**GEO 369G (27755, 27759), Geophysical Measurements and Monitoring (Undergraduate)**

**GEO 396G (27955, 27959), Geophysical Measurements and Monitoring (Graduate)**

Syllabus, Spring 2022

*The course explores measurement and error theory; motivations, methods, and techniques to measure field and lab physical quantities; theory and design of sensors and instruments; microcontroller programming; and 3D design and printing.*

**Lectures will be online between Jan 18, 2022 and Jan 31, 2022 and in-person for the rest of the semester. Online classes will be broadcasted and recorded via ZOOM, and all lectures will be recorded via ZOOM.**

2 flags: **Independent inquiry and quantitive reasoning.**

**Tuesday and Thursday, 2 – 3:30 PM:** classroom: **JGB 2.312 and** https://utexas.zoom.us/j/97783596513

Instructor: **Nicola Tisato**

E-mail: **nicola.tisato@jsg.utexas.edu**

**Zoom office:** https://utexas.zoom.us/j/8363310129 (see below for more info)

Office Hours: **Tuesday and Thursday 11 AM – 12 PM + appointment**

***~Course outline and schedule***

Listed below are the topics for the course, which might slightly change during the semester. Although they must be separated to make this list, some will be mixed together and will come up in several contexts.

**1) T, Jan 18** *Present the class and the instructor. Introduction to the course, overview of measurements and monitoring. Material/books. (Chapter 1). Example: what you can do with ARDUINO: block-spring experiment laboratory earthquake.*

**2) Th, Jan 20** *The Vajont landslide: October 9, 1963: set the case for underground water monitoring and the importance of properly interpret geo-physical data. A first look at the ARDUINO IDE and board.*

**3) T, Jan 25** *Ohm's law. Voltage, current and resistance. Resistors. Series and parallel of resistances. Overview of the most important ARDUINO (C) commands, .ino files and libraries. Use your ARDUINO board to make an LED blinking when a button is pressed.*

**4) Th, Jan 27** *Analog to digital conversion. RS-232 (COM port / USB) communication. Measuring voltage and resistance with a tester and with your ARDUINO board.*

**5) T, Feb 1** *Sensors based on resistance variation: strain gauges, temperature sensors (NTC-PTC) and potentiometers. Water-level sensor based on a float and a potentiometer. Use a potentiometer with your ARDUINO to measure linear displacement.*

**6) Th, Feb 3** *Voltage, current and digital sensors. Use and concepts of water conductivity measurement. How to create an Alternate Current (AC) with ARDUINO to properly measure conductivity.*

**7) T, Feb 8** *Design a conductivity probe with Free-CAD and creation of a STL file for 3D printing. 3D printing concepts (slicing). Introduction to CURA software.*

**8) Th, Feb 10** *Test the in-class built conductivity meter. Calibration concepts: what does mean calibrating a sensor. Calibrate the conductivity meter with standard solutions.*

**9) T, Feb 15** *Test the in-class built conductivity meter. Explain the code.*

**10) Th, Feb 17** *Measurements and uncertainties: accuracy, precision, full scale, resolution, linearity. Modify the in-class conductivity meter to increase the precision with vertical staking and high-resolution measurements.*

**11) T, Feb 22** *Calibration of a sensor: load cell. Measurements and uncertainties: accuracy, precision, full scale, resolution, linearity. Error propagation. Modify the in-class conductivity meter to increase precision and provide measurement uncertainty.*

**12) Th, Feb 24** *Wheatstone bridge and strain gauges: pressure sensors and load cells. Dimensioning of a load cell. Design of a pressure sensor diaphragm and mechanical testing with Finite Element Modeling (FEM) in Free-CAD.*

**13) T, Mar 1** *Test 1*

**14) Th, Mar 3** *Capacitors, how capacitors are used in sensors and measurements. Signal noise reduction: Resistance-Capacitor (RC) filters. Charge and discharge of a capacitor, analytical solution and experiment with ARDUINO.*

**15) T, Mar 8***Temperature measurements, use of charge and discharge of a capacitor as base concept to build an inexpensive 0.01 K precision temperature sensor. Build a temperature datalogger by using the TMP36 and the microSD card.*

**16) Th, Mar 10** *Example of a project: studying the correlation between calcite over-growth and driprate on stalagmites. The driplogger for climate research.*

*>>> March 14-19 Spring Break! EUREKA!...who said EUREKA and why? <<<*

**19) T, Mar 22** *Load cell dimensioning and Wheatstone Bridge.*

**20) Th, Mar 24** *Semiconductors: Diodes, Transistors and Operational amplifiers*

**21) T, Mar 29** *Present your project: motivations, plan, technical part: hardware, software placing locations (7 min presentation + 4 min questions) + If time allows: Monitoring of Volcanoes.*

**22) Th, Mar 31** *Present your project: motivations, plan, technical part: hardware, software placing locations (7 min presentation + 4 min questions) + If time allows: Monitoring of Volcanoes.*

**23) T, Apr 5** *Creating a GPS-accelerometer based seismometer and tiltmeter for volcano monitoring.*

**24) Th, Apr 7** *Seismic monitoring. Transfer function of a sensor (Laplace transform and Bode diagrams): the geophone.* Working on your project.

***25) T, Apr 12*** *Phoronomy: monitoring and measuring level and flow rate of water stream: spillways, weirs dimensioning and sensors to measure water level. Working on your project.*

**26) Th, Apr 14** *How to present the results of your experiment (results of my project - drip rate datalogger)*. Working on your project.

**27) T, Apr 19** *Working on your project. Boris Brodsky from the foundry talks about 3D printing.*

**28) Th, Apr 21** *(If time allows: Measuring elastic properties of rocks in the laboratory. Vp, Vs with ultrasonic equipment. What is and how to use an oscilloscope.)*

**29) T, Apr 26**

**30) Th, Apr 28** Test 2

**29) T, May 3**

**30) Th, May 5** *Final assessment. Present the results of your project: (xx min, xx-4 min presentation + 3 min questions)*

*Two lessons are not filled in to allow for flexibility.*

**You might need to install Zoom on your computer and connect to the internet during lectures and labs.** We might use Zoom for live online meetings and lectures. Please click on this link to download, install, and login to get "zoom-ready". While it is possible to log in to Zoom through a personal account, please use your UT institutional account tied to your UT EID. See instructions below, or here: https://zoom.its.utexas.edu/

**Other requires software and websites**: We will be using Canvas to coordinate all activities, assignments and meetings. Canvas will be used to post homework, schedules and other files. Our course on Canvas is here: https://utexas.instructure.com/courses/1327103
You need to install on your computer: Arduino IDE (www.arduino.cc), Fritzing (https://fritzing.org/home/ installer https://utexas.box.com/s/ng27qux0go5qskxz0dia40305dh653oi), FreeCAD (https://www.freecadweb.org/).

## ***Course Description***

In the last decades geophysical, environmental and geotechnical measurements have become fundamental components of geo-related jobs and research activities. Moreover, the miniaturization and dissemination of "easy-to-use", affordable and high-quality microcontroller-based sensors enable everybody to create new or improving existing measuring tools. The

course “Geophysical Measurements and Monitoring” will provide the student the basis to understand environmental monitoring system and instruments.

The course will treat: i) natural scenarios where monitoring is needed; ii) practical examples of monitoring systems applied to geo-problems, iii) field and lab methods to measure water level, pressure and conductivity, stress and deformation, water flow and flash-floods, vibrations (e.g., earthquakes), monitoring of volcanoes; iv) uncertainties and error propagation; v) electric circuits, ARDUINO platform, communication, sensors and their application. During the class and as an assignment, the student will design and develop an ARDUINO-based data-logger (sensor+microcontroller+memory), also by using 3D modeling and 3D printing tools. The developed data-logger, which for instance could measure the water level in a river, will be deployed, and let measuring for some weeks. Then, the data-logger will be collected and the data analyzed to produce a final report.

For undergraduates (GEO369G): the course carries 2 flags: **Independent inquiry and quantitive reasoning.**

The student should have taken the courses of calculus, physics, chemistry and basic-level-MATLAB knowledge.

Reference books (not mandatory) are *Geotechnical instrumentation for monitoring field performance by John Dunnicliff; Environmental monitoring by G. Bruce Wiersma, CRC press; Environmental Monitoring with ARDUINO by Emily Gertz and Patrick Di Justo.*

Additional reference articles, datasheets, presentations and journal papers will be posted on UT Canvas. Students are responsible for material presented in lecture and lab, but are encouraged to use the library and UT Canvas reference materials to expand their knowledge base. Lecture notes, homework assignments, and labs will also be posted on UT Canvas. In any case, your own notes are the most important part of the studying material, thus class attendance is important and required. A large portion of the class tests will be drawn from lectures, discussions, and class exercises. So, the instructors must be notified of any absence and the student is responsible for the missed lectures and exercises.

Assignments, Assessment, and Evaluation: some weeks a homework problem set might be assigned in the class. Assignments, their issue dates, and their due dates will be mentioned in class. Each assignment will be due at the beginning of the lecture period on the day that it is due. For each day an assignment is late, the grade for that assignment can be dropped 10%, down to a minimum of 50% as long as the assignment is submitted before the graded assignments are returned. After the graded assignments are returned, no credit will be given. However, the main assignment consists in the design and realization of your own monitoring project that will be the topic of the final report/presentation.

Two midterm tests and a final presentation and report will be given. A midterm presentation will be given to exposing to the class the conceptualized monitoring project. This will include: motivation for the monitoring, design of the instrument (selected hardware, location etc), budget analysis, expected results. A midterm test may be made up at the discretion of the instructor if the student can provide valid and substantiated reasons for the absence prior to the test. Each midterm test will take place during lecture. Students with disabilities may request appropriate academic accommodations through Services for Students with Disabilities.

Class recordings are reserved only for the use of members of this class (students, TAs, and the instructor) and only for educational purposes. Recordings should not be shared outside the class in any form. Violation of this restriction could lead to Student Misconduct proceedings.

***Tests/Reports/Presentations***

Midterm **Test I**: Mar 2.

Midterm **Presentation** Mar 30.

Midterm **Test II**: Apr 29 (?).

Final **Presentation**: May 6.

*Grade Percentage Basis*

| | ***UNDERGRADUATE*** | ***GRADUATE*** |
|---|---|---|
| Homework | 30% | 20% |
| Mid-term presentation | 25% | 20% |
| Midterm tests: (10% each) | 20% | 20% |
| Final presentation | 25% | 40% |
| TOTAL | 100% | 100% |

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**University of Texas Policies**: 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, trust, fairness, and respect toward peers and community. You are responsible for understanding UT's Academic Honesty and the University Honor Code which can be found at the following web address: https://deanofstudents.utexas.edu/conduct/standardsofconduct.php

**Services for Students with Disabilities:** This class respects and welcomes students of all backgrounds, identities, and abilities. If there are circumstances that make our learning environment and activities difficult, if you have medical information that you need to share with me, or if you need specific arrangements in case the building needs to be evacuated, please let me know. I am committed to creating an effective learning environment for all students, but I can only do so if you discuss your needs with me as early as possible. I promise to maintain the confidentiality of these discussions. Any student with a documented disability who requires academic accommodations should contact Services for Students with Disabilities at 471-6259 (voice) or 512-410-6644 (Video Phone) as soon as possible to request an official letter outlining authorized accommodations. For more information, visit http://ddce.utexas.edu/disability/about/.

**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.

**Q Drop Policy:** If you want to drop a class after the 12th class day, you'll need to execute a Q drop before the Q-drop deadline, which typically occurs near the middle of the semester. Under Texas law, you are only allowed six Q drops while you are in college at any public Texas institution. For more information, see: http://www.utexas.edu/ugs/csacc/academic/adddrop/qdrop

**Title IX Reporting:** Title IX is a federal law that protects against sex and gender-based discrimination, sexual harassment, sexual assault, sexual misconduct, dating/domestic violence and stalking at federally funded educational institutions. UT Austin is committed to fostering a learning and working environment free from discrimination in all its forms. When sexual misconduct occurs in our community, the university can:
1. Intervene to prevent harmful behavior from continuing or escalating.
2. Provide support and remedies to students and employees who have experienced harm or have become involved in a Title IX investigation.
3. Investigate and discipline violations of the university's relevant policies (https://titleix.utexas.edu/relevant-polices/).

Beginning January 1, 2020, Texas Senate Bill 212 requires all employees of Texas universities, including faculty, report any information to the Title IX Office regarding sexual harassment, sexual assault, dating violence and stalking that is disclosed to them. Texas law requires that all employees who witness or receive any information of this type (including, but not limited to, writing assignments, class discussions, or one-on-one conversations) must be reported. I am a Responsible Employee and must report any Title IX related incidents that are disclosed in writing, discussion, or one-on-one. Before talking with me, or with any faculty or staff member about a Title IX related incident, be sure to ask whether they are a responsible employee. If you would like to speak with someone who can provide support or remedies without making an official report to the university, please email advocate@austin.utexas.edu. For more information about reporting options and resources, visit http://www.titleix.utexas.edu/, contact the Title IX Office via email at titleix@austin.utexas.edu, or call 512-471-0419.

Although graduate teaching and research assistants are not subject to Texas Senate Bill 212, they are still mandatory reporters under Federal Title IX laws and are required to report a wide range of behaviors we refer to as sexual misconduct, including the types of sexual misconduct covered under Texas Senate Bill 212.

The Title IX office has developed supportive ways to respond to a survivor and compiled campus resources to support survivors.

**Zoom Etiquette:**
1. Mute yourself unless you are speaking. This will cut down on background noise and limit distractions.
2. Be mindful of your surroundings when on camera. Be sure to avoid as much distraction as possible.
3. Turn your camera off if you are leaving the meeting temporarily.
4. If the video or audio is choppy, try turning off your video.
5. Please always use reliable private or enterprise WIFI.

**Diversity Statement:** As The University of Texas at Austin strives to meet its mission of unlocking potential and preparing future leaders of the state, it embraces diversity in many forms. The university is dedicated to attracting highly-qualified students, faculty and staff with a wide range of backgrounds, ideas and viewpoints. This includes those from all races and ethnicities; first-generation college students; women; and others who have been historically underrepresented on campus. As a university with a past history of denying equitable access to qualified students, UT recognizes the profound benefits of creating an inclusive environment in which students can learn from one another. All students are better prepared to succeed in an increasingly diverse state and interconnected society when they receive the educational benefits of learning on a diverse campus.

## Nicola Tisato Zoom office

**https://utexas.zoom.us/j/8363310129** Meeting ID: 836 331 0129

One tap mobile
+13462487799,,8363310129# US (Houston)
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Dial by your location
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- +1 253 215 8782 US (Tacoma)
- +1 301 715 8592 US (Washington D.C)
- +1 312 626 6799 US (Chicago)
- +1 929 205 6099 US (New York)

Meeting ID: 836 331 0129
Find your local number: https://utexas.zoom.us/u/abFChL7CAR

Join by SIP
8363310129@zoomcrc.com

Join by H.323
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162.255.36.11 (US East)
115.114.131.7 (India Mumbai)
115.114.115.7 (India Hyderabad)
213.19.144.110 (Amsterdam Netherlands)
213.244.140.110 (Germany)
103.122.166.55 (Australia)
209.9.211.110 (Hong Kong SAR)
64.211.144.160 (Brazil)
69.174.57.160 (Canada)
207.226.132.110 (Japan)
Meeting ID: 836 331 0129

## Tuesday and Thursday, 2 – 3:30 PM

Nicola Tisato is inviting you to a scheduled Zoom meeting.

Topic: Sp22 - GEOPHYSCL MEASRMNT/MONITRNG (27750)
Time: Jan 18, 2022 02:00 PM Central Time (US and Canada)
Every week on Tue, Thu, until May 5, 2022, 32 occurrence(s)
Please download and import the following iCalendar (.ics) files to your calendar system.
Weekly: https://utexas.zoom.us/meeting/tJMqf-qtpz0vG9dlhG0xJ6rXPDsxSAEMjcYU/ics?icsToken=98tyKuCvqTMpH92TtRiERowEB4qgb-_xmCFYjfpZkBfCUzh5NBHOBsZRKoFeNfXa

Join Zoom Meeting: https://utexas.zoom.us/j/97783596513

Meeting ID: 977 8359 6513
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+1 301 715 8592 US (Washington DC)
+1 312 626 6799 US (Chicago)
Meeting ID: 977 8359 6513
Find your local number: https://utexas.zoom.us/u/awguUkgRT

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162.255.36.11 (US East)
115.114.131.7 (India Mumbai)
115.114.115.7 (India Hyderabad)
213.19.144.110 (Amsterdam Netherlands)
213.244.140.110 (Germany)
103.122.166.55 (Australia Sydney)
103.122.167.55 (Australia Melbourne)
209.9.211.110 (Hong Kong SAR)
64.211.144.160 (Brazil)
69.174.57.160 (Canada Toronto)
65.39.152.160 (Canada Vancouver)
207.226.132.110 (Japan Tokyo)
149.137.24.110 (Japan Osaka)
Meeting ID: 977 8359 6513