degree-certification/deadlines-for-graduation> to keep their graduation on schedule. The appropriate student forms may be accessed through UAccess, <http://uaccess.arizona.edu/>, by clicking on the drop-down menu under the Academics section and selecting "GradPath Forms"

**THE RESPONSIBLE CONDUCT OF RESEARCH STATEMENT:** This is the first form you must complete in order to go forward in GradPath. You cannot open the next form until this form is completed. To see the form, click **Create New**. Make sure you've read the General Information section. Then, in the **Certified Section**, read the statement and check the box. This form does not require any approval. Once submitted you are immediately able to access the Plan of Study (POS) form. To return to your forms page, click the **Return** button.

**PHD MAJOR ADVISOR:** Students are required to have a major advisor in order to maintain Satisfactory Academic Progress and the major advisor should be selected no later than the third semester in the program. In the first few weeks after joining the program, students should meet with the Director of Graduate Studies to discuss options and procedures for choosing a Major Advisor. Major Advisors should specialize in the student's main field of interest. The major professor is responsible for meeting with the student periodically to review the student's progress.

**RESEARCH TOPICS:** Students need to select their research topics and submit it to their graduate committee before the last day of class during their third semester in the program.

**DISSERTATION REQUIREMENTS:** Students are required to submit a minimum of two papers for publication. Student must submit the papers along with their Dissertation to their Committee for review three weeks prior to the defense. Student needs to:

- Receive approval for submission to a refereed journal from their major committee and major advisor.
- To be listed as the first author in at least one of the papers approved for submission.

ABE Students should review through the Graduate College manual to ensure that their Dissertation is set up in the proper format. <https://grad.arizona.edu/degrecert/dissertations-theses>. Copies of Filed Dissertation papers are available for check out with the Department Program Coordinator or via the University Libraries: <http://arizona.openrepository.com/arizona/handle/10150/129649/>



**ABE 693 INTERNSHIP REQUIREMENTS:** All PhD students are required to have one unit of ABE 693 teaching internship experience that may include participating in extension activities, workshops, and short course offerings, considered to be equivalent to teaching a one unit class or lab. Teaching experience includes paid teaching assistantship anywhere at the university, teaching a lab course in the department, or lecturing in a formal classroom setup. If a student teaches more than one unit of class or lab on unpaid teaching, he/she can register up to 3 units of teaching practicum that can be used towards his/her degree program. This requirement excludes grading and office hours.

Students are required to complete ABE 693 registration form located at the ABE main office. Upon registration students are required to have an internship plan and must select an internship advisor. A report is required at the end of the semester. Reports must be submitted to the internship advisor.

**PLAN OF STUDY:** In conjunction with his/her major professor or advisor, each student is responsible for developing a Plan of Study (POS) starting their first year in residence, ABE PhD students are required to submit their POS in Gradpath by the end of their 3rd semester.

<http://grad.arizona.edu/academics/program-requirements/doctor-of-philosophy/plan-of-study>.

- The required Dissertation (ABE 920) units will not be entered on the Gradpath POS. The 920 units must be completed prior to degree completion.

**Transfer credits** may apply towards the ABE PhD degree. Students who wish to have Transfer units apply towards their ABE degree need to file a petition with the Program Coordinator. The Graduate Committee will review petition and determine if the transfer course is equivalent, if approved granted, the Course may be listed on the POS. For more information on Graduate College Transfer Credit policies students should review the following link: <http://grad.arizona.edu/academics/program-requirements/doctor-of-philosophy/credit-requirements-and-transfer-credit> , or contact the ABE Program Coordinator, and/or their Graduate College Degree Auditor.

**COMPREHENSIVE EXAMINATION:** Before admission to candidacy for the doctoral degree, the student must pass a Written and Oral Doctoral Comprehensive Examination. The exam will determine whether the student will be permitted to continue the PhD program. This examination is intended to test the student's comprehensive knowledge of the major and minor subjects of study, both in breadth across the general field of study and in depth within the area of specialization. The examination, therefore, should not take place until the student has completed all, or almost all, of his/her coursework. The Comprehensive Examination is considered a single examination, although it consists of written and oral parts. <https://grad.arizona.edu/academics/program-requirements/doctor-of-philosophy/comprehensive-examination>

**COMP EXAM COMMITTEE APPOINTMENT FORM:** PhD students need to select their graduate committee before the last day of class during their third semester. Students should receive verbal approval, from their major advisor, prior to submitting the Comp Exam form in Gradpath.

- The examining committee must consist of a minimum of three (3) members all of whom must be current University of Arizona faculty members who are tenured, tenure-track, or approved as equivalent. Minimum of Two (2) of the members should be from the ABE and one (1) from the any U of A department per student's program specialty. Additional members may be tenured or tenure-track, or a special approved member. Special members must be pre-approved by the Dean of the Graduate College.
- If a member is not a current tenure-track UA faculty member, he or she must be approved by the Graduate College as a special member. Please contact the Program Coordinator, to process the Special Member request.
- Once the committee has been approved, by the assigned approvers students will proceed to the Announcement of Doctoral Comprehensive Exam.

**ANNOUNCEMENT OF DOCTORAL COMPREHENSIVE EXAM:** This Gradpath form officially notifies your Committee, Department Approvers and the Graduate College of the date and time of the Exam. Students need to complete the form, once your committee has agreed on a time and place for the Exam. After the form is approved, Gradpath will send the members an email to confirm the date and time via email.

- Note: At this time you may make changes to your committee by clicking "Adjust Committee Members." Any changes will be routed for re-approval.

**REPORTING RESULTS OF COMPREHENSIVE EXAM:** The Committee Chair reports the Final results of the (Oral and Written) Exam in Gradpath.

- If the student passes the exam, he/she will be Advanced to Candidacy and proceed to completing the Dissertation Committee Appointment form.
  - When the student has an approved doctoral Plan of Study on file with the Graduate Degree Certification Office, has satisfied all course work, language, and residence requirements, and passed the written and oral portions of the Comprehensive Examination their bursar account will be billed the <http://grad.arizona.edu/financial-resources/costs/degree-audit-processing-fee> . This is a one-time fee and the student will not be billed again if they change their anticipated graduation date. Copyrighting is optional and carries an additional fee.
- If the student does not pass the exam, they will be allowed no more than one re-take.

**DOCTORAL DISSERTATION COMMITTEE:** A Student need to form a dissertation committee, submit his/her Dissertation Committee members for approval in Gradpath soon after passing his/her Comprehensive Exam and receiving his/her Advancement to Candidacy from the Graduate College.

- The Graduate College requires a minimum of three members, all of whom must be University of Arizona tenured, tenure-track, or approved as equivalent. The ABE Departments requires that a minimum of two (2) members be from the ABE Department and one (1) from the any U of A department per student's program specialty. The student's advisor must be a member of the ABE faculty and serve on the committee. If a committee has only three members, all must approve the dissertation.
- Special members must be pre-approved by the Dean of the Graduate College. Any members beyond the fourth can also be tenured or tenure-track, or special approved members. Please contact the Program Coordinator, to process the Special Member request.
- **All dissertation committee members are required to attend the final defense.** The ABE Department would prefer that all members are present in the room; however, we understand that circumstances may arise that may prevent a committee member from being physically present in the room. Per Graduate College policies, a member may participate in the Defense via Skype. If a member is requesting to participate via Skype, the student will need to receive permission from Graduate Director and Department Head. Student should send an email request to the Director of Graduate Studies, Department Head and the Program Coordinator at least 5 days in advance of the Defense date. If a member is not able to participate via Skype, the student will need to find another Tenured Track Faculty member and if needed update their Committee Appointment form.

**PROSPECTUS PROPOSAL:** A Student need to develop a proposal of sufficient academic merit and on a topic to satisfy his/her committee.

- A Student is required to send the title of his/her Prospectus Proposal to the Program Coordinator, via email prior to completing the Announcement of Final Oral Defense.
- Once the Prospectus is received, the Program Coordinator will submit the Prospectus Proposal form in Gradpath.

**ANNOUNCEMENT OF FINAL ORAL DEFENSE:** A student should complete the Gradpath form, once his/her committee has agreed on a time and date for the Defense. All members must be present/participate during the entire examination.

- This Gradpath form should be submitted far enough in advance of the examination that all approvers can grant his/her approval in time for the form to reach the Graduate College one week prior to the exam. The Department recommends that the student submit the form at least two weeks prior to the date of the exam.
- The student should provide a copy of the Dissertation to the committee no later than three weeks prior to the defense.
- Members will be sent an email to confirm date and time.
- The student should send an Announcement Flyer to the Program Coordinator, via email to be sent to the Department Faculty and Students as well as posted.

Per Graduate College policies, a member may participate in the Defense or other similar video conferencing tools (hereafter "Skype"). If a member is requesting to participate via Skype, the student will need to receive permission from Graduate Director and Department Head. Student should send an email request to the Director of Graduate Studies, Department Head and the Program Coordinator at least 5 days in advance of the Defense date. If a member is not able to participate in person or via Skype, the student will need to find another Tenured Track Faculty member and update their Committee Appointment form.

**FINAL ORAL DEFENSE EXAMINATION:** Upon the completion and approval by the committee of the dissertation, the candidate is to take the Final Oral Defense Examination. A student must be in good academic standing to schedule the defense. The examination focuses on the dissertation itself but can include general questioning related to the field(s) of study within the scope of the dissertation. The exact time and place of this examination must be scheduled through Gradpath at least two weeks in advance. The dissertation Chair presides over the examination. The examination is closed to the public, except for an initial seminar portion during which the student presents the dissertation and entertains questions.

There is no minimum time limit for the Final Oral Examination, but the entire proceedings may not exceed three hours. Members of the committee must be present for the entire examination.

Students should provide a print of the Final Oral Examination Instructions to their Committee Chair at least 1 week prior to the date of the defense:

<https://grad.arizona.edu/gcforms/sites/gcforms/files/page/finaldefenseinstructions.pdf>

**REPORTING RESULTS:** After the Defense the Committee will determine if the student passed or passed with revisions, or failed the exam. The committee chair will submit the results in Gradpath.

- If the Student passed without revisions, the student may proceed with submission process. The Chair should submit a **Change of Grade Form**.
- If the student passed with revisions:
  - The committee must determine the date that the student needs to resubmit the corrections to the committee.
  - The Chair will need to enter this date in the Gradpath form.
  - After the Committee approves the final corrected revisions, the Chair sends an email to the Graduate Auditor and the Graduate Coordinator confirming the final results for degree completion, as well as submits a **Change of Grade Form**. Once the Final revisions are approved, the student will be advised to complete the submission process.
- If the student fails, he or she should contact the Graduate College.

**DISSERTATION SUBMISSION:** Upon receipt of the finalized dissertation, the Dean of the Graduate College will recommend conferral of the doctoral degree by the Arizona Board of Regents. Once the Graduate College Degree Auditor receives the final result for the Defense they will send the student information on the Dissertation Submission process.

The candidate will need to submit the dissertation electronically for forwarding to the Library of The University of Arizona and to University Microfilms, Inc. (UMI). The ABE department requires a bound hard copy.

A processing fee will be charged to the Students Bursars <https://grad.arizona.edu/financial-resources/costs/degree-audit-processing-fee> also must be paid to the University Bursar.

**CHANGE OF DEGREE PROGRAM:** Students who wish to change degree objective from an ABE PhD to the ABE Master's can file a Change of Degree form. Students must complete and submit the Change form to the Program Coordinator: <https://grad.arizona.edu/gcforms/degree-certification-forms>

**STUDENTS WHO WISH TO PURSUE A MASTERS WHILE COMPLETING THE ABE PhD:**

The Graduate College allows this option subject to the following restrictions:

- No credit may be counted for more than two degrees. Thus UA credits could not be used for a master's in UA major 1, a doctorate in UA major 1, and a master's in UA major 2.
- A student may use no more than a total of 30 credits from all master's degrees toward a doctorate. Thus, if a student earned a non-UA master's, up to 30 credits could be used toward a UA doctorate. In that case, none of the transfer credit nor any additional coursework toward the UA doctorate could be used toward a UA master's in a major that differs from the doctorate because the student would have exhausted the 30 credit limit of master's coursework that can be shared with a doctorate.
- The student should make sure that the department is aware his/her intent to pursue this option.

# **THESIS/DISSERTATION PAPER REQUIREMENTS**

## **Objectives**

Students are required to submit papers for publication refereed scientific journals by the time of their final Thesis/Dissertation Defense. The primary objectives of the option are:

- i. To encourage graduate students to learn the submission/publication processes of refereed journals before graduation
- ii. To shorten the process of publishing papers from thesis/dissertation

Similar options are available in many European and US institutions (including at least two departments at the UA). Thesis and Dissertation papers completed under this option are available for students to check out, in the Program Coordinators office. Please review the [ABE Committee Paper-Option Signature Approval Form](#).

If you have any questions please do not hesitate to contact the Director of Graduate Studies and/or your advisor.

## **Guidelines**

- MS – one paper/manuscript with the student as the first author approved for submission to a refereed journal by the committee and the major advisor is required.  
PhD – two papers/manuscripts with the student as the first author in at least one paper approved for submission to a refereed journal by the committee and the major advisor is required.
- Prior to the submission of each manuscript, an advisor's (and co-advisor's, if any) approval is required. After the advisor's review, each manuscript must be approved by majority of the thesis/dissertation committee members. Please remember to attach the signature page for the ABE paper for each manuscript.
- The committee will decide when the paper is ready for defense. Students must give a copy of the pen ultimate copy of the paper three weeks (minimum) before the scheduled defense.

## **RECOMMENDED THESIS/DISSERTATION FORMAT:**

TITLE PAGE

SIGNATURE PAGE (DISSERTATION ONLY)

STATEMENT BY AUTHOR

ACKNOWLEDGEMENTS

DEDICATION

TABLE OF CONTENTS (BEGINS WITH LIST OF ILLUSTRATION/TABLES)

LIST OF ILLUSTRATIONS (FROM INTRODUCTION & PRESENT STUDY)

LIST OF TABLES (FROM INTRODUCTION & PRESENT STUDY)

ABSTRACT

### **CHAPTER 1. Introduction**

- Explanation of the problem(s), objectives, and uniqueness
- The relationship of the manuscripts included and your contribution to each of the manuscripts
- Specify your role in the research and production of the manuscript(s). Where research efforts are part of larger collaborative project, identify one aspect of the project as your own and demonstrate an original contribution.
- An overall literature review and background

### **CHAPTER 2. Present Study**

- Overall Summary
- Overall Conclusions and Recommendations

### **Appendices:**

- Manuscript No. 1<sup>1</sup>
- Manuscript No. 2<sup>1</sup>
- Supplementary materials - Materials such as data tables, additional references, graphs, computer programs, and maps.
- All appendix pages are part of the single pagination sequence of the thesis/dissertation.

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<sup>1</sup>The first page each manuscript must include the title, a list of co-authors, and a refereed journal to which the manuscript was submitted. The statement of permission for use of copyrighted material should be attached if needed.

**THESIS/DISSERTATION PAPER COMMITTEE CERTIFICATION**

FOR  
SUBMITTED/PUBLISHED MANUSCRIPT

DEPARTMENT OF AGRICULTURAL AND BIOSYSTEMS ENGINEERING  
THE UNIVERSITY OF ARIZONA

As members of the final examination committee, we have read the manuscript(s)

Prepared by \_\_\_\_\_

Entitled: \_\_\_\_\_

and approved submission to: \_\_\_\_\_

In partial fulfillment of the requirements for the Degree of: \_\_\_\_\_

APPROVED BY:

\_\_\_\_\_  
Major Advisor (*print and sign name*)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Committee Member (*print and sign name*)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Committee Member (*print and sign name*)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Committee Member (*print and sign name*)

\_\_\_\_\_  
Date



## **ABE GRADUATE PROGRAM CONTACT INFORMATION**

### **PROGRAM COORDINATOR:**

Ms. Dava Jondall

[davaj@email.arizona.edu](mailto:davaj@email.arizona.edu)

(520) 621-1753

Shantz Building, room 413

### **DIRECTOR OF GRADUATE STUDIES**

Dr. Muluneh Yitayew

[myitayew@email.arizona.edu](mailto:myitayew@email.arizona.edu)

(520) 621-7232

Shantz Building, room 533

### **DEPARTMENT HEAD**

Dr. Donald Slack

[slackd@email.arizona.edu](mailto:slackd@email.arizona.edu)

Shantz Building, room 403

(520) 621-1607

### **GRADUATE COLLEGE DEGREE AUDITOR/STUDENT ACADEMIC SPECIALIST**

Frank Whitehead

[fwhitehead@grad.arizona.edu](mailto:fwhitehead@grad.arizona.edu)

Graduate College

PO Box 210066

Administration Building, room 316

### **DEPARTMENT OF AGRICULTURAL AND BIOSYSTEMS ENGINEERING**

1177 E. 4<sup>th</sup> Street, Shantz Bldg. #38, Room 403

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Tucson AZ 85721-0038

(520) 621-1607 · Fax: (520) 621-3963

Web Site address: <http://ag.arizona.edu/ABE>

## **ABE FACULTY**

The Department faculty has a wide range of experience and research interest as indicated below.

AN, LINGLING, Assistant Professor, Biometry, PhD, 2008, Purdue University. **Statistical Bioinformatics, Statistical methods for detecting and predicting biological threats.**

ANDRADE-SANCHEZ, PEDRO, Assistant Professor & Specialist, PhD, 2004, University of California, Davis. **Precision agriculture.**

CUELLO, JOEL L., Professor, PhD, 1994, The Pennsylvania State University. **Bioreactor design and scale up, algae production systems, controlled-environment systems, cell and organ cultures regulations.**

FARRELL-POE, KATHRYN, Professor & Specialist, PhD, 1990, Purdue University. **Water quality, onsite-wastewater treatment, safe drinking water, extension education/outreach.**

GIACOMELLI, GENE A., Professor, and Director of Controlled Environment Agriculture Program (CEAC), PhD, 1983, Rutgers University, **Horticultural engineering, energy conversions engineering, bioresource engineering, greenhouse engineering design, hydroponic crop production.**

Hurwitz, Bonnie, Assistant Professor, Biometry, PhD, 2012, University of Arizona. **Bioenvironment & One Health, functional Metagenomics, big data, system Biology, Bioinformatics and Computational Biology.**

KAÇIRA, MURAT, Associate Professor, PhD, 2000, The Ohio State University. **Controlled environment agriculture, Food, agricultural, and biological engineering.**

MARTIN, ED, Professor & Specialist, Interim Director, Maricopa County Extension, PhD, 1992, Michigan State University. **Water resources, irrigation management.**

POE, STEPHEN E., Professor, PhD, 1987, Purdue University. **System mechanization, livestock waste management, ventilation housing, and computer software development.**

SIEMENS, MARK, Associate Professor & Specialist, Ph. D., 1996, University of Arizona. **Specialty crops mechanization, agricultural machine design and testing; tillage.**

SLACK, DONALD C., Professor & Department Head, PE, PhD, 1975, University of Kentucky. **Irrigation scheduling, water resources, infiltration, porous media flow, soil and water conservation engineering.**

WALLER, PETER, Associate Professor, PhD, 1990, University of California, Davis. **Water quality engineering, irrigation engineering, drainage engineering.**

YITAYEW, MULUNEH, Professor & Director of Graduate Studies, PhD, 1982, University of Arizona. **Irrigation engineering, hydraulics, water resources engineering.**

YOON, JEONG-YEOL, Associate Professor, PhD, 2004, University of California. Los Angeles. **Biosensors, water safety, lab-on-a-chip, protein nanoarray, immunoassay, biomaterials.**

*The Department works closely with the USDA Water Conservation Laboratory in Phoenix, Arizona and with the Southwest Watershed Research Center in Tucson. Scientists and engineers from both organizations serve on student advisory committees.*

**Faculty continued:**

**BARNES, EDWARD**, Adjunct Associate Professor, PhD, 1996, Oklahoma State University. Simulation models and remotely sensed data and precision crop management.

**BARTON, JENNIFER K.**, Interim Vice President for Research & Professor, PhD, 1998, The University of Texas at Austin. Primary appointment BME.

**BILLHEIMER, DEAN D.**, Associate Professor, Biometry, PhD, 1995, University of Washington. **Statistical Methods for Biological Monitoring Data: State-Space Models for Relative Abundance of Species.**

**CLEMMENS, ALBERT J.**, Adjunct Associate Professor, PhD, 1990, Arizona State University. Research Hydraulic Engineer and Research Leader, USDA-ARS, Water Conservation Laboratory. Irrigation engineering, canal hydraulics, automatic controls.

**FANGMEIER, DELMAR D.**, Professor Emeritus, PE, PhD, 1967, University of California, Davis. Surface Irrigation, Sprinkler and Trickle Irrigation.

**FITZSIMMONS, KEVIN**, Professor, PhD, 1999, University of Arizona. Wildlife and Fisheries Science. Primary appointment in Soil, Water and Environmental Science.

**HAWKINS, RICHARD H.** Professor Emeritus, PhD, 1968, Colorado State University. Watershed Management.

**HATCH, KATHRYN L.**, Professor Emeritus, PhD, 1975, Southern Illinois University. Expertise in textiles as they relate to Biosystems or biomedical engineering.

**HOENIG, STUART A.**, Adjunct Professor, PhD, 1960, University of California, Berkeley. Professor Emeritus, Electro-mechanical systems.

**HUNSAKER, DOUGLAS**, Adjunct Professor, PhD, University of Arizona. Research Hydraulic Engineer, USDA-ARS, Water Conservation Laboratory. Irrigation Engineering, Irrigation Management

**KUBOTA, CHERI**, Associate Professor, PhD, University of Tokyo, Controlled environment agriculture. Primary appointment in Plant Sciences.

**LARSON, DENNIS L.**, Associate Professor Emeritus, PE, PhD, 1971, Purdue University. System analysis, energy engineering.

**MATLOCK, GERALD W.**, Professor Emeritus, PhD, 1965, University of Arizona. Structures and environment.

**NEARING, MARK**, Adjunct Professor, PhD, 1986, Purdue University. Soil and Water resources engineering; erosion prediction technology. Research Hydraulic Engineer, USDA - Southwest Watershed Research Center, Tucson, AZ.

**NICHOLS, MARY**, Adjunct Assistant Professor, PhD, 1999, New Mexico State University. Semi-arid erosion and sedimentation process. Research Hydraulic Engineer, USDA - Southwest Watershed Research Center, Tucson, AZ.

**OGDEN, KIMBERLY L.**, Professor, PhD, 1991, University of Colorado, Boulder. Bioreactor design for production of alternative e fuels from algae and sweet sorghum and microbiological water quality. Primary appointment in Chemical and Environmental Engineering.

**PEPPER, IAN**, Professor, PhD, 1975, The Ohio State University. Soil Microbiology, primary appointment in Soil, Water and Environmental Science.

**PIEGORSCH, WALTER W.**, Professor & Chair of Statistics GIDP, PhD, 1984, Cornell University. Statistics, primary appointment in Mathematics.

**RASMUSSEN, WILLIAM O.**, Associate Professor Emeritus, PhD, 1973, U of Arizona. Simulation and modeling, geophysics, hydrology.

**RENARD, KENNETH G.**, Adjunct Professor, PhD, 1972, University of Arizona. Research Hydraulic Engineer, USDA-ARS, Southwest Watershed Research Center. Erosion control and sedimentation.

**REPLOGLE, JOHN A.**, Adjunct Professor, PhD, 1964, University of Illinois, Research Hydraulic Engineer, USDA-ARS Water Conservation Laboratory. Flow measurement, irrigation engineering, irrigation system control.

**ROTH, ROBERT L.**, Professor Emeritus, PhD, 1983, University of Arizona. Resident Director Maricopa Agricultural Center. Field research in irrigation and fertilizer management.

**STONE, JEFFRY**, Adjunct Assistant Professor, PhD, 1990, University of Arizona. Research Hydraulic Engineer, USDA-ARS, Southwest Watershed Research Center. Decision support systems, watershed management, hydrology.

**STRELKOFF, THEODOR**, Research Professor, PhD, 1962, State University of Iowa. Surface Irrigation hydraulics and modeling.

**TAKAKURA, TADASHI**, Adjunct Professor, PhD, 1967, Nagasaki University. Professor and Associate Dean, College of Environmental Studies, Nagasaki University. Environmental control, plant environment systems modeling.

**TAMIMI, AKRUM H.**, Adjunct Assistant Professor, PhD, 1995, University of Arizona. Irrigation engineering, water resources, computer modeling.

**WONG, PAK KIN**, Associate Professor, PhD, 2005, University of California, Los Angeles, 2005. Single molecule detection and manipulation, molecular and cellular biomechanics, bioMEMS, micro- and nanofluidics, computational systems biology, point-of-care diagnostic. Primary appointment in Aerospace and Mechanical Engineering.