



## **BE/PLS 479/579 Applied Instrumentation for Controlled Environment Agriculture**

**LECTURES: Tuesday/Thursday, 10:00AM – 11:15AM**

**(Access to Lecture via <https://arizona.zoom.us/j/84444909009>; Passcode: 479579)**

**LAB (CEAC Classroom) - Thrs. 10:00-11:15 am**

**(for students rotating on Lab sessions, access to Lab sessions sessions**

**<https://arizona.zoom.us/j/84444909009>; Passcode: 479579)**

### **Description of Course**

Students will learn principles, methods, and techniques related to the measurement and control of environmental factors in controlled environment agriculture systems. Light intensity, light quality, temperature (air, plant), relative humidity, carbon dioxide, water, air current, and related factors are important variables in controlled environment plant production systems to measure and control since they affect and determine plant growth and development and processes such as heating, ventilating and air conditioning, fertigation etc. Therefore, students will learn application of sensors, instrumentation and designing of a simple system to measure and control environments for plant production systems.

### **Course Prerequisites or Co-requisites**

MATH 113 and PHYS 102, Adv. Stdg: Engineering, or (PLS major or minor. Junior or Senior status).

### **Instructor and Contact Information**

Murat Kacira, Ph.D.

Professor, Biosystems Engineering Department

Office: Controlled Environment Agric. Center (CEAC located at 1951 E. Roger Rd.) Room 101.

Phone: 520-626-4254, [mkacira@arizona.edu](mailto:mkacira@arizona.edu)

#### **Office Hours:**

- With Instructor: Monday 11:00am-12:00noon via Zoom
- (Zoom Link: TBD), and other than regular office hours please email me to make an appointment for Zoom based meeting and discussion.

#### Lab/Teaching Assistant

KC Shasteen, MS Student

Biosystems Engineering Department.

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

**Note:** This syllabus is longer than any syllabus in the past due to all the language around all of the course modalities for Spring 2021.

### **Course Objectives and Expected Learning Outcomes**

**The Course Objectives are:** 1) to outline for the student and expose them to the advantages, complexities, and problems of sensors and instrumentation for Controlled Environment Agriculture (CEA) related to environmental variables that control plant growth and development and also affect

climate in controlled environments, and 2) to provide student a hands-on experience that the student can apply to achieve the goal of their research or other applications being pursued in the controlled environment.

### ***Expected Learning Outcomes***

Upon completing the course, students will be able to:

- 1) **Apply** the skills to measure and record various environmental variables affecting plant growth/development and interior climate in the controlled environment plant production system.
- 2) **Recognize** the advantages, complexities and problems associated with environmental monitoring and control of plant growth and development.
- 3) **Analyze** and **Practice** guidelines for measuring and reporting the environmental variables for reporting.
- 4) **Design** and **Build** a prototype system for plant growth and development.
- 5) **Apply** and **Practice** the techniques and principles used for measuring temperature, humidity, light intensity, light quality, air current speed, and CO<sub>2</sub> concentration in controlled environment.
- 6) **Carry out** the maintenance and calibration of sensors.
- 7) **Interpret, Visualize** and **Verify** the measured environmental variables and results.
- 8) **Identify** and **Practice** with data loggers, data acquisition boards and environmental control systems.

In addition, graduate students are expected to work on a class project to learn how to:

- 9) **Propose, Design** and **Carry out** experiment with control applications.
- 10) **Write a Final Report** and **Present** the student design project, experiment and the results to an audience.

In accordance with the Accreditation Board for Engineering and Technology (ABET) goals of preparing graduates to meet the quality standards of their profession and global workforce, the course also supports the following ABET ***Program Educational Outcomes***:

- **ABET Criterion 5:** An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- **ABET Criterion 6:** An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions
- **ABET Criterion 3:** An ability to communicate effectively with a range of audiences (graduate students' projects presentation and final report)

### **Course Format and Teaching Methods**

The lectures sessions will be via Zoom. Lab assignments will be given following each lab sessions and report submissions will be made through course D2L. One midterm and a final exam will be taken and proctored in real-time via Zoom session. Lectures will include the use of power point presentations and discussions. The lab sessions will be both via Zoom sessions and at the Controlled Environment Agriculture Center (CEAC) classroom with students rotating for in-person lab sessions (details for student lab rotations will be shared in course D2L and discussed in the lectures). Facilities at CEAC, e.g. greenhouses and/or vertical farm facility will also be included as part of lab sessions as they are relevant for the lab/lecture contents and discussions. Students will also work on a lab project to design and develop a measurement, recording and control application for a prototype CEA system. Details of the class projects will be discussed with students and an instruction document will be made available via course D2L.

## Course Communications:

All lecture notes and administrative information, including course syllabus, will be posted on the D2L course webpage.

## COVID-19-Related Considerations

- This class is scheduled to be taught in the Flex0in-Person modality.
  - For lecture sessions, the entire class will be meeting on Tuesday and Thursday during 10am-11:15pm **via Live Zoom** (<https://arizona.zoom.us/j/84444909009>; **Passcode:** 479579). Our synchronous meetings will give us the opportunity to discuss about the course content scheduled for the session.
  - For lab sessions: The students will be divided into groups. The lab sessions will be both via Zoom sessions and at the Controlled Environment Agriculture Center (CEAC) classroom with students rotating for in-person lab sessions (details for student lab rotations will be shared in course D2L and discussed in the lectures). Lab procedures/guidelines will be posted in course D2L and communicated in the lecture discussions.
- If you feel sick:
  - Stay home. Except for seeking medical care, avoid contact with others and do not travel.
  - Notify your instructors if you will be missing an online course.
  - Campus Health is testing for COVID-19 - please call (520) 621-9202 before you come in.
    - Campus Health is testing individuals who are concerned that they are infected with or have been exposed to COVID-19.
    - They continue to test only students, staff, and faculty of the University at this time.
    - Campus Health providers will evaluate patients and order testing if appropriate.
    - Visit the **Campus Health website** for more information.
  - Visit the [UArizona COVID-19](#) page for regular updates
- If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The [Dean of Students Office](#) can be reached at 520-621-2057 or [DOS-deanofstudents@email.arizona.edu](mailto:DOS-deanofstudents@email.arizona.edu).
- Equipment and software required: For this class you will need daily access to the following hardware: [laptop or web-enabled device with webcam and microphone]; regular access to reliable internet signal; ability to download and run the following software: [web browser, Adobe Acrobat, etc.]. (2) A smart phone or a camera in which to take photos of your written exam pages for exam, (3) Zoom (free), (4) Adobe Acrobat (downloadable from site license). Watching the course lectures on a smartphone is not feasible due to the nature of the material and my writing on the notes. Note, please contact me ASAP if for any reason accessing this technology is a significant financial barrier for engaging in this course, so that I may connect you with the appropriate campus resources.
- Class Recordings:
  - Live Online class sessions will be recorded and posted to D2L. Students may not modify content or re-use content for any purpose other than personal educational reasons. All recordings are the intellectual property of the University of Arizona. Therefore, Students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension or civil action.
  - University of Arizona has decided that class session recordings are a part of your academic record. Accordingly, if you would like to not to be recorded, you are welcome to turn off your video and change your name during our synchronous lecture sessions.

## 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>

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>.

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

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Absences may affect a student's final course grade. If you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible. To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or [drc-info@email.arizona.edu](mailto:drc-info@email.arizona.edu). If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.

### **Recommended Textbook or Readings**

Langhans, R.W. and T.W. Tibbitts (Eds). 1997. Plant Growth Chamber Handbook. North Central Regional Publication No. 340. <https://www.controlledenvironments.org/growth-chamber-handbook/>

Fraden J. 2004. Handbook of Modern Sensors; Physics, Design and Applications. Springer Science+Business Media, LLC, ISBN 978-0-387-00750-2

Dunn, W. C. 2006. Introduction to Instrumentation, Sensors, and Process Control. Arctech House, Inc. Norwood, MA 02062, ISBN: 1-58053-011-7

### **Required or Special Materials**

Student will need to bring their own calculator, and writing/erasing instruments into the exam room for exams, nothing else will be allowed during the exams (if not mentioned by the Instructor specifically).

### **Required Extracurricular Activities**

Students are encouraged to study and work collaboratively outside the class hours and have discussions, especially for the class projects.

### **Assignments and Examinations: Schedule/Due Dates**

**Exam:** There will be one midterm and one final exam. Exams will be based on the topics covered in the lectures and lab sessions. Exams will only be re-graded when there is evidence of grading error. Midterm exam is scheduled on Feb 18<sup>th</sup> during class hour and will be given via Zoom session.

**Homework:** There will be several homework assignments based on the topics covered in the class and also in the lab sessions and will be posted in D2L. Students will submit homework and lab report via D2L.

### **Final Examination or Project**

The final exam will be given on May 10<sup>th</sup> (Monday) during 8:00-10:00am during Live Zoom Session.

Please review the Final Exam Regulations and Final Exam Schedule, <https://registrar.arizona.edu/courses-catalog/final-examination-schedule-spring-2021>

### **Grading Scale and Policies**

Total possible points obtained are 600 pts. These points will be awarded based on attendance, two

exams (midterm and final), homework assignments, design project, final technical report and end of semester presentation. The grading scale and requirements for undergraduate and graduate students is different. The undergraduate students will conduct a design project consisting of sensors and data acquisition system for monitoring and recording environmental parameters in a controlled environment system. However, the design project for the graduate students will require integration of control applications as well as monitoring and recording of environmental variables in a controlled environment system. In addition, the graduate students will also need to prepare a final technical report for the design project. Graduate students will prepare and make a technical end of semester oral presentation while undergraduate students will contribute to the presentation.

<b>Criteria</b>	<b>Undergraduate</b>	<b>Graduate</b>
Attendance/Participation	100 (17%)	100 (17%)
Midterm exam	150 (25%)	100 (17%)
Final exam	150 (25%)	100 (17%)
Homework assignments/Lab Reports	100 (17%)	100 (17%)
Design project with <i>monitoring application</i> , and presentation	100 (17%)	
Design Project with <i>control applications, Presentation and Final Project Report</i>	N/A	200 (33%)
<b>Total</b>	<b>600</b>	<b>600</b>

Grade for the course will be based on points accumulated over the course of the semester: 541-600 pts.= A; 481-540 pts.= B; 421-480 pts.= C; 361-420 pts.= D; 360 or below = E

A make-up exam may be scheduled only when a student has a valid excuse. The valid excuses for missing an examination are serious personal illness, or serious illness or death in your family, and pre-approved leave of absence signed by the UA Dean of Students (or Dean Designee) to attend a professional event. If you determine that you will be unable to attend an examination, inform the instructor. If you miss any of the exams without a valid excuse or documentation, you will be assigned a score of zero for the exam missed.

**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> and <http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively.

## **Classroom Behavior Policy**

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

## **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**

Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcomed to contact the Disability Resource Center (520-621-3268) to establish reasonable accommodations. For additional information on the Disability Resource Center and reasonable accommodations, please visit <http://drc.arizona.edu>.

If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

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-act-1974-ferpa?topic=ferpa>

## **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.

## Scheduled Topics/Activities

Schedule is approximate and maybe adjusted but all topics will be addressed.

Week	Topic
Week 1	Introduction to the course, format, and expectations
Week 2	Environmental factors and plant growth
Week 3	Data acquisition <ul style="list-style-type: none"> <li>• Sensor, Signals and Systems</li> <li>• Sensor Classification</li> <li>• Units of Measurements</li> </ul>
Week 4	Data recording and monitoring <ul style="list-style-type: none"> <li>• Data loggers</li> <li>• Automated data acquisition</li> </ul>
Week 5	Temperature Measurement <ul style="list-style-type: none"> <li>• Air temperature</li> <li>• Plant leaf and canopy temperature</li> <li>• Growing media temperature</li> </ul>
Week 6	Light Measurement <ul style="list-style-type: none"> <li>• Light intensity and quality</li> </ul>
Week 7	Humidity measurement <ul style="list-style-type: none"> <li>• Relative humidity</li> <li>• Absolute humidity</li> <li>• Vapor pressure deficit</li> </ul>
Week 8	Psychrometrics <ul style="list-style-type: none"> <li>• Fundamentals, processes, and applications</li> </ul>
Week 9	Air Current Speed Measurement <ul style="list-style-type: none"> <li>• Boundary layer</li> <li>• Cup anemometer</li> <li>• Hot wire anemometer</li> <li>• Sonic anemometer</li> </ul>
Week 10	Carbon Dioxide Concentration Measurement
Week 11	Plant Water Consumption Measurement <ul style="list-style-type: none"> <li>• Transpiration</li> <li>• Plant energy balance/model</li> <li>• Lysimeters</li> <li>• Sap flow gauges</li> </ul>
Week 12	Growing Media and Root Zone Sensing <ul style="list-style-type: none"> <li>• Water content</li> <li>• Electrical conductivity and pH</li> <li>• Dissolved oxygen</li> </ul>

Week 13	Control Process and Applications <ul style="list-style-type: none"><li>• ON/OFF control</li><li>• Feed-back and feed-forward control</li><li>• Proportional-Integral-Derivative (PID) control</li></ul>
Week 14	Environmental control technology and systems in CEA
Week 15	Information and control technologies in CEA
Finals week	<b><i>Final exam</i></b>