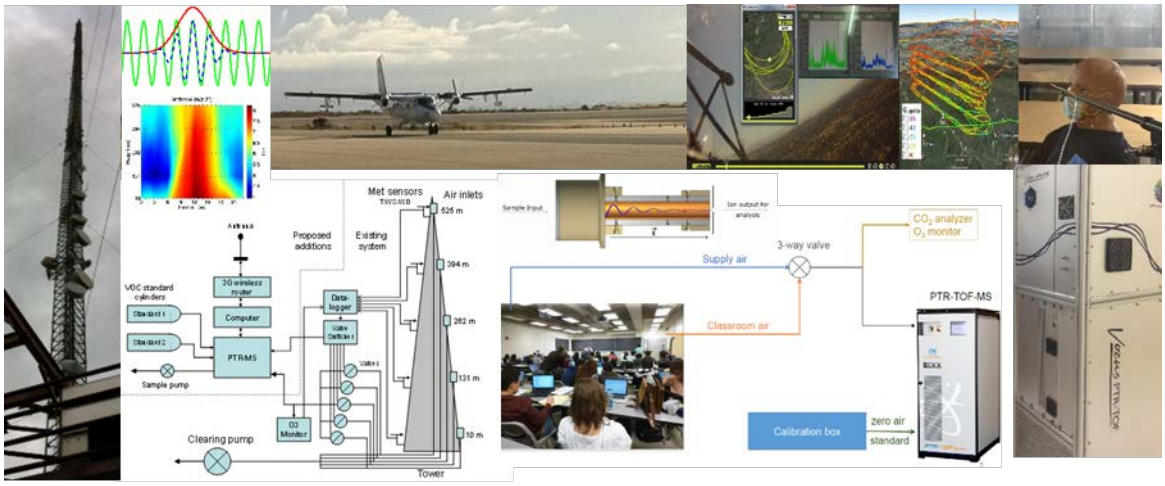
# Novel Air Quality Measurement Techniques CE 397 Fall 2020

The University of Texas at Austin
Department of Civil, Architectural, and Environmental Engineering




**Course Unique Numbers:** 15525 (hybrid), 15529 (online)
**Course Website:** https://utexas.instructure.com/courses/1289246
**Classroom and Time:** ECJ 3.122 Tuesday 12:30 – 2:00 pm, Thursday 12:30 – 2:00 pm
**Prerequisites**: Graduate student. For undergraduate students: CE369R or consent of instructor.
**Instructor**: Dr. Pawel Misztal
**Office**: ECJ 5.428
**Phone**: 512-232-5840
**e-mail**: misztal@utexas.edu
**website:** https://sites.utexas.edu/MisztalLab/
**TA**: Emma Hall echall3@utexas.edu

**Office Hours** Tuesday and Thursday 2:00 PM - 3:00 PM or by appointment.
While these are the standard office hours, I am *always* happy to speak with students in my office if the door is open or if encountered in the hallway. Appointments are welcome too either in person or via Zoom (link on Canvas).
**TA Office and office hours:** TBA (on Canvas)

**Course Catalog Description**
Technological advancements in measurements of indoor and outdoor air quality. Operation principles of novel real-time trace-gas sensors and mass spectrometers. Air quality measurements at different spatiotemporal scales: *hands-on* use of analytical instrumentation, data acquisition and data processing.

**Course Summary**
Students will gain practical knowledge and experience how to pose their air quality questions and address them through taking hands on measurements. The instruments of focus would be mass spectrometers measuring real-time gas-phase chemistry as well as other real-time sensors (e.g. ozone, wind data, CO2, particles, water vapor, carbon monoxide, etc). This course has both theoretical and laboratory character, as well as it could include excursions to measurement sites such as a test house, environmental chambers or an outdoor field site where measurements would be made (e.g. landfill, agricultural or forested site). A field study will be designed by students who would independently measure volatile organics from various indoor and outdoor sources. These exercises will expand the conceptual understanding of environmental sources and sinks of volatile organic compounds, will encourage synthetic and analytical thinking, and will give students a sense of achievement as an experimentalist.

Automation approaches are important for the success of the efficient experimental planning and design and the students will learn programming concepts of automations of both data acquisition and data processing.

**Course Objectives and Student Outcomes**

1. An ability to identify major chemical exposure sources indoors and outdoors and motivations for air quality measurements
2. An ability to familiarize with concepts of instrument's time resolution, chemical completeness, and chemical selectivity to guide appropriate tools for tackling general and specific air quality problems.
3. An ability to understand the principles of real-time and time-integrated analytical instruments applied to air quality measurements indoors and outdoors.
4. An ability to design an experiment to identify major volatile emission sources, characterize chemicals emitted from different materials (e.g. consumer care products) and/or chemical processes (e.g. cell metabolism).
5. An ability to conduct supervised hands-on measurement of comprehensive chemical composition from various sources and materials.
6. An ability to determine emission and/or uptake rates of different gaseous pollutants using a flow-through chamber and at larger scales indoors (e.g. classroom) and outdoors (e.g. tower).
7. An ability to connect knowledge by attending a field trip to a measurement site or industrial facility where air quality is monitored.
8. An ability to analyse data using manual, semi-automated and fully automated programming approaches to inform about abundant volatile pollutants, composition of sources, and comprehensive air quality.

**Textbooks and supplemental reading materials**

Students are encouraged to read provided papers and refer to textbooks to broaden air quality measurement aspects and interests. However, specific handouts (paper or electronic) and reading assignments may be provided as tailored to the specific topics.

**References**

Ellis, A.M. and Mayhew, C.A., 2013. Proton transfer reaction mass spectrometry: principles and applications. John Wiley & Sons. ISBN 9781118682883

Farmer, D.K., Vance, M.E., Abbatt, J.P., Abeleira, A., Alves, M.R., Arata, C., Boedicker, E., Bourne, S., Cardoso-Saldaña, F., Corsi, R. and DeCarlo, P.F., 2019. Overview of HOMEChem: House observations of microbial and environmental chemistry. Environmental Science: Processes & Impacts, 21(8), pp.1280-1300.

Koppmann, R.: Volatile Organic Compounds in the Atmosphere, John Wiley & Sons, 2008. ISBN: 978-1-405-13115-5

Krechmer, J., Lopez-Hilfiker, F., Koss, A., Hutterli, M., Stoermer, C., Deming, B., Kimmel, J., Warneke, C., Holzinger, R., Jayne, J. and Worsnop, D., 2018. Evaluation of a new reagent-ion source and focusing ion–molecule reactor for use in proton-transfer-reaction mass spectrometry. Analytical chemistry, 90(20), pp.12011-12018.

Liu, Y., Misztal, P.K., Xiong, J., Tian, Y., Arata, C., Weber, R.J., Nazaroff, W.W. and Goldstein, A.H., 2019. Characterizing sources and emissions of volatile organic compounds in a northern California residence using space-and time-resolved measurements. Indoor Air, 29(4), pp.630-644.

Misztal, P. K., Karl, T., Weber, R., Jonsson, H. H., Guenther, A. B., and Goldstein, A. H.: Airborne flux measurements of biogenic isoprene over California, Atmos. Chem. Phys., 14, 10631–10647, https://doi.org/10.5194/acp-14-10631-2014, 2014.

Misztal, P.K., Lymperopoulou, D.S., Adams, R.I., Scott, R.A., Lindow, S.E., Bruns, T., Taylor, J.W., Uehling, J., Bonito, G., Vilgalys, R. and Goldstein, A.H., 2018. Emission factors of microbial volatile organic compounds from environmental bacteria and fungi. Environmental science & technology, 52(15), pp.8272-8282.

Nazaroff, W.W. and Goldstein, A.H., 2015. Indoor chemistry: research opportunities and challenges. Indoor Air, 25(4), pp.357-361.
Nazaroff WW, Weschler CJ. Cleaning products and air fresheners: exposure to primary and secondary air pollutants. Atmospheric Environment. 2004 Jun 1;38(18):2841-65.
Salthammer, T., Zhang, Y., Mo, J., Koch, H.M. and Weschler, C.J., 2018. Assessing human exposure to organic pollutants in the indoor environment. Angewandte Chemie International Edition, 57(38), pp.12228-12263.
Tang, X., Misztal, P.K., Nazaroff, W.W. and Goldstein, A.H., 2016. Volatile organic compound emissions from humans indoors. Environmental science & technology, 50(23), pp.12686-12694.
Twilley, N. The Hidden Air Pollution in Our Homes. The New Yorker, April 1, 2019.

**Topics**

*Theoretical*

| | | |
|---|---|---|
| 1. | Course introduction and background | 0.5 wk |
| 2. | Chemical exposure sources around us | 0.5 wk |
| 3. | Measurements of air quality at different spatiotemporal scales | 1.5 wks |
| 4. | Operation principles of trace gas analysers and mass spectrometers | 2.5 wks |
| 5. | Designing experiments to measure indoor air quality in various environmental contexts | 2 wk |

*Hands-On*

| | | |
|---|---|---|
| 6. | Building and testing an emission-rate measurement setup (aka a “sniffing” experiment) | 1 wk |
| 7. | Measurement of emission rate of different trace gases from different materials (e.g. wood, consumer care products, sanitizers, air fresheners, beer, sodas) | 2 wk |
| 8. | VOC measurements in a classroom or the UTestHouse. | 1 wk |
| 9. | Excursion to a measurement facility at JJ Pickle or a field/industrial site | 1 wk |
| 10. | Data analysis: automation, quality control, interpretation | 1.5 wk |
| 11. | Summary and the future of air quality measurements | 0.5 wk |
| | | Total: 14 wks |

**Grading**

| | |
|---|---|
| Classroom Participation (attendance) | 5% |
| Midterm Test 1 | 15% |
| Midterm Project | 10% |
| Midterm Test 2 | 15% |
| Final Project & Presentation | 30% |
| Homework Assignments | 25% |
| | Total: 100% |

**Course Letter Grades** (for graduate and undergraduate students)

90-93, >93 A-, A
80-83, >83-86, >86-90 B-, B, B+
70-73, >73-76, >76-80 C-, C, C+
60-63, >63-66, >66-70 D-, D, D+

**Personal Problems**

Illnesses or personal problems need to be reported to me as soon as possible by email, phone or in person, so I can try to help, excuse the absence and provide study-at-home materials.

**Honor Code**
The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the university is expected to uphold these values through integrity, honesty, thrust, fairness, and respect towards peers and community.

**Academic Integrity statement**
Sharing of Course Materials is Prohibited: No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

**Wearing Masks**
Wearing a recommended protective face mask at all times when inside university buildings will be mandatory except when alone in a private office, eating in a campus dining facility or when students are in their own residence hall rooms. UT will encourage compliance by increasing awareness and fostering a spirit of cooperation. Students who refuse to follow directives to wear a mask will be referred to Student Conduct and Academic Integrity in the Office of the Dean of Students for disciplinary action.
More information on how you can help keep our campus healthy this Fall can be found here: "Protect Texas Together."

**Class Recordings**
Class recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings.

**COVID Caveats**
To help keep everyone at UT and in our community safe, it is critical that students report COVID-19 symptoms and testing, regardless of test results, to University Health Services, and faculty and staff report to the HealthPoint Occupational Health Program (OHP) as soon as possible. Please see this link to understand what needs to be reported. In addition, to help understand what to do if a fellow student in the class (or the instructor or TA) tests positive for COVID, see this University Health Services link.

**Disability statement**
The University of Texas at Austin provides, upon request, appropriate academic accommodations for qualified students with disabilities. For more information, contact the Division of Diversity and Community Engagement, Services for Students with Disabilities, 512-471-6259 (Videophone: 512-410-6644) or http://diversity.utexas.edu/disability/.

**Course Instructor Survey/Evaluation**
An evaluation of the course and instructor will be conducted at the end of the semester using the approved UT Course/Instructor evaluation forms.

**Emergency Preparedness Plan**

Emergency Preparedness means being ready. It takes an effort by all of us to create and sustain an effective emergency preparedness system. You are your own best first responder. Please use https://preparedness.utexas.edu/welcome-emergency-preparedness as a resource to better understand emergency preparedness at the university, and how you can become part of and contribute to the preparedness community. To monitor emergency communications for specific instructions go to utexas.edu/emergency. To report an issue (none emergency) call 512-471-4441. In case of emergency, call 911.

**Policy of Scholastic Dishonesty**
Students who violate University rules on scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and/or dismissal from the University. Since such dishonesty harms the individual, all students, and the integrity of the University, policies on scholastic dishonesty will be strictly enforced. For additional information, see the Dean of students' website and University General Information Catalog at: http://deanofstudents.utexas.edu/conduct/ and http://catalog.utexas.edu/general-information/appendices/appendix-c/student-discipline-and-conduct/.

**Privacy – Web Based Class Sites**
Web-based, password-protected class sites may be associated with all academic courses taught at the University. Syllabi, handouts, assignments and other resources are types of information that may be available within these sites. Site activities could include exchanging email, engaging in class discussions and chats, and exchanging files. In addition, electronic class rosters will be a component of the sites. Students who do not want their names included in these electronic class rosters must restrict their directory information in the Office of the Registrar, Main Building, Room 1. For information on restricting directory information, see: http://www.utexas.edu/student/registrar/catalogs/gi00-01/app/appc09.html.

**Student Drop Policy**
*Undergraduate Students*: From the 1st through the 12th class day (4th class day in the summer sessions), an undergraduate student can drop a course via the web and receive a refund, if eligible. From the 13th (5th class day in the summer sessions) through the university's academic drop deadline, a student may Q drop a course with approval from the Dean, and departmental advisor.
*Graduate Students*: From the 1st through the 4th class day, graduate students can drop a course via the web and receive a refund. During the 5th through 12th class day, graduate students must initiate drops in the department that offers the course and receive a refund. After the 12th class day, no refund is given. No class can be added after the 12th class day. From the 13th through the 20th class day, an automatic Q is assigned with approval from the graduate advisor and the Graduate Dean. From the 21st class day through the last class day, graduate students can drop a class with permission from the instructor, graduate advisor, and the Graduate Dean.

**Attendance Policy**
Regular attendance and participation are essential and expected. Random attendance will be taken throughout the semester by various means and it can affect the grade up to 5% (participation grade). A student who misses classes or other required activities, including examinations, for the observance of a religious holy day should inform the instructor as far in advance of the absence as possible, so that arrangements can be made to complete an assignment within a reasonable time after the absence. General university attendance policies and procedures are provided at http://catalog.utexas.edu/general-information/academic-policies-and-procedures/attendance/.

**Course Evaluations**
Each student will be given the opportunity to evaluate the course and the instructor using the standard course/instructor evaluation form at the end of semester.

**Computer Usage**
Some homework assignments and the term projects will require extensive use of computers, chemistry and mass spectrometry reference databases. The basic familiarity of Matlab and LabVIEW is recommended but extra tutoring/tutorials will be available for those students who are less familiar.

**Final Exam**
This course will not have a final exam. The final project and the final project presentation will replace the final exam.

**Projects**
There will be two projects assigned. The midterm projects will count for 10% and final for 30% of your final grade. Midterm project will be an individual project.

**Final Project Description**
Hands-on measurements of air quality tailored and guided to individual interests and predetermined research questions prior to the assignment. Example research projects include experimental determination of emission factors of selected compounds from consumer care products, indoor composts, paints, humans, indoor plants, etc. Measurements and data analysis of air quality inside and outside the UTest House, environmental chambers, and other ideas are also possible.
The project report should have a form of an extended abstract and include: (i) Title (needs to relate to air quality), (ii) Goals, (iii) Methods, (iv) Results and discussion, (v) Conclusions. The length should be aimed at between 1000 and 2500 words (the exact word count will not be checked). Figures and tables not included in the word count.

**Important Dates**
Test 1: September 29
Midterm project due: November 06
Preliminary results for the final project due: November 10
Test 2: November 24
Final project due: December 3

**Due Dates Policy**
All assignments are due at the end of the day and those turned in late will count off 5% per day unless excused or arranged otherwise in advance.

**Recommendations regarding emergency evacuation from the Office of Campus Safety and Security, 512-471-5767, https://financials.utexas.edu/avp-campus-safety**:

- Occupants of buildings on The University of Texas at Austin campus are required to evacuate buildings when a fire alarm is activated. Alarm activation or announcement requires exiting and assembling outside (across the bridge).
- Familiarize yourself with all exit doors of each classroom and building you may occupy. Remember that the nearest exit door may not be the one you used when entering the building.
- Students requiring assistance in evacuation shall inform their instructor in writing during the first week of class.
- In the event of an evacuation, follow the instruction of faculty or class instructors. Do not re-enter a building unless given instructions by the following: Austin Fire Dept., The University of Texas at Austin Police Dept., or Fire Prevention Services office.
- **Behavior Concerns Advice Line (BCAL) 512–232-5050. For more information visit the BCAL website:** http://www.utexas.edu/safety/bcal/

- Link to information regarding emergency evacuation routes and emergency procedures can be found at: www.utexas.edu/emergency

**All other university policies not explicitly included on this syllabus can be found on the General Information Catalog: http://catalog.utexas.edu/general-information/.**

## COURSE SCHEDULE

| Date | Topics | Due date for |
|---|---|---|
| 8/27 | Course introduction and background | |
| 9/01 | Chemical exposure sources around us | HW0 |
| 9/03 | Measurements of air quality at different spatiotemporal scales I | |
| 9/08 | Measurements of air quality at different spatiotemporal scales II | |
| 9/10 | Measurements of air quality at different spatiotemporal scales III | |
| 9/15 | Operation principles of trace gas analysers and mass spectrometers I | HW1 |
| 9/17 | Operation principles of trace gas analysers and mass spectrometers II | |
| 9/22 | Operation principles of trace gas analysers and mass spectrometers III, + Midterm project assignment | HW2 |
| 9/24 | Operation principles of trace gas analysers and mass spectrometers IV, + Review for midterm test 1 | |
| 9/29 **Online Canvas Quiz** | Midterm test 1 | Test 1 |
| 10/01 | Designing experiments to measure air quality I (outdoors) | |
| 10/06 | Designing experiments to measure air quality II (indoors) | |
| 10/08 | Designing experiments to measure indoor air quality III (indoors) | HW3 |
| 10/13 | Building an air quality measurement setup (e.g. “sniffing” experiment) | |
| 10/15 | Testing an air quality measurement setup + Final project assignment | |
| 10/23* **PRC** | Measurement of emission rates of different trace gases from different materials (construction materials – wood, wallboard, carpet, student ideas) Vocus 2R - PTRTOF | |
| 10/23* **PRC** | Measurement of emission rates of different trace gases from different materials (consumer products – antiperspirants, shampoos, student ideas) Vocus 2R - PTRTOF | |
| 10/30* **PRC** | Measurement of emission rates of different trace gases from different materials (food and beverages – sodas, beers, juice, student ideas) Vocus 2R - PTRTOF | HW4 |
| 10/30* **PRC** | Measurement of emission rates of different trace gases from different materials (plants - uncut and cut leaves, flowers, mosses) Vocus 2R - PTRTOF | |
| 11/06* **PRC** | Trace-gas measurements at the UTestHouse/Lab using VOCUS-PTRTOF and other trace gases, eddy covariance measurements | Midterm project |
| 11/06* **PRC** | Trace-gas measurements at the UTestHouse/Lab using VOCUS-PTRTOF | |
| 11/10 ECJ | Data analysis: automation, quality control, interpretation | Final project – preliminary results |
| 11/12 ECJ | Data analysis: automation, quality control, interpretation/ Review for Test 2 | HW5 |
| 11/20 | Excursion to a measurement facility at JJ Pickle or a field/industrial site | |
| 11/20 | Excursion to a measurement facility at JJ Pickle or a field/industrial site | |
| 11/24 **Online Canvas Quiz** | Midterm Test 2 | Test 2 |
| 11/26 | *Thanksgiving Day* | |
| 12/01 (online) | Discussion of current progress in air quality measurements (Texas, NYC, California), impact of COVID19 on air quality (outdoors and indoors) | |
| 12/03 (online) | Summary and the future advancements in air quality measurements | Final project |

*exact dates/times of some hands-on activities may change - to be confirmed in class to fit everyone’s schedule.