GRADUATE STUDY
in
AGRICULTURAL AND BIOSYSTEMS ENGINEERING
2008-2009

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DEPARTMENT OF AGRICULTURAL AND BIOSYSTEMS ENGINEERING

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I. INTRODUCTION

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

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

Biological and/or Biosystems Engineering
Controlled Environment Engineering
Alternative Energy Engineering
Sensors and Control Systems
Water Resources and/or Irrigation Engineering

Application material for admission should be sent directly to the department:

Graduate Admissions Office
Agricultural and Biosystems Engineering (ABE) Dept.
The University of Arizona
1177 E. 4th Street, Shantz Bldg., Room 403
Tucson, Arizona 85721-0038

Graduate research assistantships and graduate teaching assistantships may be available (through the Department). The current departmental level of assistantship stipends range from $17,725 to $20,716 (based on degree objectives and progress) for the academic year for one-half time services. Regardless of the source of funding, Department policy provides that M.S. students will be supported for no more than four (4) semesters (2 years) and Ph.D. students for no more than six (6) semesters (3 years). The non-resident tuition fee is waived for students on assistantships of 25% time or more; the registration fee ($2,640 per semester in the 2006-2007 academic year) is not waived. There is a tuition remission of 50% or more of the registration fee depending on the appointment. Graduate assistants and associates, on half-time assistantships, are expected to work 20 hours per week. This may be increased to 40 hours during the summer months in order to increase annual income and professional experience. Students on Research Assistantships or those who have been awarded Graduate Registration Scholarships or Graduate

Tuition Scholarships are required to register for 12 credits during all regular sessions. All students undertaking graduate work in the Department are expected to have a microcomputer.

II. Master of Science (M.S.) Degree Program in Agricultural and Biosystems Engineering

A. ADMISSION GUIDELINES

In evaluating applications sent to the department, the following criteria are followed:

1. Grade Point Average
   A minimum GPA of 3.0 (out of 4.0) is required for admission to this program.
   Non-technical, agricultural mechanics, lower-division, and non-lecture (except engineering laboratory) courses are excluded from the calculations.

2. Previous Degree
   A B.S. in agricultural engineering, biological engineering, a related engineering, or suitable technical discipline is required. Students who do not have such a degree may still be admitted but they may have to take a number of courses ordinarily taken by B.S. agricultural and biosystems engineering students. These will not count toward degree requirements.

3. TOEFL
   Students whose native language is other than English must meet University English language entrance requirements (TOEFL ≥ 550 or CBT ≥ 213 or iBT 80 or English language education).

4. GRE
   The Graduate Record Examination (GRE) is ***required*** of all applicants, and GRE scores should be submitted to the ABE Department and the Graduate College with other application materials.

5. Statement of Purpose

6. Three Letters of Recommendation

B. REQUIREMENTS FOR GRADUATION

Except where otherwise noted, previous work at the B.S. level may contribute to meeting the M.S. degree requirements. In addition to the following requirements, students must meet all those for the M.S. degree which may be set by the University or the Graduate College.

A minimum of thirty units of graduate credit of which 5 are for the thesis is required. Specific requirements are:

1. A minimum of 6 units in mathematics and/or statistics and /or numerical analysis

2. A minimum of 12 units of ABE courses exclusive of seminar, thesis, dissertation, and independent studies units

3. A minimum of 15 units in the major (including thesis units)

4. ABE 601 is a required course and may be used to meet the 30 unit requirement. Students are required to take this course the first spring semester in residence.

5. ABE 696a seminar (1 unit every semester). One unit may be used to meet the 30 unit requirement

6. All ABE graduate students will be required to submit a Progress Report with the exception of first semester graduate students. However, it is recommended that new students also submit the report. Submission of the report is required to receive a passing grade in ABE 696a (seminar) except for new graduate students. Each Progress Report must include a research abstract if you have completed (2) semesters in the ABE Department. ***Failure to include an abstract will result in a decrease in your assigned grade by two letters (e.g. S to C).***

C. SPECIFIC DEPARTMENTAL REQUIREMENTS

1. The student must meet with his/her advisor once every semester to review the progress made based on the progress report submitted and plan the work ahead.

2. The student must meet with his/her committee members at least once an academic year.

3. The student forms his/her graduate committee not later than the last day of class of the second semester after joining the department, for MS, and not later than the last day of classes of the third semester for PhD students.

4. The same deadline applies for selecting research topics and submitting it to the committee. These deadlines are the same as those on the degree checklists provided to every incoming graduate student by Daniela Ibarra, Graduate Student Coordinator (please see **Appendix A**).

5. Every incoming graduate student must attend departmental orientation available for graduate students and post-docs every semester. This will be administered by Dr. Muluneh Yitayew, Graduate Advisor.

D. TYPICAL PROGRAMS

BIOLOGICAL ENGINEERING

Typical M.S. courses

ABE 547	3	Sensors and Controls
ABE 581A	3	Engineering of Biological Processes
ABE 581B	3	Bioprocess Engineering Applications
ABE 584	3	Advanced Biosystems Transport Phenomena
ABE 586	3	Biomaterial-Tissue Interactions
ABE 589B	3	Bio Micro/Nanotechnology Applications
MATH 509C	3	Statistics for Research
MATH 522	3	Advanced Applied Analysis
ABE 601	2	Research Methods in Biosystems Engineering
ABE 696A	1	Agricultural and Biosystems Engineering
ABE 910	5	Thesis
Total	**32**	

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

ABE 523	3	Biosystems Analysis and Design
ABE 582	3	Simulation of Biological Systems
ABE 583	3	Controlled Environment Systems
BME 510	3	Biology for Biomedical Engineering
BME 511	3	Physiology for Biomedical Engineering
BME 516	3	Principles of Biomedical Engineering
BME 517	3	Measurement and Data Analysis in Biomedical Engineering
CHEE 505	3	Advanced Chemical Engineering Transport Phenomena
CHEE 520	3	Chemical Reaction Engineering
CHEE 577A	4	Microbiology for Engineers
CHEE 577L	1	Microbiology for Engineers Laboratory
CHEE 577R	3	Microbiology for Engineers
MSE 561	3	Biological and Synthetic Materials
PL S 575A	3	Physiology of Plant Production under Controlled Environment

PL S 580	3	Medicinal Plants
SWES 525	3	Environmental Microbiology
SWES 526	2	Environmental Microbiology Laboratory
MATH 561	3	Regression and Multivariate Analysis
MATH 575A	3	Numerical Analysis

WATER RESOURCES AND/OR IRRIGATION ENGINEERING

Typical M.S. Courses

MATH 522	3	Advanced Analysis for Engineers
MATH 509C	3	Statistics for Research
ABE526	3	Soil and Water Conservation Engineering
ABE 555	3	Soil and Water Resources Engineering
ABE 547	3	Sensor and controls
ABE 556	3	Irrigation system Design
ABE 558	3	Agricultural Drainage and Effluent Treatment
ABE 601	2	Research Methods in Biosystems Engineering
ABE 696a	1	Seminar-Agricultural & Biosystems Engineering
ABE 910	5	Thesis
TOTAL	**32**	

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

C E 522	3	Open-Channel Flow
ABE 559	3	Design of Onsite Wastewater Treatment and Dispersal Systems
ABE 567	3	Advanced Watershed Hydrology
ABE 605	3	Soil-Water Dynamics
C E 502	3	Introduction to Finite Element Methods
C E 504	4	Numerical Methods in Subsurface Hydrology
CE 523	3	Hydrology
C E 527	3	Computer Applications in Hydraulics
C E 576A	3	Water Treatment System Design
C E 576B	3	Wastewater Treatment Design System
C E 676	3	Advanced Water and Wastewater Treatment
SWES 501	3	Management of Arid Land and Salt-Affected Soils
SWES 520	3	Environmental Physics
SWES 553	3	Remote Sensing of the Environment
SWES 565	3	Contaminant Transport in Porous Media
SWES 570	3	Soil Physics
SWES 602	3	Nutrient Dynamics in Soils
SWES 605	3	Soil-Water Dynamics
WS M 560	3	Watershed Hydrology
WS M 562	3	Watershed Management
WS M 567	3	Advanced Watershed Hydrology
WS M 573	3	Spatial Analysis and Modeling

WS M 605	3	Watershed Modeling
RNR 503	3	Applications of Geographic Information Systems
RNR 517	3	Geographic Information Systems for Natural Resources
RNR 520	3	Advanced Geographic Information Systems
RNR 573	3	Spatial Analysis and Modeling
RNR 575	3	Economics of Natural Resource Policy
RNR 580	3	Natural Resources Policy and Law
RNR 583	3	Geographic Applications of Remote Sensing
HWR 517	3	Fundamentals of Water Quality
C E 526	3	Soil and Water Conservation Engineering

SENSORS

Typical M.S. courses

ABE 523	3	Biosystems Analysis and Design
ABE 547	3	Sensors and Controls
ABE 579	3	Applied Instrumentation for CEA
ABE 589B	3	Bio Micro/Nanotechnology Applications
A ME 586	3	Micro fluidics
SWES 553	3	Remote Sensing of the Environment
ABE 696A	1	Agricultural and Biosystems Engineering
MATH 562	3	Time Series Analysis
MATH 575A	3	Numerical Analysis
ABE 601	2	Research Methods in Biosystems Engineering
ABE 910	5	Thesis
TOTAL	**32**	

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

ABE 583	3	Controlled Environment Systems
ABE 584	3	Biosystems Transport Phenomena
BME 517	3	Measurement and Data Analysis in Biomedical Engineering
CHEE 413	3	Process Control and Simulation
CHEE 577A	4	Microbiology for Engineers
CHEE 577L	1	Microbiology for Engineers Laboratory
CHEE 577R	3	Microbiology for Engineers
ECE 583	3	Remote Sensing Instrumentation and Techniques
SWES 525	3	Environmental Microbiology
SWES 526	2	Environmental Microbiology Laboratory
MATH 509C	3	Statistics for Research
MATH 522	3	Advanced Applied Analysis

CONTROLLED ENVIRONMENT ENGINEERING

Typical M.S. Courses

ABE 581A	3	Engineering of Biological Processes
ABE 582	3	Simulation of Biological Systems
ABE 583	3	Controlled Environment Systems
ABE 584	3	Biosystems Transport Phenomena
ABE/PLS 575A	3	Physiology of Plant Production under CE
ABE/PLS 579	3	Applied Instrumentation for CEA
MATH 522	3	Advanced Applied Analysis
MATH 509C	4	Statistics for Research
ABE 601	2	Research Methods in Biosystems Engineering
ABE 696a	1	Graduate Seminar
ABE 910	5	Thesis
TOTAL	**33**	

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

ABE 523	3	Biosystems Analysis and Design
ABE 547	3	Sensors and Controls
ABE 555	3	Soil and Water Resource Engineering
ABE 556	3	Irrigation System Design
ABE 581B	3	Bioprocess Engineering Applications
ABE 597C	3	Greenhouse Pest Management Applications and Practices
CHEE 530	3	Advanced Chemical Reaction Engineering
CHEE 574	3	Environmental Transport Processes
CHEE 577A	3	Microbiology for Engineers
SIE 500A-C	3	Introduction to Systems and Industrial Engineering Methods
SIE 530	3	Engineering Statistics
SIE 531	3	Simulation Modeling and Analysis
SIE 545	3	Fundamentals of Optimization
SIE 570	3	Intelligent Control Systems & Applications
SWES 520	3	Environmental Physics
SWES 525	3	Environmental Microbiology
SWES 540	3	Biodegradation of Pollutants in Soil and Groundwater
SWES 553	3	Remote Sensing of the Environment
SWES 573	3	Monitoring Biosphere Processes
PL S 508	3	Crop Ecology
PL S 540	3	Plant Growth and Development
PL S 550	3	Plant Anatomy and Morphology
PL S 560	3	Core Concepts in Plant Biology

ALTERNATIVE ENERGY ENGINEERING

Typical M.S. Courses

ABE 581A	3	Engineering of Biological Processes
AME 545	3	Renewable Energy Systems
ABE 547	3	Sensors and Controls
SWES 525	3	Environmental Microbiology
A ME 540	3	Energy Utilization and Management
ABE 584	3	Biosystems Transport Phenomena
MATH522	3	Advanced Applied Analysis
MATH 509C	3	Statistics for Research
ABE 601	2	Research Methods in Biosystems Engineering
ABE 696a	1	Agricultural and Biosystems Engineering Seminar
ABE 910	5	Thesis
TOTAL	**32**	

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

ABE 581B	3	Bioprocess Engineering Applications
ABE 601	2	Research Methods in Biosystems Engineering
ABE 523	3	Biosystems Analysis and Design
ABE 579	3	Applied Instrumentation for CEA
ABE 582	3	Simulation of Biological Systems
ABE 583	3	Controlled Environment Systems
AME 532	3	Convective Transport Phenomena
AME 533	3	Conduction and Radioactive Heat Transfer
CHEE 520	3	Chemical Reaction Engineering
CHEE 577A	4	Microbiology for Engineers
CHEE 577L	1	Microbiology for Engineers Laboratory
CHEE 577R	3	Microbiology for Engineers
SWES 526	2	Environmental Microbiology Laboratory
MATH 562	3	Time Series Analysis
MATH 575A	3	Numerical Analysis
MATH 522	3	Advanced Applied Analysis

E. MASTER OF ENGINEERING PROGRAM

The Master of Engineering (ME) program in Agricultural and Biosystems Engineering is designed primarily for part- and full-time students seeking a Master's degree who are employed in industrial positions. The goal of the program is to provide a graduate-level educational opportunity (ME) to individuals whose primary interests are the enhancement of their existing skills and the development of new skills pertinent to their industrial positions.

The Master of Engineering program emphasizes several areas, including: Biological and/or Biosystems engineering, Controlled Environment Engineering, Alternative Energy Engineering, Sensors and control systems, and Water Resources and/or Irrigation Engineering. The ME program does not require a research project leading to the completion of a masters thesis, but rather the completion of a design project report.

Students should apply and be admitted to the University of Arizona. Appropriate graduate level courses satisfactorily completed at any of the cooperative institutions (i.e., Arizona State University and Northern Arizona University) will be applicable to the degree program, so long as these courses meet the program of study guidelines. However, at least one-half of the course requirements must be completed at the University of Arizona. For more information regarding this program go to http://ag.arizona.edu/abe/me_in_abe.phtml

F. DUAL MASTERS PROGRAM WITH ELLER COLLEGE OF MANAGEMENT

Interested graduate students have the option of receiving two graduate degrees on a concurrent basis. One of these degrees will be an MBA degree from the Eller College of Management. The other will be a graduate degree from ABE. For more information regarding this program go to: http://mba.eller.arizona.edu/dual/dual/

III. Doctoral of Philosophy (PH.D.) Degree Program in Agricultural and Biosystems Engineering

A. ADMISSION GUIDELINES

In evaluating applications sent to the Department by the Graduate College, the following criteria are followed:

1. Grade Point Average
   A minimum GPA of 3.3 (out of 4.0) is required for admission to this program. Non-technical, agricultural mechanics, lower-division, and non-lecture (except engineering laboratory) courses are excluded from the calculations.

2. Previous Degree
   A B.S. in agricultural engineering, biological engineering, a related engineering, or suitable technical discipline is required. Students who do not have such a degree may still be admitted but they may have to take a number of courses ordinarily taken by B.S. agricultural and biosystems engineering students. These will not count toward degree requirements.

3. TOEFL
   Students whose native language is other than English must meet University English language entrance requirements (TOEFL ≥ 550 or CBT ≥ 213 or iBT 80 or English language education).

4. GRE
   The Graduate Record Examination (GRE) is ***required*** of all applicants, and GRE scores should be submitted to the ABE Department and the Graduate College with other application materials.

5. Statement of Purpose

6. Three Letters of Recommendation

B. QUALIFYING EXAMINATION

A qualifying examination or diagnostic evaluation may be required to demonstrate acceptability to pursue the doctorate as well as to determine areas of study where further course work is necessary. The examination is only waived at the discretion of the department if the candidate has completed a master's degree at The University of Arizona in the same field. The examination should be taken during the first semester of residence and preferably during the first two weeks of residence. Many departments also require a qualifying examination in the minor field, but this requirement may be waived at the option of the minor department. (Examination is not administered during the summer sessions).

- Purpose -> determine and evaluate student's technical background as well as to determine areas of study where further course preparation is necessary.

- Who -> qualifying exam will be administered by the Graduate Committee and faculty will be invited to attend.

- When -> The second Friday of September (Fall semester admits)
  The second Friday of February (Spring semester admits)

- How -> Oral format The question will covered the following areas:
  a) Mathematics/Statistics
  b) Thermodynamics/Heat Transfer/Fluid Mechanics
  c) Materials/Chemistry
  d) Biology
  e) Language assessment (International students)
  f) Additional topics may be covered depending upon the student's background as determined by transcripts of their previous degrees.

- Outcome -> results/evaluation will be reported to student and major advisor by the chair of the Graduate Committee.

C. COMPREHENSIVE EXAMINATION

Departmental & Graduate College Requirements:

Students must pass their comprehensive examinations before admission to candidacy for the Ph.D. degree. The exams will include a written exam covering the major and minor fields and an oral exam by a faculty committee. Examinations will be administered when major and minor departments consider the student is sufficiently prepared. The exam will determine whether the student will be permitted to continue the Ph.D. program. Scheduling and process details will be available from your Graduate Advisor.

Comprehensive Examination Committee:

The examining committee must consist of a minimum of four (4) members. Three (3) of the members should be from the major and one (1) from the minor department. If student has two minors, an additional member will be required, making a total of five (5) committee members.

D. FINAL ORAL DEFENSE EXAMINATION

Upon the completion of the dissertation, the candidate is to submit to a Final Oral Defense Examination. A student must be in good academic standing to schedule the defense. The examination focuses on the dissertation itself but can include general questioning related to the field(s) of study within the scope of the dissertation. The exact time and place of this examination must be scheduled with the Graduate Degree Certification Office at least 7 working days in advance. The dissertation director presides over the examination. The examination is closed to the public, except for an initial seminar portion during which the student presents the dissertation and entertains questions.

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

ABE Dissertation Committee:

The department requires a minimum of four (4) members. Three (3) of the members should be from the major and one (1) from the minor department. If student has two minors, an additional member will be required, making a total of five (5) committee members. For further information on committee member, please see the Graduate College requirements below:

Graduate College Dissertation Committee Requirements:
Students will form a dissertation committee by the time of Advancement to Candidacy. Some departments require earlier committee formulation. Individual faculty members may decline membership on committees for academic reasons. Candidates must be able to develop a proposal of sufficient academic merit and on a topic to satisfy their committee.
Candidates can be suspended if they do not have an approved dissertation chair and committee. The Graduate College requires a minimum of three members, all of whom must be University of Arizona tenured, tenure-track, or approved as equivalent. If a committee has only three members, all must approve the dissertation. In departments that require four or five members, there may be one dissenting vote.

The fourth member may be tenured or tenure-track, or a special approved member. Special members must be pre-approved by the Dean of the Graduate College. Any members beyond the fourth can also be tenured or tenure-track, or special approved members.

All dissertation committee members are expected to attend the final defense.

E. REQUIREMENTS FOR GRADUATION

Except where otherwise noted, previous work at the B.S. and M.S. level may contribute to meeting the Ph.D. degree requirements. In addition to the following requirements, students must meet all those for the Ph.D. degree, which may be set by the University or the Graduate College.

1. A *minimum* of 63 units of graduate credit.

- The *minimum* graduate credit (63 units) is subject to change depending on the qualifications of each student. Additional units may be determined and required by each student's advisor(s) upon consultation with dissertation committee members.

- The total units (63 units) must include a *minimum* of 45 course work units (including 2 seminar units) and 18 dissertation units.

- The course work units (45 units) must include a *minimum* of 36 units in the area of the major subject and 9 units of the minor subject area. Note that the minor department generally requires 9 ~ 15 units. The following are some possible minors:

  Soil, Water and Environmental Science
  Plant Sciences
  Chemical and Environmental Engineering
  Civil Engineering & Engineering Mechanics
  Electrical and Computer Engineering

Hydrology and Water Resources
Agricultural & Resource Economics
Mathematics
Renewable Natural Resources
Systems and Industrial Engineering
Aerospace and Mechanical Engineering
Biomedical Engineering
Optical Science

- The major subject units (36 units) must include a *minimum* of 12 units of graduate credit in mathematics, statistics, and/or numerical analysis and 12 units of A.B.E. courses exclusive of seminar, thesis, dissertation and independent studies.

2. ABE 601 is a required course and may be used to meet the 30 unit requirement. Students are required to take this course the first spring semester in residence.

3. ABE 696a seminar (1 unit **every** semester). Two units may be applied to the graduate credit requirement.

4. All ABE graduate students will be required to submit a Progress Report with the exception of first semester graduate students. However, it is recommended that new students also submit the report. Submission of the report is required to receive a passing grade in ABE 696a (seminar) except for new graduate students. Each Progress Report must include a research abstract if you have completed (2) semesters in the ABE Department. ***Failure to include an abstract will result in a decrease in your assigned grade by two letters (e.g. S to C).***

E. SPECIFIC DEPARTMENTAL REQUIREMENTS

1. The student must meet with his/her advisor once every semester to review the progress made based on the progress report submitted and plan the work ahead.

2. The student must meet with his/her committee members at least once an academic year.

3. The student forms his/her graduate committee not later than the last day of class of the second semester after joining the department, for MS, and not later than the last day of classes of the third semester for PhD students.

4. The same deadline applies for selecting research topics and submitting it to the committee. These deadlines are the same as those on the Degree Checklist(s) provided to every incoming graduate student by Daniela Ibarra, Graduate Student Coordinator (please see **Appendix A**).

5. Every incoming graduate student must attend departmental orientation available for graduate students and post-docs every semester. This will be administered by Dr. Muluneh Yitayew, Graduate Advisor

6. Graduate students from other departments, who are seeking a minor in the ABE department, are required to take12 units of ABE courses and 1 unit of ABE 696a Section 2 (presentation). The exact courses will be determined by the student and his/her minor advisor

7. Please see **Appendix B** regarding: Thesis/Dissertation Option for Submitted/Accepted/Published Manuscript(s).

F. TYPICAL PROGRAMS

BIOLOGICAL ENGINEERING

Typical Ph.D. courses

ABE 523	3	Biosystems Analysis and Design
ABE 547	3	Sensors and Controls
ABE 581A	3	Engineering of Biological Processes
ABE 581B	3	Bioprocess Engineering Applications
ABE 584	3	Biosystems Transport Phenomena
ABE 586	3	Biomaterial-Tissue Interactions
ABE 589B	3	Bio Micro/Nanotechnology Applications
MATH 509C	3	Statistics for Research
MATH 522	3	Advanced Applied Analysis
MATH 562	3	Time Series Analysis
MATH 575A	3	Numerical Analysis
ABE 601	2	Research Methods in Biosystems Engineering
ABE 696A	2	Agricultural and Biosystems Engineering
ABE 920	18	Dissertation
Minor	12	Minimum of Minor courses
Total	**67**	

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

ABE 582	3	Simulation of Biological Systems
ABE 583	3	Controlled Environment Systems

BME 510	3	Biology for Biomedical Engineering
BME 511	3	Physiology for Biomedical Engineering
BME 516	3	Principles of Biomedical Engineering
BME 517	3	Measurement and Data Analysis in Biomedical Engineering
CHEE 505	3	Advanced Chemical Engineering Transport Phenomena
CHEE 520	3	Chemical Reaction Engineering
CHEE 577A	4	Microbiology for Engineers
CHEE 577L	1	Microbiology for Engineers Laboratory
CHEE 577R	3	Microbiology for Engineers
MSE 561	3	Biological and Synthetic Materials
PL S 575A	3	Physiology of Plant Production under Controlled Environment
PL S 580	3	Medicinal Plants
SWES 525	3	Environmental Microbiology
SWES 526	2	Environmental Microbiology Laboratory

With a minor in Biomedical Engineering:

BME 510	3	Biology for Biomedical Engineering
BME 511	3	Physiology for Biomedical Engineering
BME 516	3	Principles of Biomedical Engineering
BME 517	3	Measurement and Data Analysis in Biomedical Engineering

With a minor in Chemical and Environmental Engineering

CHEE 520	3	Chemical Reaction Engineering
CHEE 577A	4	Microbiology for Engineers
CHEE 577L	1	Microbiology for Engineers Laboratory
CHEE 577R	3	Microbiology for Engineers

With a minor in Soil, Water and Environmental Science

SWES 501	3	Management of Arid Land and Salt-Affected Soils
SWES 520	3	Environmental Physics
SWES 525	3	Environmental Microbiology
SWES 526	2	Environmental Microbiology Laboratory

WATER RESOURCES ENGINEERING AND/OR IRRIGATION ENGINEERING

In addition to the general graduation requirements listed in Section C, students whose programs emphasize Water Resources and/or Irrigation Engineering must demonstrate an advanced understanding of hydraulics and fluid mechanics as determined by the qualifying examination.

Typical Ph.D. courses

ABE 526	3	Soil and Water Conservation Engineering
ABE 555	3	Soil and Water Resources Engineering
ABE 556	3	Irrigation system Design
ABE 558	3	Agricultural Drainage and Effluent Treatment
MATH 509C	3	Statistics for Research
MATH 522	3	Advanced Applied Analysis
MATH 562	3	Time Series Analysis
MATH 575A	3	Numerical Analysis
ABE 547	3	Sensor and controls
ABE 567	3	Advanced Watershed Hydrology
ABE 601	2	Research Methods in Biosystems Engineering
ABE 605	3	Soil-Water Dynamics
ABE 696A	2	Seminar-Agricultural & Biosystems Engineering
ABE 910	5	Thesis transfer
ABE 920	18	Dissertation
Minor	12	Minimum of Minor courses
TOTAL	**72**	

With a minor in Soil, Water and Environmental Science

SWES 501	3	Management of Arid Land and Salt-Affected Soils
SWES 520	3	Environmental Physics
SWES 570	3	Soil Physics
SWES 565	3	Contaminant Transport in Porous Media

With a minor in Civil Engineering

C E 522	3	Open-Channel Flow
C E 502	3	Introduction to Finite Element Methods
C E 504	4	Numerical Methods in Subsurface Hydrology
C E 523	3	Hydrology

With a minor in Watershed Management and/or in Renewable Natural Resources

For a list of minor courses, please consult a Natural Resources Academic Advisor.

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

C E 522	3	Open-Channel Flow
C E 502	3	Introduction to Finite Element Methods
C E 504	4	Numerical Methods in Subsurface Hydrology
C E 523	3	Hydrology
SWES 501	3	Management of Arid Land and Salt-Affected Soils
SWES 520	3	Environmental Physics

SWES 553	3	Remote Sensing of the Environment
SWES 565	3	Contaminant Transport in Porous Media
SWES 570	3	Soil Physics
SWES 602	3	Nutrient Dynamics in Soils
SWES 605	3	Soil-Water Dynamics
WS M 560	3	Watershed Hydrology
WS M 562	3	Watershed Management
WS M 567	3	Advanced Watershed Hydrology
WS M 573	3	Spatial Analysis and Modeling
WS M 605	3	Watershed Modeling
RNR 503	3	Applications of Geographic Information Systems
RNR 517	3	Geographic Information Systems for Natural Resources
RNR 520	3	Advanced Geographic Information Systems
RNR 573	3	Spatial Analysis and Modeling
RNR 575	3	Economics of Natural Resource Policy
RNR 580	3	Natural Resources Policy and Law
RNR 583	3	Geographic Applications of Remote Sensing
HWR 517	3	Fundamentals of Water Quality
CE 526	3	Soil and Water Conservation Engineering

SENSORS

Typical Ph.D. courses:

ABE 523	3	Biosystems Analysis and Design
ABE 547	3	Sensors and Controls
ABE 579	3	Applied Instrumentation for CEA
ABE 589B	3	Bio Micro/Nanotechnology Applications
A ME 586	3	Micro fluidics
SWES 525	3	Environmental Microbiology
SWES 553	3	Remote Sensing of the Environment
ABE 696A	2	Agricultural and Biosystems Engineering
MATH 509C	3	Statistics for Research
MATH 522	3	Advanced Applied Analysis
MATH 562	3	Time Series Analysis
MATH 575A	3	Numerical Analysis
ABE 601	2	Research Methods in Biosystems Engineering
ABE 920	18	Dissertation
Minor	12	Minimum of Minor courses
TOTAL	**67**	

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

ABE 583	3	Controlled Environment Systems
ABE 584	3	Biosystems Transport Phenomena
A ME 455	3	Control System Design

BME 517	3	Measurement and Data Analysis in Biomedical Engineering
CHEE 413	3	Process Control and Simulation
CHEE 577A	4	Microbiology for Engineers
CHEE 577L	1	Microbiology for Engineers Laboratory
CHEE 577R	3	Microbiology for Engineers
ECE 583	3	Remote Sensing Instrumentation and Techniques
OPTI 550	3	Fundamentals of Remote Sensing
OPTI 566	3	Optical Detectors and Detector Systems
OPTI 587	3	Fiber Optics Laboratory
OPTI 630	3	Biomedical Optics and Biophotonics
SWES 526	2	Environmental Microbiology Laboratory

With a minor in Biomedical Engineering:

BME 510	3	Biology for Biomedical Engineering
BME 511	3	Physiology for Biomedical Engineering
BME 516	3	Principles of Biomedical Engineering
BME 517	3	Measurement and Data Analysis in Biomedical Engineering

With a minor in Optical Sciences:

OPTI 550	3	Fundamentals of Remote Sensing
OPTI 566	3	Optical Detectors and Detector Systems
OPTI 587	3	Fiber Optics Laboratory
OPTI 630	3	Biomedical Optics and Biophotonics

With a minor in Soil, Water and Environmental Science

SWES 501	3	Management of Arid Land and Salt-Affected Soils
SWES 520	3	Environmental Physics
SWES 526	2	Environmental Microbiology Laboratory

CONTROLLED ENVIRONMENT ENGINEERING

Typical Ph.D. courses

ABE 547	3	Sensors and Controls
ABE 581A	3	Engineering of Biological Processes
ABE 582	3	Simulation of Biological Systems
ABE 583	3	Controlled Environment Systems
ABE 584	3	Biosystems Transport Phenomena
ABE 585	3	Engineering Biological Processes
ABE/PLS 575A	3	Physiology of Plant Production under CE
ABE/PLS 579	3	Applied Instrumentation for CEA
ABE 601	2	Research Methods in Biosystems Engineering
MATH 522	3	Advanced Applied Analysis

MATH 509C	3	Statistics for Research
MATH 562	3	Time Series Analysis
MATH 575A	3	Numerical Analysis
ABE 696A	2	Graduate Seminar
ABE 920	18	Dissertation
Minor	12	Minimum of Minor courses
TOTAL	**67**	

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

ABE 523	3	Biosystems Analysis and Design
ABE 555	3	Soil and Water Resource Engineering
ABE 556	3	Irrigation System Design
ABE 581B	3	Bioprocess Engineering Applications
ABE 597C	3	Greenhouse Pest Management Applications and Practices
CHEE 530	3	Advanced Chemical Reaction Engineering
CHEE 574	3	Environmental Transport Processes
CHEE 577A	4	Microbiology for Engineers
MATH 556	3	Applied Partial Differential Equations
MATH 575A	3	Numerical Analysis
SIE 500A-C	3	Introduction to Systems and Industrial Engineering Methods
SIE 530	3	Engineering Statistics
SIE 531	3	Simulation Modeling and Analysis
SIE 545	3	Fundamentals of Optimization
SIE 570	3	Intelligent Control Systems & Applications
SWES 520	3	Environmental Physics
SWES 525	3	Environmental Microbiology
SWES 540	3	Biodegradation of Pollutants in Soil and Groundwater
SWES 553	3	Remote Sensing
SWES 573	3	Monitoring Biosphere Processes
WFSC 556	3	Aquaculture

Minor Courses (Plant Sciences):

PL S 508	3	Crop Ecology
PL S 550	3	Plant Anatomy and Morphology
PL S 560	3	Core Concepts in Plant Biology
PL S 580	3	Medicinal Plants

Minor courses (Systems & Industrial Engineering):

SIE 558	3	Computational Intelligence for Systems Analysis and Decision Making
SIE 570	3	Intelligent Control Systems & Applications
SIE 531	3	Simulation Modeling and Analysis
SIE 550	3	Theory of Linear Systems

APPENDIX - A

DEGREE CHECKLIST FOR: **Master of Science Students**

WHAT	WHEN	COMPLETION DATE	NOTES
Choose advisor and meet with your advisor to plan your program of study	First semester		
Progress Report—Informal individual contact with each committee member	Every semester – Fall (2nd Friday of October) & Spring (2nd Friday of March)		
Submit Plan of Study to Graduate Degree Certification	Second semester in residence		
Select research topic and prepare research project proposal	By end of second semester		
Select graduate committee members — Formal meeting to discuss research project proposal	By or before the last day of classes on your second semester of residence		
Submit thesis to committee for approval and format review	Two weeks before thesis defense		
Schedule final thesis defense with your committee	Final semester		
Submit the Completion of Degree Requirements Form to Graduate Degree Certification	Final semester		
Submit final two library copies of thesis to Graduate Degree Certification **(if microfilming)**	Final semester		
Submit one bound copy of thesis to the A.B.E. Graduate Coordinator	Final semester		
Clear all fees with Bursar's Office	Final semester		

APPENDIX - A (CONT.)

DEGREE CHECKLIST FOR: **Doctoral Students**

WHAT	WHEN	COMPLETION DATE	NOTES
Qualifying Examination	First semester		
Choose advisor and meet with your advisor to plan your program of study	First semester		
Progress Report—Informal individual contact with each committee member	Every semester – Fall (2nd Friday of October) & Spring (2nd Friday of March)		
Select graduate committee members — Formal meeting to discuss research project proposal and select research topic	By or before the last day of classes on your third semester of residence		
Prepare research proposal and Submit Doctoral Plan of Study	By end of third semester		
Schedule the Written Comprehensive Exam	After completion of a minimum of 3/4 of your coursework		
Submit request to schedule the Oral Comprehensive Exam to the Graduate Degree Certification Office	At least a week before exam		
Submit the Doctoral Advancement to Candidacy form to Graduate Degree Certification	No later than 6 months before you schedule the final oral defense exam		
Submit a copy of the dissertation to your committee for approval and format review	Two weeks before the final oral exam		
Submit Announcement of Oral Defense Examination to Graduate Degree Certification	At least a week before the date of the final oral defense examination		
Submit final two library copies of the dissertation to Graduate Degree Certification	Final semester		
Submit a bound copy of the dissertation to the A.B.E. Graduate Coordinator	Final semester		
Clear all fees with Bursar's Office	Final semester		

APPENDIX B

THESIS/DISSERTATION PAPER-OPTION

Objectives

The primary objectives of the new option are:

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

Similar options are available in many European and US institutions (including at least two departments at the UA). Note that an ABE graduate student, Elisa Suarez-Rey, recently completed her Masters degree under this option. You may review the original copy of her thesis is available in the department office. Three sample dissertations from the Department of Civil Engineering and the Soil, Water and Environmental Science Department are available in the ABE main office for your reference. Although the formats of these samples are somewhat different from the ABE Paper-Option Format, these dissertations will give you general ideas for your thesis/dissertation. Please review the ABE Committee Paper-Option Signature Approval Form.

If you have any questions regarding this new thesis/dissertation option, please do not hesitate to contact Dr. Muluneh Yitayew and/or your advisor.

Guidelines

- There is no restriction on the number of manuscripts.

- Manuscript(s) must be submitted to or published in refereed journal(s) before final committee approval of the thesis/dissertation. The student must be the first author for all papers included. A formal letter or email response from the journal editor must accompany the thesis/dissertation if the manuscript(s) is in review or in press. His/her role in the research and production of the manuscript(s) should be clearly specified.

- Prior to the submission of each manuscript, an advisor's (and co-advisor's, if any) approval is required. After the advisor's review, each manuscript must be approved by a majority of the thesis/dissertation committee members. A majority of the committee members must also approve the journal to which a manuscript will be submitted. Attach the signature page for the ABE paper option for each manuscript.

Recommended Thesis/Dissertation Format

TITLE PAGE

SIGNATURE PAGE (DISSERTATION ONLY)

STATEMENT BY AUTHOR

ACKNOWLEDGEMENTS

DEDICATION

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

LIST OF ILLUSTRATIONS (FROM INTRODUCTION & PRESENT STUDY)

LIST OF TABLES (FROM INTRODUCTION & PRESENT STUDY)

ABSTRACT

CHAPTER 1. Introduction
- Explanation of the problem(s), objectives, and uniqueness
- The relationship of the manuscripts included and your contribution to each of the manuscripts
- Specify your role in the research and production of the manuscript(s). Where research efforts are part of larger collaborative project, identify one aspect of the project as your own and demonstrate an original contribution.
- An overall literature review and background

CHAPTER 2. Present Study
- Overall Summary
- Overall Conclusions and Recommendations

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

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

APPROVAL BY COMMITTEE MEMBERS

THESIS/DISSERTATION OPTION
FOR SUBMITTED/PUBLISHED MANUSCRIPT

DEPARTMENT OF AGRICULTURAL AND BIOSYSTEMS ENGINEERING
THE UNIVERSITY OF ARIZONA

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

_____

entitled

_____

and approved submission to

_____

in partial fulfillment of the requirements for the Degree of

_____

APPROVAL BY ADVISOR(S):

_____ _____
(Advisor) Date
Department of Agricultural and Biosystems Engineering

APPROVAL BY COMMITTEE MEMBERS (Print name after signature):

_____ _____
Member Date

_____ _____
Member Date

_____ _____
Member Date

Faculty of the Department

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

AN, LINGLING, Assistant Professor, Biometry, Ph.D., 2008, Purdue University. Dynamic clustering of periodic gene expression.

ANDRADE-SANCHEZ, PEDRO, Assistant Professor/Specialist, Ph.D., 2004, University of California Davis. Biological and Agricultural Engineering.

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

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

BOGOSIAN, GREGG, Adjunct Professor, Ph.D., 1983, Purdue University. Biotechnology. Primary appointment as a Senior Fellow and Head of Microbial and Molecular Biology for Animal Agriculture in Monsanto BB3M, Chesterfield, MO.

CARPENTER, EDWIN H., Adjunct Professor, Ph.D., 1972, Penn. State University. Media and information transfer, operations and systems.

CHOI, CHRISTOPHER Y., Professor, Ph.D., 1990, Colorado State University. Heat and mass transfer through porous media, numerical and experimental heat transfer.

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

CUELLO, JOEL L., Associate Professor, Ph.D., 1994, The Pennsylvania State University. Bioreactor design and scale up, controlled-environment micropropagation, cell and organ cultures regulations.

D'SILVA, AECIO M., Adjunct Associate Professor, Ph.D., 1993, University of Arizona. Aquaculture Biotechnology, Warm Water Aquaculture, and Computer Intelligent Systems.

FANGMEIER, DELMAR D., Professor Emeritus, PE, Ph.D., 1967, Univ. Cal. Davis. Surface Irrigation, Sprinkler and Trickle Irrigation.

FARRELL-POE, KATHRYN, Professor, Ph.D., 1990, Purdue University. Water quality, on-farm composting.

FITZSIMMONS, KEVIN, Professor, Ph.D., 1999, University of Arizona. Wildlife and Fisheries Science, primary appointment in Soil, Water and Environmental Science.

FREITAS, ROBERT, Associate in Extension, M.S., 1991, University of Arizona. Water quality, animal waste management.

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

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

HAYDEN, ANITA, "TEENA", Adjunct Assistant Professor, Ph.D., 2001, University of Arizona. Hydroponic and aeroponic plant systems, green houses, controlled environment agriculture.

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

HOFFMAN, GLENN, Adjunct Professor, Ph.D., 1967, North Carolina State University, Management and reclamation of salt-affected soils, the influence of various environmental factors on crop salt tolerance and plant growth, and instrumentation for measuring plant response to salt and water stress.

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

KAÇIRA, MURAT, Associate Professor, Ph.D., 2000, Ohio State University. Food, agricultural, and biological engineering.

KUBOTA, CHIERI, Associate Professor, Ph.D., University of Tokyo, primary appointment in Plant Sciences.

LARSON, DENNIS L., Associate Professor, PE, Ph.D., 1971, Purdue University. System analysis, energy engineering.

MARTIN, ED, Specialist & Professor, Ph.D., 1992, Michigan State University. Water resources, irrigation management.

MATLOCK, GERALD W., Professor Emeritus, Ph.D., 1965, University of Arizona. Structures and environment.

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

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

OGDEN, KIMBERLY L., Professor, Ph.D., 1991, University of Colorado, primary appointment in Chemical and Environmental Engineering.

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

PIEGORSCH, WALTER W., Professor, Ph.D., 1984, Cornell University. Statistics, primary appointment in Mathematics. Chair, Graduate Interdisciplinary Program in Statistics, University of Arizona.

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

RASMUSSEN, WILLIAM O., Associate Professor, Ph.D., 1973, U of Arizona. Simulation and modeling, geophysics, hydrology.

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

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

RILEY, MARK R., Associate Professor, Ph.D., 1995, Rutgers University. Biotechnology, Animal cell culture, Applied spectroscopy, Immobilized enzymes.

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

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

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

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

SWADER, FRED N., Adjunct Professor, Ph.D.,, Cornell University. USDA-CSREES National Program Leader for Water Quality (retired).

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

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

WALLER, PETER, Associate Professor, Ph.D., 1990, University of California at Davis. Water quality engineering, irrigation engineering, drainage engineering.

WELCHERT, WILLIAM T., Professor Emeritus, Ph.D. 1963, Michigan State University

WIERSMA, FRANK, Professor Emeritus, Ph.D., 1966, Oklahoma State University. Structures and environment.

YITAYEW, MULUNEH, Professor, Ph.D., 1982, U of Arizona. Irrigation engineering, hydraulics, water resources engineering.

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

ZIMMT, WERNER S., Adjunct Professor, Ph.D., 1947, University of Chicago, Ph.D., 1951, University of Chicago. Chemistry and Physics of Coating, Polymer Science, Application of Polymers, Atmospheric Chemistry.

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