



THE UNIVERSITY OF ARIZONA  
COLLEGE OF AGRICULTURE & LIFE SCIENCES  
COLLEGE OF ENGINEERING

**Biosystems Engineering**

# Graduate Manual for the Biosystems Engineering Programs



Department of Biosystems Engineering  
1177 E. 4<sup>th</sup> Street, Shantz, Room 403  
The University of Arizona  
Tucson AZ 85721-0038  
(520) 621-1607 · Fax: (520) 621-3963  
Web Site address: <http://BE.arizona.edu/>

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# BIOSYSTEMS ENGINEERING (BE) MISSION, PURPOSE, VISION, VALUES

## Mission

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

## Purpose

BE develops and facilitates the use of innovative technologies for the 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

BE 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 in our programs.

## Shared Values

|                          |  |
|--------------------------|--|
| <i>Innovation</i>        | We are innovative in our solutions and how we approach engineering, life science, and data science practices to solve grand challenges.                    |
| <i>Inclusiveness</i>     | We bring together different people, ideas, backgrounds, and perspectives to produce lasting solutions for all. We encourage and help all to be successful. |
| <i>Interdisciplinary</i> | We embrace on-campus collaboration to develop better solutions that address the needs of all.  |
| <i>Cooperation</i>       | We forge off-campus partnerships to solve society's complex problems and improve the quality of life.  |
| <i>Sustainability</i>    | We manage the use of natural resources to maintain healthy ecosystems throughout the production cycle of food, bioenergy, and bioproducts.                 |
| <i>Connectedness</i>     | We work with industry and communities to understand tomorrow's needs and open up opportunities for our students and alumni to help.                        |
| <i>Ethics</i>            | High ethical standards and sound decision-making are at the heart of our research, discovery, business, and financial practices.                           |

## 1.0 INTRODUCTION

This handbook provides students with information on the requirements and procedures for pursuing a graduate degree (MS, AMP, or PhD) in the Department of Biosystems Engineering (BE) at The University of Arizona. The Department is active in research. We have four general emphasis areas: Biometry and Biosystems Informatics; Controlled Environment Agriculture; Food, Bioproducts, and Renewable Energy; and Water Resources. However, students will find that a graduate program in the BE department 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 program's flexibility allows foreign and domestic students to develop programs specifically suited to their career goals and interests in consultation with their advisors. The University of Arizona is a diverse institution and therefore provides courses in many different areas to support specific and general programs.

This manual is a compilation of current policies, practices, and procedures of the Graduate School and the Department of Biosystems Engineering. Information found in the Graduate Catalog [<http://catalog.arizona.edu/policy-audience/graduate>], which the student is expected to be familiar with, is to be used as the basis for the resolution of any special problems, the treatment of any extraordinary conditions, and the source for details not covered by this manual.

This manual contains general program information, admission requirements, general administration of the graduate program, and deadlines for submission to the Graduate College of items such as study programs, reports on examinations, etc. The Graduate College publishes official specific deadline dates. A copy of the official deadline dates can be obtained from the BE Academic Advisor or the Graduate College website [<http://grad.arizona.edu/>].

## 2.0 DEGREE PROGRAM INFORMATION

The Department offers the following degrees:

- Biosystems Engineering:
  - Accelerated Master of Science (AMP)
  - Traditional Master of Science (2-year MS)
  - Doctor of Philosophy (PhD)
- Biosystems Analytics & Technology
  - Traditional Master of Science (2-year MS)
  - Doctor of Philosophy (PhD)

Students in either of the MS programs have the option of completing a thesis or a report. The thesis option is intended for students who want to study in a specialized area and to work closely with a faculty member on a unique research topic. It will also prepare the student for the independent research needed for the PhD program. The report option is intended for students desiring a broad education and engineering practice. It comprises coursework in several areas and an engineering report under the supervision of the student's major professor and the student's committee members.

### 2.1 BE Accelerated Master's Program (AMP)

The BE Accelerated MS program (AMP) provides Biosystems Engineering BS (BEBS) majors with the opportunity to leverage their undergraduate coursework into a graduate degree by enabling advanced BEBS undergraduate students to complete both the Bachelor of Science degree and the Master of Science degree (BEMS) in a total of 5 years. The AMP is designed for the top BEBS undergraduate students who plan to pursue a graduate degree in Biosystems Engineering. Biosystems Engineering majors must have a 3.30 GPA or higher to qualify for the program. AMP

students may complete up to 12 units of graduate-level coursework during the fourth year of their BEBS program. AMP students will receive credit toward their *BS and MS after completing* the course requirements with a 3.0 GPA or higher. The AMP students who chose the MS report option typically complete the remainder of the MS program requirements within one year.

## **2.2 Traditional Master of Science (2-year MS)**

A Master's degree involves advanced training gained through intensive study, beyond the bachelor's degree, in a special field (or major) supplemented by study in supporting subjects. The MS in Biosystems Engineering is designed for graduate engineers and scientists aspiring to advance their careers or prepare themselves for advanced degrees or research opportunities.

## **2.3 Doctor of Philosophy (PhD)**

Obtaining a Doctor of Philosophy (PhD) in the Biosystems department is for students seeking an intense research focus and academic contributions to either the biosystems engineering or biosystems analytics & technology disciplines. The doctoral program prepares engineers for senior responsibility in industry, research, or teaching. The successful candidate must demonstrate the ability to devise and execute a program of study and research which makes a fundamentally new contribution to the chosen field. The most important aspect of the doctoral program is the dissertation, which is the evidence of this fundamental contribution. The student should be prepared for a very demanding period of study beyond the master's degree. A minor field will also be a part of the departmental doctoral programs.

# **3.0 ADMISSION**

## **3.1 General Admission Requirements**

All candidates must apply online through the Graduate College application site at:

<https://apply.grad.arizona.edu/users/login>. Graduate Admission Requirements are listed in the Graduate Catalog and Program Descriptions: <https://grad.arizona.edu/catalog/>. The application for admission includes official transcripts from all previous colleges and universities attended, a resume (CV), three letters of recommendation, and the applicant's statement of purpose. NOTE: applications for the Accelerated Master's Program are for Fall semester admittance only. Other graduate programs can be admitted in both the fall and spring semesters.

The GPA requirements differ depending on the graduate program:

- BE AMP: GPA = 3.3
- 2-year MS: GPA = 3.0
- PhD: GPA = 3.3

Applicants are evaluated on the individual merits of their academic achievements and scholarly potential to complete graduate-level coursework and research requirements. A departmental review committee made up of faculty from the student's area of interest evaluates the candidate's application. Once the decision is made, the departmental recommendation will be transmitted to the Graduate College, and the candidate will be notified of the decision.

### **3.2 BE Admission Requirements**

To be considered for the BE MS program, the candidate must hold a Bachelor's degree in engineering or BS in a STEM field and complete required deficiency courses. To be considered for the BE PhD program, the candidate must hold a BS and/or MS degree in engineering or BS and/or MS in a STEM field and complete required deficiency courses.

### **3.3 BAT Admission Requirements**

To be considered for the BAT MS program, the candidate must hold a Bachelor's degree. To be considered for the BAT PhD program, the candidate must hold a BS and/or MS degree. Candidates with degrees from non-STEM fields may be asked to complete additional coursework.

For more details on the admission process, please see <http://grad.arizona.edu/admissions/requirements>.

### **3.4 Requirements for International Candidates**

In addition to the academic requirements for all applicants, international students must satisfy English proficiency, financial guarantee, and health insurance requirements. To demonstrate proficiency in English, refer to the Graduate College policies: <https://grad.arizona.edu/international-students>.

## **4.0 FINANCIAL SUPPORT IN THE BE DEPARTMENT**

Although there is no guarantee of funding for pursuing a graduate degree, several options are available to graduate students.

### **4.1 Graduate Research and Teaching Assistantships**

Depending on funding allocations, Graduate Research Assistantships (GRAs) and Graduate Teaching Assistantships (GTAs) 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 (0.25, 0.33, or 0.50). Graduate assistants on half-time (0.50 FTE) assistantships are expected to work 20 hours per week.

#### **4.1.1 Graduate Research Assistantships (GRAs)**

The department provides a limited number of GRAs, typically offered to incoming PhD students. Additional GRAs may be supported by an individual faculty member's research grant(s). Faculty members are responsible for identifying students to work on funded projects.

#### **4.1.2 Graduate Teaching Assistantships (GTAs)**

A limited number of 0.25 FTE (full-time equivalent) GTAs available each semester provided by the department. Students hired on GTAs need to review policies and complete training and orientations required by the Graduate College [see <https://grad.arizona.edu/funding/ga>].

### **4.2 Graduate College Thesis/Dissertation Scholarship**

International students who have completed their coursework within two years of completing their PhD degree or



two semesters of completing their MS degree may qualify for this Scholarship. This award *excludes* the mandatory registration fees and any additional tuition the individual charges. Students hired as GRA or GTA appointments do not qualify for this waiver.

To be *eligible for a Graduate College Thesis/Dissertation Scholarship*, students must be enrolled at the University of Arizona for fewer than one (1) and not more than six (6) units of 910/909/920 level units only. Generally, waivers for students enrolling in 1 unit will be approved. Students must meet all course and unit requirements and finish their Report/Thesis/Dissertation.

*International students* who qualify for the Graduate College Thesis/Dissertation Scholarship should request this scholarship through the BE Academic Program Manager at least two months before the beginning of the semester that they are eligible to apply for the scholarship. For more information on this scholarship, see <https://grad.arizona.edu/funding/opportunities/thesis-dissertation-tuition-scholarships>.

### **4.3 Hourly Graders**

The BE Department often offers hourly grader positions on a class-by-class basis. Contact either the Academic Program Manager or the Department Head for possible opportunities.

## **5.0 GENERAL ADMINISTRATION OF THE GRADUATE PROGRAM**

### **5.1 Orientations**

#### 5.1.1 Graduate School

New students and graduates hired as Graduate Assistants must attend all Graduate College orientations. Locations and times will be posted each year on the following site: <https://grad.arizona.edu/announcements>.

#### 5.1.2 Departmental

Most semesters, departmental Orientations are conducted for graduate students by the department's Director of Graduate Studies and the Academic Program Manager.

### **5.2 Registration**

Registration is accomplished using UAccess, the University's web-based course registration program (<http://www.uaccess.arizona.edu/>). Registration for the first semester in residence should be completed after meeting with the Director of Graduate Studies and the Academic Program Manager.

### **5.3 Deficiencies**

Candidates with deficiencies identified in the communications from the Academic Program Manager must complete the required coursework satisfactorily before completing their graduate degree program.

If a student disagrees with the written statement of deficiencies given at the time of admission, they should contact the Academic Program Manager to file a petition for a review of the deficiencies and previous coursework completed.

## **5.4 Continuous Enrollment Policy for Domestic Students**

To be considered full-time, domestic graduate students must enroll in 3 units per semester. Students who cannot enroll in the fall or spring semester need to submit a Leave of Absence form. 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 readmission by the Associate Dean of Academic Programs.

### **5.4.1 Summer Enrollment**

MS and PhD students who plan to defend their Report/Thesis/Dissertation and have completed their required coursework are not required to enroll in a Summer Session.

### **5.4.2 International Students**

International students need to follow their individual visa enrollment requirements. For more information regarding the University of Arizona's international graduate student enrollment policies, see <https://global.arizona.edu/international-students>.

### **5.4.3 Graduate Assistantships**

Students who are supported by or through The University of Arizona via assistantships as a Graduate Teaching Assistant (GTA) or Graduate Research Assistant (GRA) are expected to enroll in at least six-nine units per semester, depending on the funding source (refer to notice of appointment). Individual Colleges may set their own GTA/GRA enrollment requirements. For more information on enrollment requirements for students on assistantships, see <https://grad.arizona.edu/funding/ga>.

Graduate students hired on an assistantship through the College of Agriculture & Life Sciences must be enrolled in at least nine units per College requirements.

Those students holding a Graduate Teaching Assistantship must be evaluated by their instructor at the end of each semester.

### **5.4.4 Graduate Scholarships**

Students who have been awarded Graduate Registration Scholarships or Graduate Tuition Scholarships are required to be enrolled as full-time student per Graduate College policies. For more information, see <http://grad.arizona.edu/funding/opportunities>.

## **5.5 Graduate Committee Meetings**

Students are expected to meet with their committee members at least once a semester. The purpose of the meeting is to have the overall committee review the student's academic progress.

## **5.6 Leave of Absence Policy**

Students do not need to apply for a Leave of Absence (LOA) if they have a registration record for that semester. A "W" counts as a registration record. An LOA is inappropriate for a student who withdraws from all classes after the start of a semester and receives "W" grades since a Leave of Absence presupposes no registration at all for a term. Since, in such cases, the student has maintained continuous enrollment by having a registration record, they are eligible to register the following semester (or Summer or Winter term). Students suffer no adverse effects because they were not eligible to apply formally for a Leave of Absence. An LOA may affect the status of a graduate student's financial aid. Only academic services or facilities available to the general public can be used during the LOA. Students

are responsible for determining the requirements of their funding agency and/or academic unit before applying for a Leave of Absence.

International students must check with the International Students Programs and Services before filing for a Leave of Absence.

If a student fails to register and does not have a Leave of Absence on file, the student will be discontinued from their program. A new application will be necessary for the student to continue the program. Re-admission is not guaranteed. See Continuous Enrollment and Re-admission Policies for more information [<http://grad.arizona.edu/policies/enrollment-policies/leave-absence>].

## **5.7 Enrollment in Departmental Graduate Seminar (BE 596A/B)**

BE 596A and 596B are combined for a single departmental graduate seminar course. It is intended to enhance graduate student development through the exchange of scholarly information through the combination of graduate-student research presentations, guest presentations, discussion, reports, and/or papers. There is an expectation that all graduate students will participate in either BE 596A or 596B continuously throughout their graduate program.

### **5.7.1 BE 596A (Presenting Class)**

MS students must enroll in two (2) units, and PhD students must enroll in four (4) units during their graduate program. These units will be included in the student's plan of study. Students enrolled in BE 596A class must give a presentation on their research/project to the class and the course assignments to receive credit. PhD students who have proof that they have made a presentation in another institution may petition and receive a waiver for the number of units required. Grades available are A, B, C, D, E, I, W.

### **5.7.2 BE 596B (Non-presenting Class)**

MS and PhD students are required to enroll in (2) units of 596B. These units will be included in the student's plan of study. Students enrolled in the 596B section are expected to coordinate and preside over the seminar presentations and the course assignments to receive a passing grade. Grades available are S, P, F, I, W.

Students who have completed their 596A/B credit requirements will be enrolled in 596B as a guest in the D2L system. To remain in good standing in the program, these students must complete the graduate program assignments posted in D2L and are encouraged to attend the weekly seminar.

### **5.7.3 International Students on a Thesis/Dissertation Scholarship Award**

International students on a Thesis or Dissertation Scholarship Award are waived from the enrollment requirement for 596A. However, these students are required to attend the course and meet all other requirements.

## **5.8 UAccess GradPath**

Graduate Students must use GradPath [<http://uaccess.arizona.edu/>], the Graduate College's degree audit system. Students can access GradPath through their UAccessStudent accounts. Students are expected to complete their Graduate College degree certification forms through GradPath. Once a student completes the required form in GradPath, the form automatically routes to everyone who needs to see or approve the form. The BE Academic Program Manager can assist with this process.

## **5.9 UAccess GradPath Forms**

Each of the following steps requires completion and should be taken at the appropriate time during the student's tenure in the department. To keep on schedule for graduation, please refer to the dates and deadlines posted on <http://grad.arizona.edu/gsas/degree-requirements/important-degree-dates-and-deadlines>. The appropriate student forms may be accessed through UAccess [<http://uaccess.arizona.edu/>].

### **5.9.1 Responsible Conduct of Research Statement**

Students must complete the Responsible Conduct training in the UAccess Gradpath forms to gain access to the Plan of Study (POS), Committee Appointment, and other required forms.

### **5.9.2 Plan of Study (POS) Form**

In conjunction with their major professor, each student is responsible for developing and submitting a Plan of Study (POS) during their semester in residence. Before creating the POS, students should read the Graduate College's requirements at <http://grad.arizona.edu/gsas/degree-requirements>. For further information on the POS, MS students should see section 6.4, and the PhD students should see section 7.8.

### **5.9.3 Committee Appointment Form**

Students should complete their Committee Appointment Form in GradPath 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, and the title of their Thesis/Dissertation. For more information on submitting and archiving your thesis/dissertation, please refer to <https://grad.arizona.edu/gsas/degree-requirements/masters-degrees#thesis-committee>.

### **5.9.4 Degree (MS, AMP, PhD) Completion Form**

The Academic Program Manager completes this GradPath form after receiving the Final Oral Defense (Examination) results from the Major Professor (Committee Chair). For more information, please refer to <http://grad.arizona.edu/gsas/degree-requirements>.

## **5.10 Graduate Student Academic Progress Reports**

All departmental graduate students must submit a Graduate Student Academic Progress Report (Progress Report) as Graduate College Requirement annually. The Director of Graduate Studies will review Progress Reports for completion. The department offers a Progress Checklist that helps you to identify milestones and deadlines. Both forms are on the Graduate Programs D2L support site.

## **5.11 Enrollment in Multiple Graduate Degree Programs**

University of Arizona students may pursue simultaneous multiple graduate degrees. This process is controlled by the Graduate College. Students must go through the UA Graduate College application system and meet all admission requirements for any additional graduate program. Please refer to the Program Description Guide on the Graduate College website for future students <https://grad.arizona.edu/futurestudents/>.

## **5.12 Thesis/Dissertation Publication Requirements**

All MS thesis options and PhD candidates must submit papers or receive committee approval meeting the standard for publication in a refereed scientific or engineering journal by the time of their Final Oral Defense. Details about the Thesis and Dissertation paper submission requirements and forms can be found in Appendix B.

## **5.13 Archiving the Thesis/Dissertation**

A student who is completing a thesis/dissertation (with enrollment in course number 910 or 920) is required to archive their thesis/dissertation upon final approval of their graduate committee. The thesis/dissertation will be added to the University of Arizona Campus Repository and the national archive of theses/dissertations and maintained by ProQuest/UMI. There is no charge to the student for archiving the thesis/dissertation. The thesis/dissertation must have been successfully defended and approved by the candidate's committee, with all final edits completed in time for the student to submit it online for archiving by the graduation deadline for the student's graduation term.

## **5.14 Commencement**

The University of Arizona, the College of Agriculture and Life Sciences, the College of Engineering, and the Department of Biosystems Engineering all celebrate graduate degree completion.

### **5.14.1 University Commencement**

The University of Arizona holds its commencement once a year in May. UA Commencement information can be found at <http://grad.arizona.edu/gsas/commencement>. The diploma will be mailed to the address you have listed on the UAccess 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.

### **5.14.2 College of Agriculture & Life Sciences (CALs)**

The College of Agriculture and Life Sciences has hooding ceremonies twice a year, at the end of each academic semester. BAT and BE Graduate students will be expected to select a Faculty Member to perform the Hooding ceremony.

### **5.14.3 College of Engineering (COE)**

The College of Engineering holds a commencement/hooding ceremony at the end of the fall semester. BE Graduate students can attend both this ceremony and the CALs hooding ceremony. BE Graduate students will be expected to select a Faculty Member to perform the Hooding ceremony.

### **5.14.4 Biosystems Engineering Department**

The BE department holds a pre-commencement reception/dinner twice a year -- at the end of each academic semester. Students completing degree requirements in August can attend either the May or December pre-commencement events. Students not completing all graduation requirements, but are close, may attend one pre-commencement reception/dinner of their choosing.

## **5.15 International Student Resources**

International students must familiarize themselves with the Office of Global Initiatives for International Students [see <http://global.arizona.edu/>] and review the Student Resource Manual at <http://global.arizona.edu/international-students/student-resource-manual>.

International students should check with the Office of International Student Programs to confirm requirements for compliance with their visa status requirements since they may be required to be enrolled in additional units to maintain full-time student status. Students should also check their I-20 expiration date and, if necessary, begin the renewal process. Students need to give themselves plenty of time to maintain their status. The process may take up to 6 months or more.

## 5.16 Graduate Student Learning Outcomes Assessment

### 5.16.1. Expected Learning Outcomes

#### 5.16.1.1 Masters of Science

By the completion of the Graduate program, master's students in the Biosystems Engineering Department will:

1. demonstrate knowledge of their focus area in the department,
2. critically analyze published research results in their focus area in the department,
3. conduct research on their focus area, and
4. demonstrate effective communication skills and defend the results of research to peers and broader scientific audiences.

#### 5.16.1.2 Doctor of Philosophy

By the completion of the Graduate program, Doctoral students in the Biosystems Engineering Department will:

1. demonstrate a broad knowledge of their focus area in the department,
2. critically evaluate published research results in their focus area in the department,
3. produce and conduct original research on their focus area,
4. add to the body of knowledge of their discipline, and
5. effectively communicate and defend the results of research to peers and broader scientific audiences.

### 5.16.2. Assessment Activities

Assessments will be conducted throughout the graduate student's tenure in the BE Department, as shown in Tables 1 and 2. Common to all graduate programs in the BE department are the requirements of graduate seminar presentations, the oral defense of the research or creative activity, and the written exit survey. In addition to these common elements, the BE and BAT PhD programs require students to complete a comprehensive exam based on coursework and knowledge of their focus area. These already-existing assessment activities are also used to gather program-level assessment data. Appendix F has the rubrics for the assessments found in Tables 1 and 2.

Table 1. Graduate program assessments for Masters students.

| Assessment Activities                                 | Outcome 1:<br>Knowledge of<br>the Focus<br>Area | Outcome 2: Critical<br>Analysis of Research<br>in the Focus Area | Outcome 3:<br>Conduct<br>Research | Outcome 4:<br>Communicate<br>and/or Defend<br>Research |
|---|---|--|-----------------------------------|--|
| BE 501, Research Methods in<br>Biosystems Engineering | X   |  |                                   | X  |
| Graduate Seminar Presentations<br>(BE 596A)           |   | X  |                                   | X  |
| Oral Defense of the<br>Report/Thesis <sup>1</sup>     | X   | X  | X                                 | X  |
| Written Exit Survey                                   | X   | X  | X                                 | X  |
| <sup>1</sup> For example of rubric, see Appendix F    |   |  |                                   |  |

Table 2. Graduate program assessments for Doctoral students.

| Assessment Activities  | Outcome 1:<br>Broad Knowledge of the Focus | Outcome 2:<br>Critical Evaluation of Research in the Focus Area | Outcome 3:<br>Conduct Original Research | Outcome 4:<br>Add to Body of Knowledge | Outcome 5:<br>Communicate and/or Defend |
|--|--|---|---|--|---|
| BE 501, Research Methods in Biosystems Engineering                     | X  |   |   |  | X                                       |
| Graduate Seminar Presentations (BE 596A)                               |  | X   |   | X                                      | X                                       |
| Oral Comprehensive Exam <sup>1</sup>                                   | X  |   |   |  |   |
| Oral Defense of the Report/Thesis/Dissertation <sup>1</sup>            | X  | X   | X                                       |  | X                                       |
| Submit Manuscript to a Peer-reviewed Journal or Conference Proceedings |  |   |   | X                                      |   |
| Written Exit Survey  | X  | X   | X                                       |  | X                                       |

<sup>1</sup>For example of rubric, see Appendix F

## 6.0 MASTER'S OF SCIENCE (MS) DEGREE IN THE BIOSYSTEMS ENGINEERING DEPARTMENT

The Biosystems Engineering Department offers three Master of Science degree programs: Accelerated Masters (AMP) in Biosystems Engineering and two Traditional Masters (2-year MS) in Biosystems Engineering and Biosystems Analytics & Technology. This section summarizes the requirements and steps for completing the AMP or the 2-year MS program. Students in both the AMP and the 2-year MS programs are responsible for knowing the departmental program and Graduate College requirements. Students also need to review the Graduate College Policies and Procedures at <http://grad.arizona.edu/policies> and the degree requirements for Master's degrees at <https://grad.arizona.edu/catalog/>. The requirements for Master's Degrees on the Graduate College website (<http://grad.arizona.edu/gsas/degree-requirements>) provide additional details. Students in the BEAMP and 2-year BEMS programs may choose either the thesis or graduate report option to complete their degree requirements. NOTE: Students must apply to the BEMS in their second semester of the BEBS AMP graduate program. Once the BS degree is awarded, the AMP student will be considered a BE MS graduate student. Graduate Units taken in the BEBS will be transferred into the BE MS program. The checklist for completing the steps toward the degree is located in Appendix C.

## 6.1 Credit Requirements

### 6.1.1 BE AMP

Students enrolled in the BEAMP must maintain a 3.0 GPA in the program to be able to register for courses. A student whose GPA falls below 3.0 will not be permitted to register for additional courses. See Graduate College Policies online at <https://grad.arizona.edu/admissions/requirements>. AMP students are required to complete the [Undergraduate Enrollment form](#) during their final year of their BS program to receive permission to enroll in their 500-level coursework.

BEBSAMP students must complete a minimum of 30 units consisting of the following:

- 1 unit BE 597A (Effective 08-2020; for prior catalogs, can be substituted with 1 unit or BE 593 or Elective course) – NOTE: this will be a technical elective for your BS Advisement Report
- 2 units of BE 596A (presenting)
  - MS students not presenting in a particular semester will register for BE 596B
  - NOTE: 1 unit will be a technical elective for your BS Advisement Report
- 2 units of BE 596B (non-presenting)
  - Students must receive approval from the Department to be excused from this requirement
  - Continuous enrollment in either BE 596A or 596B is expected. Any units exceeding the 2 units of BE 596B will not be listed on your Plan of Study.
  - NOTE: 1 unit of BE 596B will be a technical elective for your BS Advisement Report
- 2 units of BE 501 – NOTE: this will be a technical elective for your BS Advisement Report
- 3 units STAT 571B
- 3 units ENV5 508 – NOTE: this course satisfies the technical writing requirement on your BS Advisement Report
- 9 units of BE courses (limit of 3 units of house-numbered courses, i.e., 592, 593, 599)
- 3 units of an Elective course (per Major Professor's approval)
  - May choose 1-unit lab rotation (BE 593) as an elective
- 5 units of either BE 910 Thesis (thesis option) or BE 909 Graduate Report (non-thesis option) under their Major Professor's section number

All coursework must be in courses graded A, B, or C except for house-numbered courses, i.e., 592, 593, 599.

NOTE: AMP students may not take more than 12 units of graduate course work while in their senior year of the AMP.

### 6.1.2 Traditional BAT MS

For an MS in Biosystems Analytics & Technology, students must complete a minimum of 30 units consisting of the following:

- 1 unit BE 597A (Effective 08-2020; for prior catalogs, can be substituted with 1 unit or BE 593 or Elective course)
- 2 units of BE 501
- 2 units of BE 596A (presenting)
  - MS students not presenting in a particular semester will register for BE 596B
- 2 units of 596B (non-presenting)
  - Students must receive approval from the Department to be excused from this requirement.
  - Continuous enrollment in either BE 596A or 596B is expected. Any units exceeding the 2 units of BE 596B will not be listed on the student's UAccess Plan of Study.
- 3 units BE 513
- 3 units BE 534
- 3 units STAT 571B



- 3 units ENVS 508
- 6 units of elective courses (per Major Professor's approval)
  - May choose to complete a 1-unit lab rotation experience (BE 593) as an elective
- 5 units of either BE 910 Thesis (thesis option) or BE 909 Graduate Report (non-thesis option) under their Major Professor's section number

All courses in the Plan of Study must be taken for a grade (A, B, C) except for BE 596B (S, P, F) and the optional 1-unit lab rotation (BE 593). To complete degree requirements, the cumulative GPA in graduate-level courses must be 3.0. A student whose GPA falls below 3.0 will not be permitted to register for additional courses. See Graduate College Policies online at <https://grad.arizona.edu/admissions/requirements>.

### 6.1.3 Traditional BE MS

For an MS in Biosystems Engineering, students must complete a minimum of 30 units consisting of the following:

- 1 unit BE 597A (Effective 08-2020; for prior catalogs, can be substituted with 1 unit of BE 593 or Elective course)
- 2 units of BE 501
- 2 units of BE 596A (presenting)
  - MS students not presenting in a particular semester will register for BE 596B
- 2 units of 596B (non-presenting)
  - Students must receive approval from the Department to be excused from this requirement.
  - Continuous enrollment in either BE 596A or 596B is expected. Any units exceeding the 2 units of BE 596B will not be listed on the student's UAccess Plan of Study.
- 3 units STAT 571B
- 3 units ENVS 508
- 9 units of BE courses (limit of 3 units of house-numbered courses, i.e., 592, 593, 599)
- 3 units of elective courses (per Major Professor's approval)
  - may choose a 1-unit lab rotation experience (BE 593) as an elective
- 5 units of either BE 910 Thesis (thesis option) or BE 909 Graduate Report (non-thesis option) under their Major Professor's section number

All courses in the Plan of Study must be taken for a grade (A, B, C) except for BE 596B (S, P, F) and the optional 1-unit lab rotation (BE 593). To complete degree requirements, the cumulative GPA in graduate-level courses must be 3.0. A student whose GPA falls below 3.0 will not be permitted to register for additional courses. See Graduate College Policies online at <https://grad.arizona.edu/admissions/requirements>.

## 6.2 Time Limitation

All requirements for the master's degree must be completed within six (6) years. Time-to-degree begins with the earliest course to be applied toward the degree, including credits transferred from other institutions. Coursework more than six (6) years old are not accepted toward meeting degree requirements:

<http://grad.arizona.edu/gsas/degree-requirements/masters-degrees#time-limitation>.

## 6.3 Transfer Credit

Transfer credits may apply towards the BE MS degree. Students who wish to have Transfer units apply towards their BE degree must communicate with the Academic Program Manager with the desired substitutions and may be required to provide course descriptions and/or syllabi. The Graduate Program Committee will review the requested substitutions and determine if the transfer course(s) are equivalent. The course may be listed on the Plan of Study (POS) if approval is granted. More information on Graduate College Transfer Credit policies is found at

<http://grad.arizona.edu/academics/program-requirements/masters-degrees> or by contacting the BE Academic Program Manager and/or their Graduate College Degree Auditor. Up to six (6) units for a master's degree may be transferred from other accredited institutions. The minimum grade for transferred graduate-level credits must be an A or B or the equivalent at the institution where the course was taken. The transfer grades are not included in the student's UA GPA.

## 6.4 Master's Plan of Study (POS) Form

In conjunction with the Major Professor, each student is responsible for developing a Plan of Study (POS) by the end of their first semester. The Plan is to be filed in GradPath no later than the end of the first semester in residence. The Plan of Study identifies:

1. Courses already completed and planned at The University of Arizona, which the student intends to apply toward the graduate degree and
2. Approved Transfer courses.

The student should receive approval from the entire Thesis/Report Committee before submitting their Plan of Study into the GradPath. The Plan of Study must have the approval of the Academic Program Manager, the Major Professor, the Minor Advisor, the BE Director of Graduate Studies, and the Graduate College. For more information on the plan of study, please refer to <http://grad.arizona.edu/gsas/degree-requirements/masters-degrees#plan-of-study>.

## 6.5 MS Major Professor

In the first few weeks after joining the program, students need to meet with the BE Director of Graduate Studies to discuss options and procedures for choosing a Major Professor. A permanent Major Professor must be selected by the *end of the first semester of study*. The candidate's Major Professor should specialize in the student's main field of interest. The primary role of the Major Professor is to guide the student in coursework and to keep the student informed on whether they are making satisfactory progress. The Major Professor will act as the student's mentor, be responsible for *helping* the student select their MS/ PhD Committee members and serve as the Graduate Committee chair, and develop a Plan of Study in collaboration with the Graduate Committee. The Major Professor is responsible for meeting with the student a minimum of once per semester to review the student's progress.

The primary responsibilities of a Major Professor include the following:

1. Be a source of academic information for their graduate student(s)
2. Provide assistance with details in determining the plan of study
3. Be proficient in inputting, managing, and approving forms in GradPath as needed to assure smooth progression to the final degree
4. Act as the student's Graduate Committee Chair
5. Provide regular, timely input to their students to determine academic progress.

### 6.5.1 Faculty Eligible to Serve as the MS Major Professor

The Major Professor must be a member of the Biosystems Engineering Graduate Faculty (see Appendix D). A Graduate Faculty member from other programs/departments may not serve as the sole major professor, but may serve as a co-chair/co-major professor.

## 6.6 MS Graduate Committee

Each graduate student will form a graduate committee. The Master's Graduate Committee approves the program of study and the master's thesis/report and assesses the Final Oral Defense and report/thesis for awarding the Master's degree.

The responsibilities of the graduate committee are to:

1. mentor their graduate students in their research and research practices
2. assist in choosing classes to build skills and knowledge
3. approve their graduate students' plans of study
4. meet with the graduate student at least yearly, preferably more often
5. review and approve their graduate student's progress reports
6. attend the final oral defense
7. assess student progress and measure ability to meet program objectives

### 6.6.1 Faculty Eligible to Serve on the MS Graduate Committee

Master's Committee must consist of three members. At least two committee members must be a member of the Biosystems Engineering Graduate Faculty. The third member can be another BE faculty or a Graduate Faculty member from another program/department. If the third member is not a member of a Graduate Faculty, they must be approved by the Graduate College to serve as a Special Member. Special member requests are initiated by the Academic Program Manager and approved by Graduate College [<https://grad.arizona.edu/forms/gsas/special-member-request>]. Please contact the Academic Program Manager to process the Special Member request. Appendix D states the criteria for departmental Graduate Faculty for both MS programs in the department as well as a list of the members of the Biosystems Engineering Graduate Faculty.

## 6.7 MS Thesis/Graduate Report Requirements

The thesis option is the typical and traditional option to articulate the findings of the master's research. This option is valuable to demonstrate the student's ability to express, in writing, their work is the precursor for the dissertation; and may initiate the student's publishing record.

Students may choose the graduate report option when:

- When the research project is not funded
- When the research is limited in scope
- When the research is not publishable work, but the industry would/could value the information
- When the research is related to a project at their work

Depending on the scope of the project, the major professor or graduate committee may require the thesis route. Students must complete the thesis option to receive a Graduate Assistantship (GA) or tuition waivers.

Once the Plan of Study has been submitted (and the thesis/report option is declared), the student is expected to complete the chosen option. NOTE: this option is declared in GradPath, so AMP students cannot declare their option until they apply to the Graduate College.

### 6.7.1 Thesis Option

Students are required to

1. submit a minimum of one paper for publication;
2. receive approval for submission to a refereed journal from their Committee and Major Professor; and
3. be listed as the first author in at least one paper approved for submission.

Copies of sample Thesis papers are available online through the University Libraries at <https://libguides.library.arizona.edu/type/theses>.

### 6.7.2 Graduate Report Option

Students must submit a graduate report to their committee following the format required by the department. Typically, if the student is conducting experimental research, they will use the thesis option format minus the paper requirement.

## 6.8 Research Proposal

The Research Proposal is the general research plan that the candidate will pursue to obtain their master's degree and is of sufficient academic merit on a topic that satisfies their Thesis Committee. The candidate is encouraged to include the title of their Research Proposal in their Plan of Study. A draft of the Research Proposal will be completed by the completion of BE 501 (as a course requirement). The final Research Proposal will be completed by the end of the 2<sup>nd</sup> semester in the program and submitted to the Academic Program Manager. The Research Proposal will include the selected option: thesis or report.

## 6.9 Final Oral Defense/Examination

### 6.9.1 Dates and Deadlines

NOTE: All students should refer to the Graduate College Dates and Deadlines website before beginning the following steps: <https://grad.arizona.edu/gsas/degree-requirements/important-degree-dates-and-deadlines>. Scheduling the Final Oral Defense and satisfying all the requirements relating to Final Oral Defense is the sole responsibility of the student.

### 6.9.2 MS Thesis/Report Defense Process

The following lists the steps needed to complete the Master's Thesis or Report Defense. See the Biosystems Graduate Programs D2L site for the Progress Checklist (an Excel spreadsheet) and Steps to Defense.:

1. Upon completion of the research work, the student writes their thesis/report and presents to their graduate committee a draft of the thesis/report one month before the proposed defense date, recognizing that the defense date needs to be at least one week before the deadline set for final submission to the graduate college of the semester the student plans to graduate.
2. It is recommended that students also submit their departmental thesis/dissertation paper form indicating that the paper is ready for submission. Remember, MS candidates need to submit at least one paper (and is usually physically part of the thesis).
3. One week after the submission of the draft, the student meets with their committee to present their work to the committee.
4. At the meeting, the committee decides whether the student is ready to defend their work based on the presentation and draft thesis/report.
5. If the committee agrees that the student is ready to defend their thesis/report/, they signify this by signing the departmental Defense Approval Form (see Appendix E, BE Graduate Program D2L site or website). Upload the completed, signed form to the appropriate assignment folder in D2L.
6. If the committee determines that the student is not ready to defend, the Committee Chair and student will then send an email notice with the new "Program Completion Date (Graduation Term)" to the

Academic Program Manager, the BE Director of Graduate Studies, and Graduate College Degree Check Advisor.

7. Once the candidate is approved to defend, the student submits the signed copy of the Defense Approval Form to the appropriate assignment folder in D2L within 24 hours of approval by the committee.
8. Students need to be aware of the submission date for the final approved thesis for archiving before they set their final defense date. Refer to the Dates and Deadlines for their graduation term posted on Graduate Website: <https://grad.arizona.edu/gsas/degree-requirements/important-degree-dates-and-deadlines>.
9. If a committee member is absent from the committee meeting, then it is the student's responsibility to meet with that committee member(s) individually and have them sign the Defense Approval Form.
10. Upon receiving the signed Defense Approval Form from the candidate, the Academic Program Manager will notify the BE Director of Graduate Studies via GradPath. The student may then set the defense date a minimum of two weeks after consultation with the committee members.
11. The Academic Program Manager will have the necessary paperwork sent to the Graduate College and to the department faculty, students, and staff with the date and location of the defense.
12. The candidate is responsible for posting the announcement of their defense (at least one week before the defense) with the title, date, and location in the appropriate buildings. Announcement template available in D2L Graduate Programs Student Support site >> Content >> Forms.

The Major Professor (Graduate Committee Chair) presides over the defense examination. Each of the Thesis/Report Committee members must receive a copy of the thesis/project report approved by the student's Academic Advisor (not necessarily library-ready copies) at *least two weeks prior to the oral examination*.

The examination may last over two hours but cannot be more than three hours and is composed of two parts:

1. **Public presentation.** During the first part (about 30-45 minutes), the student gives an oral presentation of the thesis/project report in an open seminar. The presentation may be interrupted to permit questions to clarify points and questions concerning fundamental principles that are directly related to the thesis/project report.
2. **Committee Assessment.** The second part of the examination consists of a closed-to-the-public questioning by the thesis/report committee members on the student's knowledge of the discipline and their research project.

Please refer to the Graduate College's website for the Final Oral Examination Instructions: [https://grad.arizona.edu/forms/sites/default/files/uagc\\_page/finaldefenseinstructions.pdf](https://grad.arizona.edu/forms/sites/default/files/uagc_page/finaldefenseinstructions.pdf).

Members of the committee must be present for the entire examination. Per Graduate College policies, a member may participate in the Defense remotely (e.g., Zoom, Skype, or GoToMeeting). If a member cannot participate in person or remotely, the student will need to find another tenured, tenure-track, or continuing-appointment committee member and update their Committee Appointment form.

### 6.9.3 Reporting Final Oral Defense (Examination) Results

After the Defense:

1. The student's Graduate Committee will determine if the student passed, passed with revisions, or failed the exam.
2. The Major Professor (Committee Chair) will submit the results to the Academic Program Manager via email. Results must be reported to the Graduate College before the date on which the degree is to be conferred; specific deadlines from the Graduate College are posted online at <https://grad.arizona.edu/gsas/degree-requirements/important-degree-dates-and-deadlines>.

3. The Major Professor collects their completed Graduate Report/Thesis/Dissertation Oral Defense Evaluation Form from each committee member and submits the completed forms to the Academic Program Manager. These forms are used to assess all four of our student outcomes.
4. If the candidate **passed the final oral defense *without* revisions**, the student may proceed with the submission process.
  - The BE Academic Program Manager records the results of the MS defense in UAccess after receiving confirmation from the Major Professor.
  - The Major Professor (Committee Chair) submits a Change of Grade Form in UAccess Instructor.
  - The candidate then submits the approved thesis/report electronically to the Graduate College. For further details, refer to the Dissertation/Thesis Submission [<http://dissertations.umi.com/arizona/>]. NOTE: Students who completed the MS Report option are not required to submit their final report in the ProQuest system.
  - The candidate is required to provide electronic copies of the final thesis/report to the Major Professor, Committee members, and the Department. The candidate is advised to check with their Major Professor for any special requirements.
5. If the candidate **passed the final oral defense *with* revisions**, the following steps need to be taken:
  - The Graduate Committee must determine the date the student needs to resubmit the corrections to the committee.
  - The Major Professor (Committee Chair) is responsible for ensuring that the student makes the committee's recommendations and notifying the Academic Program Manager that the revisions are completed and the student has met the degree requirements. The Chair needs to submit a Change of Grade Form.
  - The Department Academic Program Manager records the results of the MS defense in UAccess after receiving confirmation from the Major Professor
  - The candidate then submits the approved thesis/report electronically to the Graduate College. Students need to refer to the Dissertation/Thesis Submission process [<http://dissertations.umi.com/arizona/>]. NOTE: Students who completed the MS Report option are not required to submit their final report in the ProQuest system.
  - The candidate is required to provide electronic copies of the final thesis/report to the Major Professor, Committee members, and the Department. The candidate is advised to check with their Major Professor for any special requirements.
6. If the candidate **fails the final oral defense**, the candidate may be granted a second examination upon the recommendation of the major department. The result of the second examination is final.

## 7.0 Doctor of Philosophy (PhD) Degree in Biosystems Engineering and Biosystems Analytics & Technology

Attainment of a Doctor of Philosophy (PhD) degree at The University of Arizona requires outstanding scholarship and demonstrated distinguished research leading to a dissertation that contributes significantly to the general pool of knowledge in the discipline. This section describes the requirements for completing the PhD degree within the Biosystems Engineering Department.

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

### 7.1 Pursuing PhD after MS at the University of Arizona

For both PhD programs, the department requires a minimum GPA of 3.3 in the student's MS program. A student may use a maximum of 25 credits from their UA Biosystems Analytics & Technology or UA Biosystems Engineering master's degree(s) towards their doctorate program. More information may be found at <https://grad.arizona.edu/gsas/degree-requirements/doctor-philosophy#credit-requirements>.

## 7.2 Major Professor

In the first few weeks after joining the program, students need to meet with the BE Director of Graduate Studies to discuss options and procedures for choosing a Major Professor. A permanent Major Professor must be selected by the *end of the first semester of study*. The candidate's Major Professor should specialize in the student's main field of interest. The primary role of the Major Professor is to guide the student in coursework and to keep the student informed on whether they are making satisfactory progress. The Major Professor will act as the student's mentor, be responsible for *helping* the student select their MS/ PhD Committee members and serve as the Graduate Committee chair, and develop a Plan of Study in collaboration with the Graduate Committee. The Major Professor is responsible for meeting with the student a minimum of once per semester to review the student's progress.

The primary responsibilities of a Major Professor include the following:

1. Be a source of academic information for their graduate student(s)
2. Provide assistance with details in determining the plan of study
3. Be proficient in inputting, managing, and approving forms in GradPath as needed to assure smooth progression to the final degree
4. Act as the student's Graduate Committee Chair
7. Provide regular, timely input to their students to determine academic progress.

### 7.2.1 Faculty Eligible to Serve as the PhD Major Professor

The Major Professor must be a member of the Biosystems Engineering Graduate Faculty. A list of faculty who can serve on doctoral committees as sole graduate doctoral committee chairs can be found in Appendix D. No other faculty can serve as the sole chair of a doctoral committee. Faculty not meeting the endorsement criteria as set in Appendix D will need a co-chair that does meet the endorsement criteria as set in Appendix D.

NOTE: The Academic Program Manager will serve as the Administrative Advisor. The Administrative Advisor will assist the candidate with all graduate forms, entering information into GradPath, checking procedures, and other administrative activities.

## 7.3 PhD Graduate Committee

The PhD Graduate Committee approves the Doctoral Degree Plan of Study and constitutes the committee for the Final Oral Defense of the doctoral dissertation. They may also constitute the Comprehensive Examining Committee. Since the Dissertation Committee plays such a central role in the doctoral program, it should be formed soon after the selection of the major professor.

The responsibilities of the graduate committee are to:

1. mentor their graduate students in their research and research practices
2. assist in choosing classes to build skills and knowledge
3. approve their graduate students' plans of study
4. meet with the graduate student at least yearly, preferably more often

5. review and approve their graduate student's progress reports
6. attend the final oral defense
7. assess student progress and measure ability to meet program objectives

### 7.3.1 Faculty Eligible to Serve on the PhD Graduate Committee

The PhD Graduate Committee consists of at least three faculty members who represent the major subject area and one or more faculty members who represent the minor subject area. A minimum of two major-subject-area faculty must be from the Biosystems Engineering Graduate Faculty; the third major-subject-area faculty member may be from inside or outside the department. The Graduate College requires a minimum of three members, all of whom must be a member of a Graduate Faculty or be approved as equivalent. Appendix D states the criteria for departmental Graduate Faculty for both graduate programs in the department and the list of the members of the Biosystems Engineering Graduate Faculty. If a student desires a committee member who is an expert in their field but who not a member of a Graduate Faculty, the student may request a that expert to be admitted as a Special Member. Please contact the Academic Programs Manager to process the Special Member request [<https://grad.arizona.edu/forms/gsas/special-member-request>].

## 7.4 Credit Requirements for PhD

For a PhD in Biosystems Engineering, a candidate must complete 63 units (minimum) consisting of 45 non-Dissertation units and 18 Dissertation (BE 920) units. All required units of credit must be at the 500-level or above at The University of Arizona or, in the case of transfer units, their equivalent at other institutions.

### 7.4.1 Minimum Course Requirements for BAT PhD

For a PhD in Biosystems Analytics & Technology, students must complete a minimum of 63 units, consisting of the following:

- 1 unit BE 597A (Effective 08-2020; for prior catalogs, can be substituted with 1 unit or BE 593 or Elective course)
- 1 unit of BE 693 (section # under faculty sponsor)
- 2 units of BE 501
- 3 units of BE 513
- 3 units of BE 534
- 3 units of STAT 571B
- 3 units of ENVS 508
- 4 units of BE 596A (presenting)
  - Any units exceeding the 4 units of BE 596A will not be listed on the student's Plan of Study
  - EXCEPTION: Candidates with a BAT MS degree are only required to take 2 units because the other 2 units were earned from their MS program
- 4 units of 596B (non-presenting)
  - Continuous enrollment in BE 596B for each semester they are not presenting is expected. Students must receive approval from the Department to be excused from this requirement
  - Any units exceeding the 2 units of BE 596B will not be listed on the student's UAccess Plan of Study
- 9-12 units of elective courses per approval of Major Professor (depending on the required minor units)
  - may choose a 1-unit lab rotation experience (BE 593) as an elective
- 18 units (minimum) of Dissertation units (BE 920)
- 9-12 units in the minor, depending on the Minor Department requirements

### 7.4.2 Minimum Course Requirements for BE PhD



For a PhD in Biosystems Engineering, students must complete a minimum of 63 units, consisting of the following:

- 1 unit BE 597A (Effective 08-2020; for prior catalogs, can be substituted with 1 unit or BE 593 or Elective course)
- 1 unit of BE 693 (section # under faculty sponsor)
- 2 units of BE 501
- 3 units of STAT 571B
- 3 units of ENVS 508
- 4 units of BE 596A (presenting)
  - Any units exceeding the 4 units of BE 596A will not be listed on the student's Plan of Study
  - EXCEPTION: Candidates with a BE MS degree are only required to take 2 units as the other 2 units were earned from their MS program
- 4 units of BE 596B (non-presenting)
  - Continuous enrollment in BE 596B for each semester they are not presenting is expected. Students must receive approval from the Department to be excused from this requirement
  - Any units exceeding the 2 units of BE 596B will not be listed on the student's UAccess Plan of Study
- 6 units of either Numerical Analysis or other approved Mathematics/Statistics/Modeling courses
- 9 units of BE courses (limit of 3 units of house-numbered courses, i.e., 592, 593, 599)
  - may choose a 1-unit lab rotation experience (BE 593) as an elective
- 0 to 3 units of elective courses per approval of Major Professor (depending on the required minor units)
  - may choose a 1-unit lab rotation experience (BE 593) as an elective
- 18 units (minimum) of Dissertation units (BE 920)
- 9 to 12 units in the minor, depending on the Minor Department requirements

All courses in the Plan of Study must be taken for a grade (A, B, C) except for BE 693 (Teaching Internship) and 1 unit of lab rotation (BE 593).

## 7.5 Transfer Credit

Graduate credit earned at other approved institutions, if accepted by the department and the Graduate College, may be counted toward the requirements of this degree. Students who wish to have Transfer units apply towards their BE degree must communicate with the Academic Program Manager with the desired substitutions and may be required to provide course descriptions and/or syllabi.

Transferred units are subject to the following restrictions:

1. The credits must be approved by the major or minor department and the Graduate College.
2. The minimum grade for transferred credits must be an A or B or the equivalent at the institution where the course was taken.
3. Transferred units may not count toward more than one doctorate.
4. A maximum of 30 units of transfer coursework may be applied toward the PhD requirements.

The Graduate Committee will review the petition and determine if the transfer course is equivalent. If the request is approved, the course may be listed on the Plan of Study. For more information on Graduate College Transfer Credit policies, students should consult <http://grad.arizona.edu/academics/program-requirements/doctor-of-philosophy/credit-requirements-and-transfer-credit>, contact the BE Academic Program Manager, and/or contact their Graduate College Degree Auditor.

## 7.6 PhD Minor Requirements for BAT and BE PhD Candidates

BAT/BE PhD students are required to complete a minor. The minor subject area may be taken inside or outside of the BE Department, BUT it must be in a different area than the major focus. The student may choose one or two minor areas, determined in consultation with their Major Professor. The department in which the minor is sought determines specific requirements. The Graduate College requires that the minimum number of minor coursework is nine (9) units, but most minor programs require twelve (12) units of coursework.

The following are some suggested minors for BE students: Soil, Water, and Environmental Science; Plant Sciences; Chemical and Environmental Engineering; Civil Engineering and Engineering Mechanics; Electrical and Computer Engineering; Hydrology and Water Resource; Resource Economics; Mathematics; Renewable Natural Resource; Systems and Industrial Engineering; Aerospace and Mechanical Engineering; Biomedical Engineering; and Optical Science. The following are some suggested minors for BAT students: Bioinformatics, Biostatistics, Controlled Environment Agriculture, Ecology, Health Informatics, Informatics, Management Information Systems, Math, Microbiology, Natural Resources, Remote Sensing, Renewal Natural Resources, Science Information Systems, and Statistics.

## **7.7 Requirements for Minor in BAT or BE**

To minor in Biosystems Analytics & Technology or Biosystems Engineering, a candidate must complete 10 units consisting of:

- 9 units of departmental courses determined by the student and their BAT/BE minor advisor, and
- at least 1 unit of BE 596A, Graduate Seminar presentation.

Students must select their Minor advisor and receive approval from their Major advisor before completing the Graduate College Minor application and filing their POS. The Minor Advisor will serve on the Graduate Dissertation Committee.

## **7.8 Teaching Experience Requirement**

The BE department recognizes that many PhD students will have a faculty role and teach at universities or colleges. We want to help prepare our students for that event. Therefore, all PhD students are required to have one unit of BE 693, Teaching Internship, to document their teaching experience. The following are methods to achieve this teaching experience.

Graduate Teaching Experience Options:

1. Take FCSC/CALS 596E, Learner-Centered Teaching for Online Delivery: This seminar course is designed to introduce students to common pedagogical issues associated with both assisting in and teaching learner-centered courses in online formats.
2. Take IA 697A, Learner-Centered Teaching: This seminar course is designed for graduate students who serve as teaching assistants/graders or who plan to pursue a career in teaching. Pedagogical issues central to teaching/learning at the college level, such as learning styles and classroom climate and culture, will be covered.
3. Take IA 697B, Using Technology in Teaching: This seminar course combines in-depth reading and discussion related to pedagogical issues in the use of technology in teaching and learning with guided, individually focused training and practice in using technology in teaching.
4. Take IA 697G, Universal Design: Inclusive Learning Environments: This course provides a comprehensive review of the theory, strategies, and techniques used in instructional design processes that foster inclusive learning environments for all learners. The curriculum addresses characteristics of learners such as learning differences and preferences and 21st-century learning attributes, approaches for utilizing differentiated

instruction, engagement and motivation techniques, classroom management tactics, and universal design strategies. Emphasis will be placed on the critical review of the literature as practically applied to various learning environments and contexts in post-secondary education.

5. Complete the Graduate Teaching Certificate through the Office of Instruction & Assessment (<http://cct.oia.arizona.edu>).
6. Serve as a GTA for one semester if the GTA experience has significant teaching responsibilities.

Students are required to complete the BE 693 Teaching Experience plan (see Appendix E or D2L Graduate Programs Student Support site >> Content >> Forms). Students must have a plan, select a teaching experience advisor, and receive approval from their Major Professor. The Teaching Experience Advisor must be a BE Faculty member, not necessarily the Major Professor. A report must be submitted to the internship advisor at the end of the teaching internship. Completed Teaching Experience Plan will be submitted to the appropriate D2L assignment folder.

## **7.9 Time Limitation**

Students must complete their degree within five years of passing the Comprehensive Examination. A student not finished within that time period may be allowed to re-take the Comprehensive Examination with the permission of the BE Graduate Program Director.

## **7.10 Plan of Study**

In conjunction with the Major Professor, each student is responsible for developing a Plan of Study by the end of their first semester. The Plan is to be filed in GradPath no later than the end of the first semester in residence. The Plan of Study identifies:

1. Approved Transfer courses;
2. Courses already completed and planned at The University of Arizona, which the student intends to apply toward the graduate degree;
3. Approved Minor courses.

Before submitting their Plan of Study in GradPath, the student must receive approval from their Dissertation Committee, Major Professor, Minor Advisor, the BE Director of Graduate Studies, BE Academic Program Manager, and the Graduate College. For more information on the doctoral plan of study, please refer to <https://grad.arizona.edu/gsas/degree-requirements/doctor-philosophy#plan-of-study>.

## **7.11 Research Proposal (Prospectus) for the Dissertation**

The Research Proposal is the general research plan that the candidate will pursue to obtain their doctoral degree and is of sufficient academic merit on a topic that satisfies their Dissertation Committee. The candidate is encouraged to include the title of their Research Proposal in their Plan of Study. A draft of the Research Proposal will be completed by the completion of BE 501 (as a course requirement) OR, in the case of Ph.D. candidates already completing BE 501 in their master's degree program, the Research Proposal draft will be completed no later than the end of the 2<sup>nd</sup> semester in the program. The final Research Proposal will be completed by the end of the 3<sup>rd</sup> semester in the program. The student uploads the Research Proposal, dissertation title, and in their plan of study to GradPath. Once the final Research Proposal is received in GradPath, the Academic Program Manager will check that the title is correct and the plan of study meets the departmental requirements and approves the Research Prospectus form in GradPath.

## **7.12 Comprehensive Examination**

Admission to graduate study does not imply admission to candidacy for an advanced degree. Before admission to candidacy for the doctoral degree, the student must pass the Doctoral Comprehensive Examination (a general examination in the chosen fields of study). 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 research and in-depth within the area of specialization. Therefore, the examination should not occur until the student has completed all or almost all of their coursework. The exam will determine whether the student will be permitted to continue the PhD program as a BE PhD candidate.

### 7.12.1 Comprehensive Examination Structure

As per the Graduate College, “Each program determines the format and administration of the written portion. The minor department controls the minor portion of the written examination and may waive it at their discretion.” The Comprehensive Examination is considered a single examination and is composed of two parts:

1. **A written exam** covering the major and minor fields. Each committee member decides upon the time allotted to complete the written portion. A student must take and pass the written portion before taking the oral portion and
2. **An oral exam** is to be conducted after taking and passing the written exam. The oral examination is the occasion when faculty committee members have both the opportunity and obligation to require the student to display a broad knowledge of the chosen field of study and sufficient depth of understanding in areas of specialization. Discussion of proposed dissertation research may be included. The oral exam is taken with the candidate’s Comprehensive Examination Committee Members And should last for at least an hour but must not last more than 3 hours (as per Graduate College policy). The BE Department recommends that the oral portion is taken no later than two weeks after the successful completion of the written portion. However, the Graduate College allows the oral portion of the Comprehensive Examination to be completed as late as three (3) months before the Final Oral Defense. The exact time and place of the oral comprehensive exam must be scheduled with the department and announced in GradPath using the Announcement of Doctoral Comprehensive Exam form before the exam can take place (see Section 7.13.3).

### 7.12.2 Comprehensive Examination Committee and Form

Students should receive verbal approval from their Major Professor and Dissertation Committee members before submitting the Comp Exam form in GradPath. The Comprehensive Examination Committee must consist of a minimum of four (4) members. In the BE department, the practice is for the Comprehensive Examination Committee to consist of the Dissertation Committee with an additional member(s) and the Major Professor as the Comprehensive Exam Committee Chair. The additional member(s) should be tenured or tenure-track or an approved special member. Special members must be pre-approved by the Dean of the Graduate College. The Graduate College requires the Academic Programs Manager to initiate the Special Member Request [<https://grad.arizona.edu/forms/gsas/special-member-request>]. Please contact the Academic Program Manager to process the Special Member request. Any members beyond the fourth can also be current tenured or tenure-track faculty members or approved special members. Once the GradPath committee form is approved, the student will proceed to the Announcement of Comprehensive Examination.

NOTE: All committee members, including the Minor Advisor, must be present and participate in the Comprehensive Examination.

### 7.12.3 Announcement of Comprehensive Examination

Once the Comprehensive Examination Committee has agreed on a time and place for the exam, the student must complete the Announcement of Comprehensive Examination form in GradPath. The GradPath form must be approved by the Major Professor, Minor Advisor, BE Director of Graduate Studies, BE Academic Program Manager, and the Graduate College. Once approved, the GradPath will automatically notify the examining committee of the date and time of the Comprehensive Exam.

### 7.12.4 Reporting the Results of the Comprehensive Examination

Based on the student's combined performance in the written and oral portions, the examining committee awards a grade of pass or fail. The Major Professor reports the final results of the Comprehensive Examination in GradPath. In addition, each committee member completes their program assessment form for the oral comprehensive exam. The Major Professor is responsible for collecting completed assessment forms and submitting them to the Academic Program Manager. These will be compiled for the Academic Program Review.

If the student passes the comprehensive exam, the student will be Advanced to Candidacy and proceed to complete the Dissertation Committee Appointment form.

If the student fails the comprehensive exam, the student is permitted a second attempt to pass the examination if recommended by the examining committee. Students will be allowed *no more* than one re-take. For more information on the Comprehensive Examination, please refer to <https://grad.arizona.edu/gsas/degree-requirements/doctor-philosophy> and Policies and Procedures for Oral Comprehensive Examination for Doctoral Candidacy <https://arizona.app.box.com/v/grad-gsas-comporalexam>.

### **7.13 Dissertation Requirements**

Students must submit a minimum of two (2) papers for publication. The publication papers and the Dissertation must be submitted to the Dissertation Committee for review and approval three weeks before *scheduling the defense*. The student needs to:

1. Receive approval for submission to a refereed journal from their Dissertation Committee and Major Professor.
2. Be listed as the first author in at least one of the papers approved for submission.
3. Complete form, THESIS/DISSERTATION PAPER CERTIFICATION FOR SUBMITTED/PUBLISHED MANUSCRIPT (can bring to the defense, but must be completed BEFORE submission to journal)

Dissertation format requirements can be found in Appendix B. BE PhD candidates should review the Graduate College manual to ensure that their Dissertation is in the proper format. For more information on formatting, please refer to <https://grad.arizona.edu/gsas/dissertations-theses/dissertation-and-thesis-formatting-guides>. Copies of Filed Dissertation papers are available via the University Libraries at <https://libguides.library.arizona.edu/type/theses>.

### **7.14 Final Oral Defense**

Upon the completion and approval of the Dissertation by the Committee, the student is ready to schedule the Final Oral Defense. A student must be in good academic standing to schedule the Final Oral 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 Final Oral Defense must be scheduled through GradPath at least two weeks in advance. The Major Professor, who serves as the committee chair, presides over the examination. The Defense is closed to the public, except for an initial seminar portion during which the student presents the dissertation and entertains questions. The Final Oral Defense needs to be concluded within three hours. Members of the Dissertation Committee must be present for the entire examination. Students should send the Graduate College link for the Final Oral Defense Instructions to their Major Professor at least one week before the defense date. For more information on the UA's policy on the Final Oral Defense, go to <https://arizona.app.box.com/v/grad-gsas-finaldefnsinstr>. NOTE: The BE faculty support the UA's policy that all committee members must be present for the entire examination.

Per Graduate College policies, a member may participate in the Defense remotely (i.e., via Zoom, Skype, or GoToMeeting). If a member cannot participate in person or remotely, the student will need to find another tenured, tenure-track, or continuing-appointment committee member and update their Committee Appointment form.

#### **7.14.1 Dates and Deadlines**

NOTE: All candidates should refer to the Graduate College Dates and Deadlines website prior to beginning the following steps at <https://grad.arizona.edu/gsas/degree-requirements/important-degree-dates-and-deadlines>. Scheduling the Final Oral Defense and satisfying all requirements relating to this examination is the sole responsibility

of the student.

#### 7.14.2 Final Oral Defense Process

The following lists the steps to completing the final oral defense of a student's dissertation. See the Biosystems Graduate Programs D2L site for the Progress Checklist (an Excel spreadsheet):

1. Upon completion of the research work, the student writes their dissertation and presents to their Dissertation Committee a draft of the dissertation one month before the proposed defense date recognizing that the defense date should be at least one week before the deadline set for final submission to the graduate college of the semester the student plans to graduate.
2. One week after the submission of the draft, the student meets with their Dissertation Committee to present their work.
3. At the meeting, the Dissertation Committee decides whether the student is ready to defend their work based on the presentation and draft dissertation.
4. If the committee agrees that the student is ready to defend their dissertation, they signify by signing the Defense Approval Form (see Academic Program Manager for a copy of this form).
5. Students should be aware of the submission date for the final approved dissertation for archiving before they set their final oral examination date. Refer to the Graduate College's Dates and Deadlines for graduation at <https://grad.arizona.edu/gsas/degree-requirements/important-degree-dates-and-deadlines>.
6. The student is also responsible for completing the Announcement of Final Oral Defense in UAccess.
7. If the Dissertation Committee determines that the PhD student is not ready to defend, the Academic Program Manager will decline the Announcement of Final Oral Defense form in UAccess and notify the BE Director of Graduate Studies and Department Head of the findings. The Major Professor and the student will send an email notice with the new "Program Completion Date (Graduation Term)" to the Academic Program Manager, the BE Director of Graduate Studies, and the Graduate College Degree Check Advisor.
8. Upon receiving the signed Defense Approval Form from the candidate, the Academic Program Manager will notify the BE Director of Graduate Studies via GradPath. The candidate may then set the Final Oral Defense date a minimum of two weeks after consultation with their Dissertation Committee members.
9. The Academic Program Manager will have the necessary paperwork sent to the Graduate College and email the department faculty, students, and staff with the date and location of the final oral defense.
10. The student is responsible for posting the announcement at least a week prior to the final oral defense date. The announcement should include the defense's title, date, and location.
11. The Academic Program Manager will approve the Announcement of Oral Defense form in GradPath. Approval by the Director of Graduate Studies completes the process.

#### 7.14.3 Reporting Results of the Final Oral Defense

After the Final Oral Defense, the candidate's Dissertation Committee will determine if the student passed, passed with revisions, or failed. The Committee must follow the Graduate College procedures for the Final Oral Defense located at <https://arizona.app.box.com/v/grad-gsas-finaldefnsinstr>. Additionally, the Major Professor collects their completed Graduate Report/Thesis/Dissertation Oral Defense Evaluation Form from each committee member and submits the completed forms to the Academic Program Manager. These forms are used to assess all four of our student outcomes.

If the student passes the final oral defense without revisions:

1. The student may proceed with the dissertation submission.
2. The Major Professor should submit a Change of Grade Form to the Academic Program Manager and report the results in GradPath.

If the student passed the final oral defense with revisions:

1. The Dissertation Committee must determine the date the student needs to resubmit the corrections to

the committee.

2. The Major Professor will need to enter this date in the GradPath form.
3. After the Dissertation Committee approves the final corrected revisions, the Major Professor sends an email to the Graduate Auditor and the Academic Program Manager confirming the final results for degree completion and submits a Change of Grade Form in GradPath. Once the final revisions are approved, the student will be advised to complete the submission process.

If the student fails the final oral defense, they must contact the Graduate College.

### **7.15 Dissertation Submission**

Following a successful Final Oral Defense:

1. The candidate must submit an approved dissertation in electronic format to the University ProQuest system. For further instructions, refer to the Dissertation/Thesis Submission site at <https://grad.arizona.edu/gsas/degree-requirements/doctor-philosophy#final-oral-defense>.
2. In addition, the candidate's Major Professor and Dissertation Committee may require copies of the dissertation in electronic format. Check with your Major Professor for any special requirements.

Upon receipt of the finalized dissertation, the Dean of the Graduate College will recommend conferral 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.

### **7.16 Dual Degrees**

Dual degree programs allow qualified students an opportunity to earn two degrees with a reduction in the total number of credit hours required by allowing students to use a certain number of units in common between the two degrees. The number of shared units varies by the dual degree program. Please contact individual departments for more specific information about their dual degree programs.



## APPENDIX A

### EXAMPLE OF PLAN OF STUDY FOR THE ACCELERATED MASTER'S PROGRAM (AMP) in BIOSYSTEMS ENGINEERING

#### Senior Year/1<sup>st</sup> Year in AMP

| Course   | Unit      | Course                                 | Unit      |
|--|-----------|--|-----------|
| Fall Semester  |           | Spring Semester                        |           |
| BE 496A, Seminar in Engr Careers & Professions         | 1         | ENGR 498B (Cross-disciplinary Design)  | 3         |
| ENGR 498A, Cross-disciplinary Design                   | 3         | 400-level TECH Elective                | 3         |
| BE 447/547, Sensors and Controls                       | 3         | 500-level*, TECH Elective              | 3         |
| 400/500-level (BE) Design Elective                     | 3         | Tier 2 ART/HUM                         | 3         |
| AME 324A, Mechanics of Materials                       | 3         | BE 501*, Research Methods              | 2         |
| Tier 2 INDV  | 3         | BE 596B*, Grad Seminar, non-presenting | 1         |
| BE 597A*, Academic & Career Prep for Graduate Students | 1         | ENVS 508*, Technical Writing           | 3         |
| BE 596B*, Grad Seminar, non-presenting                 | 1         |  |           |
| <b>Total</b>   | <b>18</b> | <b>Total</b>                           | <b>18</b> |

\*These classes are dual enrolled, are taken during the student's senior year, and meet both the BS and MS course requirements.

#### 2<sup>nd</sup> Year in AMP

| Course   | Unit      | Course   | Unit     |
|--|-----------|--|----------|
| Fall Semester                                  |           | Spring Semester                                |          |
| BE 596A, Grad Seminar, presenting              | 1         | BE 596A, Grad Seminar, presenting              | 1        |
| 500-level BE Elective                          | 3         | STAT 571B                                      | 3        |
| 500-level TECH Elective                        | 3         |  |          |
| BE 910 (Thesis) or BE 909 (Engineering Report) | 3         | BE 910 (Thesis) or BE 909 (Engineering Report) | 2        |
| <b>Total</b>                                   | <b>10</b> | <b>Total</b>                                   | <b>8</b> |

## **APPENDIX B**

### **THESIS/ GRADUATE REPORT/DISSERTATION REQUIREMENTS**

## Thesis/Dissertation Paper Requirements

### Objectives

MS Thesis Option and PhD students are required to submit papers for publication in refereed scientific journals by the time of their Final Oral Examination. The primary objectives of the option are:

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

Similar options are available in many European and U.S. institutions (including at least two departments at the UA). Sample Thesis and Dissertation papers completed under this option are available in the department for check out. These are also available through the UA library. If you have any questions, please do not hesitate to contact the Director of Graduate Studies and/or your Faculty 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.
- Before submitting each manuscript, a Faculty Advisor's (and co-advisors, if any) approval is required. After the Faculty Advisor's review, each manuscript must be approved by a majority of the student's Graduate Committee members (or all Dissertation Committee members if there are three or less). Please remember to attach each manuscript's signature page for the BE paper. A signature page can be obtained Appendix and the Graduate Program D2L site. Please submit the fully signed form to the appropriate D2L assignment folder.
- The student's Graduate Committee will decide when the paper is ready for defense. Students must give a copy of the penultimate paper *three weeks* (minimum) before the scheduled defense.

## Recommended Thesis/Dissertation Format

Examples of Sample Pages and formatting guidelines for dissertations and theses can be found on the Graduate College site, <https://grad.arizona.edu/gsas/dissertations-theses>. All Theses and Dissertations are required to be archived in UA Campus Repository. Typically, the elements of the thesis or dissertation is as follows:

- 1 Title Page (required format)
- 2 Committee Approval Page (can be physical approval page using required format OR use Adobe Sign to gather signature)
- 3 Acknowledgments and Dedication (optional)
- 4 Table of Contents
  - 4.1 include all chapters & major sections; if you report sub-sections, be consistent in listing all subsections at the same level
  - 4.2 List of Figures/Illustrations (from Introduction & Present Study)
  - 4.3 List of Tables (from Introduction & Present Study)
- 5 Abstract
- 6 Chapter 1. Introduction
  - 6.1 Explanation of the problem(s), objectives, and uniqueness.
  - 6.2 The relationship of the manuscripts included and your contribution to each of the manuscripts. The published or publishable work must be logically connected and coherently integrated into the dissertation. Simply binding reprints or collections of publications together is not acceptable as a dissertation in either format or concept.
  - 6.3 Specify your role in the research and production of the manuscript(s). Where research efforts are part of the larger collaborative project, identify one aspect of the project as your own and demonstrate an original contribution.
  - 6.4 An overall literature review and background.
- 7 Chapter 2. Present Study
  - 7.1 Overall summary.
  - 7.2 Overall conclusions and recommendations.
- 8 Appendices:
  - 8.1 Manuscript No. 1<sup>1</sup> (required for both theses and dissertations)
  - 8.2 Manuscript No. 2<sup>1</sup> (required for dissertations, optional for theses)
  - 8.3 Supplementary materials - Materials such as data tables, additional references, graphs, computer programs, and maps.
  - 8.4 All appendix pages are part of the single pagination sequence of the thesis/dissertation.

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<sup>1</sup>The first page of 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 the use of copyrighted material should be attached if needed.

## Recommended Graduate Report (Non-thesis) Format

Students may choose the graduate report option when:

- the research project is not funded
- the research is limited in scope
- the MS program will be a terminal degree
- the research will not be publishable work, but the industry would/could value the information
- the research is related to a project at their work

Graduate reports shall follow the more traditional thesis format without the requirement of a publishable paper embedded in the thesis. NOTE: Follow Graduate College standard format/style guide throughout the text.

- 1 Title Page (required format)
- 2 Committee Approval Page (can be physical approval page using required format OR use Adobe Sign to gather signature)
- 3 Acknowledgments and Dedication (optional)
- 4 Table of Contents
  - 4.1 Include all chapters & major sections; if you report sub-sections, be consistent in listing all subsections at the same level
  - 4.2 List of Figures/Illustrations (from Introduction & Present Study)
  - 4.3 List of Tables (from Introduction & Present Study)
- 5 Abstract
- 6 Chapter 1. Introduction
  - 6.1 Explanation of the problem(s), objectives, and uniqueness
  - 6.2 Justification for the research
- 7 Chapter 2. Literature Review
- 8 Chapter 3. Methods and Materials
- 9 Chapter 4. Discussion of Results
- 10 Chapter 5. Summary and Recommendations
- 11 Appendices:
  - 11.1 Supplementary materials - Materials such as data tables, additional references, graphs, computer programs, and maps.
  - 11.2 All appendix pages are part of the single pagination sequence of the report.

## APPENDIX C

### **PROGRESS CHECKLISTS FOR COMPLETING THE STEPS IN THE BE AMP, BAT/BE TRADITIONAL MS, AND BAT/BE PhD DEGREES**

All progress checklists for completing the steps for the BE AMP, BAT/BE Traditional MS, and BAT/BE PhD degree programs are located in the Biosystems Graduate Programs D2L site [<https://d2l.arizona.edu/d2l/home/1043691>] as Excel spreadsheets. They are optional but highly recommended to help you plan your academic time and meet milestones.

## APPENDIX D

### Biosystems Analytics & Technology Graduate Faculty

To be eligible to serve on a graduate committee in the Biosystems Analytics & Technology program, a faculty member must meet one or more of the following criteria:

1. Tenured/Tenure-eligible departmental Faculty
2. Continuing Status/Continuing-eligible departmental Faculty
3. Career Track departmental Faculty
4. Emeritus status departmental Faculty
5. Members of the Graduate Faculty in Other Programs without an FTE in the departmental IF:
  - a. Faculty member has a doctoral degree in analytics, bioinformatics, statistics, computer sciences, or related analytics field or a discipline related to any of the program research focus areas, OR
  - b. Faculty currently holds a previously held “courtesy appointment” (i.e., 0% FTE or jointly-appointed position) in BE.

Anyone who does not fit into one of the criteria above will be considered a “Special Member” and must be approved by the Graduate College. See Section 1.2 <https://grad.arizona.edu/policies/academic-policies/graduate-faculty-policy>.

### Biosystems Engineering Graduate Faculty

To be eligible to serve on a graduate committee in the Biosystems Engineering program, a faculty member must meet one or more of the following criteria:

1. Tenured/Tenure-eligible departmental Faculty
2. Continuing Status/Continuing-eligible departmental Faculty
3. Career Track departmental Faculty
4. Emeritus status departmental Faculty
5. Members of the Graduate Faculty in Other Programs without an FTE in BE IF:
  - a. Faculty member has a doctoral degree in BE or related engineering field or a discipline related to any of the program research focus areas; OR
  - b. Faculty currently holds a previously held “courtesy appointment” (i.e., 0% FTE or jointly-appointed position) in BE.

Anyone who does not fit into one of the categories above will be considered a “Special Member” and must be approved by the Graduate College. See Section 1.2 <https://grad.arizona.edu/policies/academic-policies/graduate-faculty-policy>.

**Biosystems Engineering Graduate Faculty**  
**(Faculty with \* May Serve on *Doctoral* Committees as Sole Major Professor/Committee Chair)**

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\*An, Lingling, Associate Professor, PhD, 2008, Purdue University. Statistical bioinformatics, statistical methods for detecting and predicting biological threats.

\*Andrade-Sanchez, Pedro, Associate Professor and Extension Specialist, PhD, 2004, University of California, Davis. Precision agriculture.

Barreto, Armando, Assistant Professor of Practice, PhD, 2013, University of Arizona. Research and teaching interest in topics related to climate change, water conservation, crop mapping, global vegetation change and phenology.

\*Barton, Jennifer, Jointly-appointed Professor in Biomedical Engineering, PhD, 1998, The University of Texas at Austin. Translational biomedical optics and the prevention and early detection of cancer.

\*Cuello, Joel, Professor, PhD, 1994, Pennsylvania State University. Bioreactor design and scale up, algae production systems, controlled-environment systems, cell and organ cultures regulations.

\*Didan, Kamel, Professor and BE Director of Graduate Studies, PhD, 1999, University of Arizona. Remote sensing data, algorithms, and modeling time series analysis.

\*Duan, Guohong “Jennifer,” Jointly-appointed Associate Professor in Civil Engineering & Engineering Management, PhD, 1998, University of Mississippi. Experimental studies and computational simulation of turbulent flow, sediment transport, and channel morphological processes.

\*Farrell-Poe, Kathryn “Kitt,” Department Head, Professor, and Extension Specialist, PhD, 1990, Purdue University. Water quality, onsite wastewater treatment, safe drinking water, extension education/outreach.

\*Fitzsimmons, Kevin, Jointly-appointed Professor in Environmental Science, PhD, 1999, University of Arizona. Aquaculture.

\*Franklin, Edward, Jointly-appointed Associate Professor in Agricultural Education, PhD, 2000, Oklahoma State University. Renewable energy.

\*Gerba, Charles, Jointly-appointed Professor in Environmental Science, PhD, 1973, University of Miami, Miami, Florida. Environmental microbiology.

\*Giacomelli, Gene, Professor and Extension Specialist, PhD, 1983, Rutgers University. Horticultural engineering, energy conversions engineering, bioresource engineering, greenhouse engineering design, and hydroponic crop production.

\*Görtl, Florian, Assistant Research Professor, PhD, 2012, University of Vienna. Computational materials design, design of materials at an atomistic level.

Hall, Caitlyn, Assistant Professor of Practice, PhD, 2021, Arizona State University. Soil and water remediation, bioremediation, ecological engineering, climate change, policy, law, disaster epidemiology,



environmental science communication, water treatment, sustainability, disaster and hazard resilience, civic engagement, environmental justice.

Hooks, Triston, Assistant Professor of Practice, PhD, 2020, New Mexico State University. Controlled environment agriculture

\*Hurwitz, Bonnie, Associate Professor, PhD, 2012, University of Arizona. Bioenvironment & one health, functional metagenomics, big data, system biology, bioinformatics and computational biology.

\*Kacira, Murat, Professor and Director of the Controlled Environment Agriculture Program, PhD, 2000, Ohio State University. Controlled environment agriculture, food, agricultural, and biological engineering.

\*Karaniola, Vasiliki (Vicky), Jointly-appointed Assistant Professor in Chemical and Environmental Engineering, PhD, 2015, University of Arizona. Desalination, membrane filtration, and water treatment.

\*Li, Haiquan, Assistant Professor, PhD, 2010, National University of Singapore. Bioinformatics, biological mechanisms, clinical informatics, computer science, data mining, translational bioinformatics, and statistics.

\*Lyons, Eric, Jointly-appointed Associate Professor in Plant Sciences, PhD, 2008, University of California, Berkeley. Biosystems analytics, cyberinfrastructure for life sciences, computational systems for genomes, advanced visualization of genomic data.

\*Martin, Edward, Professor, Extension Specialist, and Director of the Maricopa County Extension, PhD, 1992, Michigan State University. Water resources, irrigation management.

\*Ogden, Kimberly, Jointly-appointed Professor in Chemical & Environmental Engineering, PhD, 1991, University of Colorado, Boulder. Bioreactor design for the production of alternative e fuels from algae and sweet sorghum and microbiological water quality.

\*Pepper, Ian, Jointly-appointed Professor in Soil, Water, and Environmental Sciences and Director of the Water Quality Center, PhD, 1975, The Ohio State University. Soil microbiology.

\*Piegorisch, Walter, Jointly-appointed Professor in Mathematics & Chair of Statistics GIDP, PhD, 1984, Cornell University. Statistics.

\*Poe, Stephen, Professor and Extension Specialist, PhD, 1987, Purdue University. System mechanization, livestock waste management, ventilation housing, and computer software development.

\*Pryor, Barry, Professor, Jointly-appointed Professor in Plant Sciences, PhD, 1999, University of California, Davis. Controlled environment agriculture, mycology, fungal detection, and control.

\*Rasmussen, Craig, Jointly-appointed Professor in Environmental Sciences, PhD, 2004, University of California, Davis. Soil forming processes, soil-landscape evolution.

Recsetar, Matthew "Rex," Assistant Research Professor, PhD, 2019, University of Arizona. **Aquaculture engineering, fish culture, aquaponics, controlled environment agriculture, sustainable food systems, innovative cannabis culture systems.**

\*Siemens, Mark, Associate Professor, and Extension Specialist, PhD, 1996, University of Arizona. Specialty crops

mechanization, agricultural machine design and testing, tillage.

\*Slack, Donald, Emeritus Professor, PE, PhD, 1975, University of Kentucky. Irrigation scheduling, water resources, infiltration, porous media flow, soil, and water conservation engineering.

Tamimi, Akrum, Assistant Professor of Practice, PhD, 1995, University of Arizona. Water resources, wastewater treatment, irrigation, biosystems engineering, civil engineering, environmental engineering.

\*U'Ren, Jana, Assistant Professor, PhD, 2011, University of Arizona. Earth systems genomics.

\*Waller, Peter, Associate Professor, PhD, 1990, University of California, Davis. Water quality engineering, irrigation engineering, drainage engineering.

\*Yitayew, Muluneh, Emeritus Professor, PhD, 1982, University of Arizona. Irrigation engineering, hydraulics, water resources engineering.

\*Yoon, Jeong-Yeol, Professor, PhD, 2004, University of California, Los Angeles. Biosensors, water safety, lab-on-a-chip, protein nanoarray, immunoassay, biomaterials.

## **APPENDIX E**

### **FORMS**

BE 693, TEACHING EXPERIENCE INTERNSHIP

The BE department recognizes that many PhD students will end up in faculty roles and teaching at universities or colleges. We want to help prepare you for that event. Therefore, all PhD students are required to have one unit of BE 693, Teaching Experience Internship, to document their teaching experience. You have six methods from which to choose to meet the teaching experience internship. Methods 1-4 outlined below are classes that you can take, in lieu of signing up for BE 693, to help you learn more about teaching in upper education.

METHODS

1. FCSC/CALS 596E, Learner-Centered Teaching for Online Delivery (1 unit; Fall, Spring). This seminar course is designed to introduce students to common pedagogical issues associated with both assisting in and teaching learner-centered courses in online formats.
2. IA 697A, Learner-Centered Teaching (3 units; Fall, Spring). This course provides a foundation in learner-centered teaching. It includes theories of adult learning, approaches to the course and lesson design, techniques to assess learning, and development of reflective teaching practices. It is appropriate for instructors who want to improve their teaching and is required for students in the Certificate in College Teaching program.
3. IA 697B, Using Technology in Teaching (3 units; Fall, Spring). This course combines in-depth reading and discussion related to pedagogical issues in the use of technology in teaching and learning with guided, individually focused training and practice in using technology in teaching.
4. IA 697G, Universal Design: Inclusive Learning Environments (3 units; Fall, Spring). This course provides a comprehensive review of the theory, strategies, and techniques used in instructional design processes that foster inclusive learning environments for all learners. The curriculum addresses characteristics of learners such as learning differences and preferences and 21st-century learning attributes, approaches for utilizing differentiated instruction, engagement and motivation techniques, classroom management tactics, and universal design strategies. Emphasis will be placed on critical review of the literature as practically applied to various learning environments and contexts in post-secondary education.
5. Complete the Certificate in College Teaching through the Office of Instruction & Assessment (<https://grad.arizona.edu/catalog/programinfo/CLTCRTG> or <http://cct.oia.arizona.edu>)
6. Serve as a GTA for one semester – *if the GTA experience has significant teaching responsibilities.*

PROOF OF COMPLETION

| Graduate Teaching Experience Option         | Proof of Completion          |
|---|------------------------------|
| FCSC/CALS 596E                              | Class grade                  |
| IA 697A                                     | Class grade                  |
| IA 697B                                     | Class grade                  |
| IA 697G                                     | Class grade                  |
| Certificate in College Teaching through OIA | Copy of Certificate          |
| GTA, one semester                           | Assessment by GTA instructor |

BE TEACHING EXPERIENCE PLAN for PhD Students

Student Name \_\_\_\_\_ Student ID # \_\_\_\_\_

Method to Achieve BE 693 credit

- FCSC/CALS 596E (in lieu of signing up for BE 693)
- IA 697A (in lieu of signing up for BE 693)
- IA 697B (in lieu of signing up for BE 693)
- IA 697G (in lieu of signing up for BE 693)
- Graduate Teaching Certificate
- GTA, one semester\*

Semester and Year to Complete BE 693 \_\_\_\_\_

Student's Signature \_\_\_\_\_

Date \_\_\_\_\_

\*If GTA is chosen to meet BE 693, the following section needs to be completed

Teaching Experience Advisor Name \_\_\_\_\_

Instructor's Section Number \_

Instructor's Signature \_

Date \_\_\_\_\_



THE UNIVERSITY OF ARIZONA  
COLLEGE OF AGRICULTURE & LIFE SCIENCES  
COLLEGE OF ENGINEERING

**Biosystems Engineering**

THESIS/DISSERTATION PAPER CERTIFICATION FOR SUBMITTED/PUBLISHED MANUSCRIPT  
(D2L: Journal Paper Certification for Submitted/Published Manuscript)  
(needs to be completed prior to submission to journal)

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

*Prepared by:* \_\_\_\_\_

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

*Approved submission to:* \_\_\_\_\_

*In partial fulfillment of the requirements for the degree of:* \_\_\_\_\_

APPROVED BY:

\_\_\_\_\_  
Major Professor (*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



THE UNIVERSITY OF ARIZONA  
COLLEGE OF AGRICULTURE & LIFE SCIENCES  
COLLEGE OF ENGINEERING

**Biosystems Engineering**

FINAL ORAL DEFENSE APPROVAL FORM

As members of the Graduate Committee, we certify that we have read the Thesis/Report/Dissertation and confirm that the student is ready to defend.

Student: \_\_\_\_\_ Student ID: \_\_\_\_\_

Title: \_\_\_\_\_

APPROVED BY:

\_\_\_\_\_  
Major Professor (*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

## **APPENDIX F**

### **ASSESSMENT RUBRICS**



THE UNIVERSITY OF ARIZONA  
 Biosystems Engineering Department  
 PhD Oral Comprehensive Examination Assessment Rubrics

|                            |                      |                  |
|----------------------------|----------------------|------------------|
| <b>Candidate:</b>          | <b>Date/Time:</b>    | <b>Place:</b>    |
| <b>Examining Committee</b> |                      |                  |
| <b>Member</b>              | <b>Email Address</b> | <b>Pass/Fail</b> |
|                            |                      |                  |
|                            |                      |                  |
|                            |                      |                  |
|                            |                      |                  |
|                            |                      |                  |

**Note:** Please fill this form as soon as the Oral Examination concludes. This form and rubric is used to assess all PhD students after completing their comprehensive examination. The data collected will be used to support our Annual Program Review (APR) and will provide our unit with the necessary information for adjusting our programs, reinforcing current practices and/or student performance expectations.

| Attribute  | 1 - Poor | 2- Fair | 3 - Good | 4-Very Good | 5-Excellent | Score |
|--|----------|---------|----------|-------------|-------------|-------|
| <b>General Knowledge</b>                           |          |         |          |             |             |       |
| Depth and breadth of knowledge in the focus area   |          |         |          |             |             |       |
| Knowledge of Fundamental principles in engineering |          |         |          |             |             |       |
| Overall response to questions                      |          |         |          |             |             |       |
| <b>Research</b>                                    |          |         |          |             |             |       |
| Research literature                                |          |         |          |             |             |       |
| Research purpose                                   |          |         |          |             |             |       |
| Research methods                                   |          |         |          |             |             |       |
| Research theoretical background                    |          |         |          |             |             |       |
| <b>Total</b>                                       |          |         |          |             |             |       |

**Scoring the candidate**

The score needs to follow these guidelines and consider the student's focus area, fundamental principles in engineering and/or analytics, research field literature, research methods, general theoretical background, and overall answers to questions.

| Score     | Description   |
|-----------|---|
| Poor      | Very poor answers and knowledge as demonstrated by lack of accurate responses to most of the questions even with some help.                 |
| Fair      | Limited knowledge as demonstrated by significant difficulties in responding to only few of the questions with some aid.                     |
| Good      | Adequate knowledge as demonstrated by accurate responses to most questions with some help at times.   |
| Very Good | Accurate answers without difficulties and adequate knowledge as demonstrated by complete responses to most questions without any prompting. |
| Excellent | Excellent and thorough knowledge as demonstrated by accurate response to all questions.   |



**Report/Thesis/Dissertation Oral Defense Evaluation Form**

01/21/22

**Student Name:** \_\_\_\_\_

**Title of Report/Thesis/Dissertation:** \_\_\_\_\_

**Committee Member:** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Directions:**

Evaluate this student's engineering report/thesis/dissertation oral defense of the research with a score between 1 (Poor) and 5 (Excellent) for each of the criteria described below using the attached rubric. Briefly comment on the rationale if your score is less than 5. Submit your completed scoring sheet to the committee chair before leaving the defense.

| <b>Score<br/>(1 – 5)</b> | <b>Criterion</b>             | <b>Comment</b> |
|--------------------------|------------------------------|----------------|
|                          | Organization of Oral Defense |                |
|                          | Presentation Style           |                |
|                          | Presentation Pace            |                |
|                          | Content: Depth               |                |
|                          | Content: Accuracy            |                |
|                          | Use of Visual Aids           |                |
|                          | Responsiveness to Audience   |                |

## Report/Thesis/Dissertation Oral Defense Rubric

| Criteria                   | Excellent – 5 pts  | Very Good – 4pts  | Good – 3 pts   | Fair – 2 pts   | Poor – 1 pt  |
|----------------------------|--|---|--|--|--|
| Organization               | Presentation is clear and logical. Listener can easily follow line of reasoning.   | Presentation is generally clear. Few minor points with Confusion.   | Presentation is generally clear. Few minor points may be confusing.  | Listener can follow presentation with effort. Organization Not well thought out.   | Presentation is very confused and unclear. Listener cannot follow it.  |
| Presentation Style         | Demonstrates effective presentation skills. Speaker is easy to hear and understand. Good eye contact.  | Style is generally appropriate. Listener had no trouble hearing or understanding. Eye contact mostly good.                    | Style is generally appropriate. Listener had some trouble hearing or understanding. Eye contact is inconsistent. | Presentation is too informal or unprepared. Difficult to hear or understand. Much of information is read. Eye contact is poor. | Presentation is consistently at an inappropriate level. Information is read. Speaker can't be heard or understood. No eye contact. |
| Presentation Pace          | Presentation is a planned conversation, paced for audience understanding.  | Speaker's pacing is just about right  | Speaker's pacing is somewhat too fast or too slow.   | Speaker's pacing is too fast, too slow, repetitive, or skipping important details.   | Presentation is far too long or far too short.   |
| Content: Depth             | Design, methods, results, discussion, and conclusions are clearly and coherently elucidated. Logical and persuasive agreement between data and conclusions. Impact and implications of results and "where do we go from here" discussed. | Description of project and results is generally clear. Somewhat adequate discussion of what results mean with little missing. | Description of project and results is generally clear. Some discussion of what results mean.                     | Some components of project description are minimal or missing. Little discussion of what the results mean.                     | Description of project and results are very difficult to follow. No discussion of meaning of results. Listeners learn little.      |
| Content: Accuracy          | Information given is consistently accurate. Facts and calculations are correct.  | No significant errors are made. Listeners recognize a few errors are a result of oversight or nervousness.                    | Some errors are made. Listeners recognize the errors are a result of oversight or nervousness.                   | Enough errors made to be distracting, but some information is accurate.  | Information is so inaccurate that listener cannot depend on the presentation.  |
| Use of Visual Aids         | Aids prepared in professional manner. Font is large enough to be seen by all. Well organized. Main points stand out.   | Aids contribute, most material supported by aids. Font size is appropriate for reading.                                       | Aids contribute, but only some material supported by aids. Font size is appropriate for reading.                 | Aids are poorly prepared or used inappropriately. Font is too small. Too much information is included.                         | No aids are used, or they are so poorly prepared that they detract from the presentation.  |
| Responsiveness to Audience | Responds well to questions. Restates and summarizes when needed.   | Generally responsive to questions without prompting.  | Generally responsive to questions with some help at times.   | Reluctantly interacts with audience. Responds poorly to questions.   | Avoids audience interaction. Not responsive to audience.   |

## **Exit Surveys for MS and PhD Students Near Graduation in the Department of Biosystems Engineering**

Each student will complete both a written and oral exit survey. The written exit survey is a measure of your perceptions of whether you met the program's educational objectives. The oral exit survey is with the department head and covers other information to help us improve our graduate programs. You can find the written exit survey on the D2L Graduate Programs support website under Forms in Content. Please schedule your oral exit survey with the departmental administrative associate within one month of graduation.