Aquaponics Engineering
BE 444/544 (3 units)
[Tues/Thurs - Spring]

Description of Course
This course begins with an overview of aquaponics – the culture of fish and plants together – and then provides an in depth guide into properly designing, building and troubleshooting aquaponics systems, especially on the commercial scale. Engineering aspects of aquaponics systems will be thoroughly discussed in addition to biochemical processes, filtration and designing for various flow rates, fish species and plants. The course provides students with numerous hands-on learning activities and offers students the opportunity to advance their knowledge of aquaponics well beyond the basics. Typically offered: Spring.

Course Prerequisites or Co-requisites
Advanced standing in Engineering, BE 334 (Aquaponics Design) or instructor approval required
Math 111 and Math 112 are recommended
CE 218 (Fluid Dynamics) or equivalent is also recommended

Instructor and Contact Information
Dr. Matthew “Rex” Recsetar, Office at CEAC, cell:(847) 814-2741, msrecs@email.arizona.edu
Office Hours: 10:00 am-Noon Tues, Thurs or by appointment
Course homepage: https://d2l.arizona.edu/d2l/home/593665

Course Communications
Students can communicate with the instructor through email (msrecs@email.arizona.edu), or D2l Discussion board

Course Format and Teaching Methods
The course will consist of lectures, videos, readings and interactive activities. The class will be taught in somewhat of a flipped format as many of the lectures will be completed outside of class hours with in-class time devoted to more hands-on activities, group work and discussion. Bi-weekly discussion posts will be required. There will also be multiple group activities, one of which will be a final design project of a commercial aquaponic system. There will also be short quizzes at the beginning of each class to assess participation. In addition, students will be required to complete extracurricular activities, most of which will be completed during class hours but will have options for students to do on their own time.

Course Objectives and Expected Learning Outcomes
Course Objectives
This course will
1. Emphasize engineering principles pertaining to successful aquaponics designs.
2. Familiarize students with microbiomes present in aquaponics systems.
3. Discuss different types of aquaponics systems, its components and how they can be
designed to optimize the engineering.

4. Demonstrate techniques, skills and tools necessary for building, designing and running
advanced aquaponics systems of various size and scope

**Student Learning Outcomes**

By the end of the semester, students will be able to:

1. Thoroughly **describe** what aquaponics is and **explain** how and why it works.

2. **Identify** and **select** the optimal design parameters for an aquaponic system based on
growing specific plants/crops.

3. **Develop** a framework of the various building components, sensors and controls that are
needed to fabricate successful, turn-key aquaponics systems and estimate their costs

4. **Discuss** the role aquaponics will play in the future of food.

5. **Design** and **build** a small-scale aquaponics system.

6. **Design** a commercial aquaponics system

7. **Complete** an energy balance for an aquaponics system (Grad students only)

8. **Create** a biosecurity plan for a commercial aquaponics system (Grad students only)

**Required Texts or Readings**

[There is no required text for this class]

   University of Arkansas Cooperative Extension Service FSA 9618. 6 pp.


   aquaponics system in Baltimore, Maryland, United States. Aquaculture Engineering 68
   pp 19-27.

5. Goddek S et al. 2015. *Challenges of Sustainable and Commercial Aquaponics.* Sustainability
   vol. 7 no. 4, pp. 4199-4224


   143, 342-347.

Optional and Recommended Readings


(PDF links will be provided for the above articles in D2L)

Good reference book:
- Recirculating Aquaculture by Timmons and Ebeling

Required or Special Materials

Parts for mini-aquaponics systems and labs will be provided by the instructor ($50 cost)

Required Extracurricular Activities (Graduate Students Only)

Extracurricular activities: the following activities must be completed by graduate students:
- Visit the Biosphere 2 (Write a one to two page essay on how aquaponics fits into the future of food)
- Develop a biosecurity plan for a commercial aquaponics operation
- Create an energy balance for your group’s aquaponics system
- Come up with a potential innovation that could help with the commercialization of aquaponics and discuss how it could be implemented.

*Specific direction and rubrics for the assignments will be posted in the content area of D2L.

Assignments and Examinations: Schedule/Due Dates

Exams will be taken in class on the assigned day unless other arrangements are made with the instructor. 2 hours will be allowed for exams, which will consist of multiple choice, short answer and fill in the blank questions.

There will be 5 discussion posts required that relate to course material, and we will go over discussions during class where interaction will take place.

*Specific direction and rubrics for the assignments will be posted in the content area of D2L.
Your course grade will be based on Exams and quizzes, group projects, participation in discussions, attendance and completion of system building labs.

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Value (undergrad)</th>
<th>Value (Grad)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exams (2 @ 100)</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Group Build Project</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Final Group Design project</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Discussion Posts (5 @ 15)</td>
<td>75</td>
<td>75</td>
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<tr>
<td>Reading Quizzes (10 @ 10)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Labs (10 @ 10)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Attendance (25 @ 1)</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Grad student projects (4 @ 25)</td>
<td></td>
<td>100</td>
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<tr>
<td>Total</td>
<td>700</td>
<td>800</td>
</tr>
</tbody>
</table>

**Final Examination or Project**

The final project will consist of you and your group developing plans for a commercial-scale aquaponic system of your design. Groups will collaborate both in and out of class, and develop a complete blueprint of the system with all associated costs, parts and equipment. I will closely follow the progress of each group and offer guidance as needed. The design blueprint can be done in AutoCAD, Sketch-up or Solid Works. Up to 15 points extra credit will be given to groups that build a physical model. Each project will be presented at the end of the semester in front of the class.

The final project will be in lieu of the final exam.

*Specific direction and rubrics for the assignments will be posted in the content area of D2L.*

**Grading Scale and Policies**

**DETERMINATION OF CLASS GRADES:**

<table>
<thead>
<tr>
<th>Score</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-100% (630-700)</td>
<td>A</td>
</tr>
<tr>
<td>80-89% (560-629.9)</td>
<td>B</td>
</tr>
<tr>
<td>70-79% (490-559.9)</td>
<td>C</td>
</tr>
<tr>
<td>60-69% (420-489.9)</td>
<td>D</td>
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<tr>
<td>Below 420</td>
<td>E</td>
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</tbody>
</table>

**GRADE DEFINITIONS**

A: Achievement that is outstanding relative to the level necessary to meet course requirements.

B: Achievement that is significantly above the level necessary to meet course requirements.

C: Achievement that meets the course requirements in every respect.

D: Achievement that is worthy of credit even though it fails to fully meet the course requirements.

E: Represents failure (no credit) and signifies that the work was not worthy of credit or was not completed.

**Requests for incomplete (I) or withdrawal (W)** must be made in accordance with University policies, which are available at [http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete](http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete) and [http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal](http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal) respectively.

**Dispute of Grade Policy**

Students will have one week to dispute a grade on a project, quiz or exam.
<table>
<thead>
<tr>
<th>Module</th>
<th>Date</th>
<th>Day</th>
<th>Lecture or Lab Topics</th>
<th>Required Readings or Discussions Due</th>
<th>Online Videos, lectures &amp; Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-16</td>
<td>R</td>
<td>Class Overview</td>
<td>Discussion 1 Reading 1 (Recsetar and Kelly)</td>
<td>Introduction to Aquaponics</td>
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<td>Introduction to Aquaponics</td>
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<tr>
<td></td>
<td>1-21</td>
<td>T</td>
<td>Floating Raft Systems</td>
<td>Reading 2 (Rakocy et al.)</td>
<td></td>
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<tr>
<td></td>
<td>1-23</td>
<td>R</td>
<td>Lab 1: Field Trip to Merchant’s Garden</td>
<td></td>
<td>Working with PVC</td>
</tr>
<tr>
<td></td>
<td>1-28</td>
<td>T</td>
<td>Media Bed Systems</td>
<td></td>
<td>Bell Siphons</td>
</tr>
<tr>
<td></td>
<td>1-30</td>
<td>R</td>
<td>Lab 2: PVC &amp; Bell Siphons</td>
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<tr>
<td></td>
<td>2-4</td>
<td>T</td>
<td>NFT Systems</td>
<td>Reading 3 (Tyson et al.)</td>
<td>NFT Systems</td>
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<td></td>
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<td>Visit Amhydro greenhouse</td>
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<tr>
<td>2</td>
<td>2-6</td>
<td>R</td>
<td>Filtration (Group Project 1 Assigned)</td>
<td>Reading 4 (Love et al.) Ebeling &amp; Vinci (optional)</td>
<td>Filters; Clarifier-biofilter Build; Swirl Filter</td>
</tr>
<tr>
<td></td>
<td>2-13</td>
<td>R</td>
<td>Lab 4: Group Project Work Day 2 – Gathering Parts</td>
<td>Design Blue Print</td>
<td>Selecting the Appropriate Systems</td>
</tr>
<tr>
<td></td>
<td>2-18</td>
<td>T</td>
<td>Aeration</td>
<td></td>
<td>Aeration</td>
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<tr>
<td></td>
<td>2-20</td>
<td>R</td>
<td>Lab 5: Building and Sizing Filters</td>
<td>Building a Swirl Filter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-25</td>
<td>T</td>
<td>Aquaponic System Microbiomes</td>
<td>Reading 6 (Eck et al.)</td>
<td>Aeration</td>
</tr>
<tr>
<td></td>
<td>2-27</td>
<td>R</td>
<td>Lab 6: Group Project Work Day 3 -System Build</td>
<td>Discussion 3: Which type of system is cheapest and/or most efficient for commercial production?</td>
<td>Plumbing Guides 1 and 2</td>
</tr>
<tr>
<td></td>
<td>3-3</td>
<td>T</td>
<td>EXAM 1 (Modules 1,2)</td>
<td></td>
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<tr>
<td></td>
<td>3-5</td>
<td>R</td>
<td>Group Presentations (Group Project 1 Due)</td>
<td>NO CLASS</td>
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<tr>
<td>3</td>
<td>3-10</td>
<td>T</td>
<td>Spring Break</td>
<td>NO CLASS</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3-12</td>
<td>R</td>
<td>Spring Break</td>
<td>NO CLASS</td>
<td></td>
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<tr>
<td></td>
<td>3-17</td>
<td>T</td>
<td>Pumps and Pump Curves (Group project 2 Assigned)</td>
<td>CLASS CANCELED</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-19</td>
<td>R</td>
<td>Pressure and Flow, (and Sizing pumps)</td>
<td>Quiz 6- Biofiltration</td>
<td>Sizing Your Pump</td>
</tr>
<tr>
<td></td>
<td>3-24</td>
<td>T</td>
<td>Water Quality and Fish</td>
<td>Quiz 7 – Pressure and Flow</td>
<td></td>
</tr>
</tbody>
</table>
### Absence and Class Participation Policy

The UA’s policy concerning Class Attendance, Participation, and Administrative Drops is available at: [http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop](http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop)

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, [http://policy.arizona.edu/human-resources/religious-accommodation-policy](http://policy.arizona.edu/human-resources/religious-accommodation-policy).

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: [https://deanofstudents.arizona.edu/absences](https://deanofstudents.arizona.edu/absences)

Participating in the course and attending in-person lectures and labs is crucial to learning in this class. In addition, online lectures and other course events are vital to the learning process. As such, attendance is required, and more than 3 unexcused absences will result in being dropped from the course. Students who miss quizzes or exams due to illness or emergency are required to bring documentation from their health-care provider or other relevant, professional third parties. Failure to submit third-party documentation will result in a zero on the quiz. Labs can be
made up for credit if prior arrangements are made with the instructor.

**Makeup Policy for Students Who Register Late**
Since this is a 5-week summer course, students will only be allowed to miss the first 3 days due to late registration. These students will be allowed to complete past assignments as deemed appropriate by the instructor.

**Threatening Behavior Policy**
The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

**Accessibility and Accommodations**
At the University of Arizona we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520-621-3268) to explore reasonable accommodation. For additional information on the Disability Resource Center and reasonable accommodations, please visit http://drc.arizona.edu.

If our class meets at a campus location: Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

**Code of Academic Integrity**
Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.

The University Libraries have some excellent tips for avoiding plagiarism, available at http://www.library.arizona.edu/help/tutorials/plagiarism/index.html.

*Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor’s express written consent.* Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

**UA Nondiscrimination and Anti-harassment Policy**
The University is committed to creating and maintaining an environment free of discrimination; see http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

**Additional Resources for Students**
UA Academic policies and procedures are available at http://catalog.arizona.edu/policies

Student Assistance and Advocacy information is available at http://deanofstudents.arizona.edu/student-assistance/students/student-assistance

**Confidentiality of Student Records**
http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-
Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.