Meteorology 432 – Instrumentation and Measurements  
Spring 2023

Instructor: Igor Beresnev, 162 Science I, 4-7529, beresnev@iastate.edu

Class Time: MW 3:20-4:10, F 3:20-5:00, 1022 Agronomy


Prerequisites: Math 266, Phys 222

Course Fee: $ 140 (materials, equipment, field trips)

Learning objectives and philosophy
The overarching goal of the course is to understand the physical principles behind the operation of meteorological sensors and the quality of the data that they supply.

Consequently, there are four main learning objectives:

(1) Introduction to the physics of sensing as it is revealed in the main types of meteorological measurements.

(2) Learning quantitative means of analyzing the sources of errors and uncertainties in meteorological data and the response of sensors to static and varying meteorological inputs.

(3) Understanding the principles of the representation of digital data and its storage in computer memory.

(4) Automated acquisition and analysis of measurements by weather stations.

The course generally follows the outline of the main textbook by Brock and Richardson, except the material that is not covered in the book. The lectures are designed to be self-sufficient, in that only the material given in the classroom appears on the exams and in problem-set assignments. Familiarity with elementary differential equations is expected for understanding the principles of sensor-response analysis. The mathematics is kept at a simple level and is used primarily for the illustration of concepts; algebra and elementary calculus are sufficient to complete the assignments.

The course includes measurement and data-processing labs, as well as introductory visits to and demonstrations at the National Laboratory for Agriculture and the Environment (NLAE) (see Laboratory topics below). We also organize a guest lecture by the meteorologists from the National Weather Service and a field trip to their radar facility. The field trip is mandatory and takes half-a-day on the date announced in the syllabus. It is the students’ responsibility to arrange for their availability for the period of the trip.

Laboratory and demo/visit topics
1. Introduction to measurements with data loggers
2. Introduction to measurements with data loggers – multiple sensors
3. Instrument introduction (NLAE)
4. Barometry
5. Sonic anemometers (NLAE)
6. Time constants
7. Remote sensing (NLAE)
8. Field site with 50’ tower (NLAE)

Problem-set assignments
Problem assignments will conclude the presentation of the blocks of material. There will tentatively be three problem sets, each due two weeks following the day it has been handed out; the grades will be lowered at the rate of 5 percentage points per day for late returns.

When working on a problem assignment, please follow these simple rules:

(1) Explain all your work and the steps taken at arriving at the solution. No problem will be considered complete with only the final answer provided.

(2) Make the final result clearly seen.

Student projects
All students will be required (in the groups of two) to select a subject related to sensors, instrumentation, or measurements, research it, and make a presentation during the last week of the semester (see Schedule below). The topic of the project is open except that it should be original, creative, and related to the material covered in the course. The format of the final talk is 12 + 4 (12 minutes for the talk, 4 minutes for questions). The projects will be graded based on the in-class presentation, judged upon the technical quality and presentation quality. The formation of groups and the topic selection should be reported to the instructor by Monday, February 24. All students are required to attend all presentations.

Written exams
There will be two exams (one mid-term and one final), which will cover the respective two halves of the course. The exams will include questions requiring short answers and problems; the problems will be similar to those given as homework and will cover only the lecture material. All exams require a calculator and paper and will be 50-min. long.

Course grading
Exams (average) 45 %
Assignments (average) 35 %
Presentations 20 %

Rules of mutually respectful business conduct
(1) Electronic devices unrelated to class content must be turned off

(2) No leisurely conversations or whispering during the class time

(3) Business attitude and posture must be observed

Freedom of expression
Iowa State University supports and upholds the First-Amendment protection of freedom of speech and the principle of academic freedom in order to foster a learning environment where open inquiry and the vigorous debate of a diversity of ideas are encouraged. Students will not be penalized for the content or viewpoints of their speech as long as student expression in a class context is germane to the subject matter of the class and conveyed in an appropriate manner.

**Public health**

If you are not feeling well, you should stay home and focus on your health. Should you miss class due to illness, it is your responsibility to work with the instructor to arrange for accommodations and to make up coursework.

You may choose to wear a face mask and/or receive the COVID-19 vaccine and boosters, as well as other vaccines such as influenza, but those options are not required. Thielen Student Health Center will continue to provide COVID-19 vaccinations free-of-charge to students. The university will continue to offer free masks and COVID-19 test kits during the fall 2022 semester. Other wellbeing resources for students are available at: [www.cyclonehealth.iastate.edu/wellbeing-resources/](http://www.cyclonehealth.iastate.edu/wellbeing-resources/).

Public-health information for the campus community continues to be available on Iowa State’s public-health website (health.iastate.edu/public-health/). All questions should be directed to [publichealthteam@iastate.edu](mailto:publichealthteam@iastate.edu).

**Schedule**

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
</table>
Lab # 1 – Data loggers (Friday) |
| Week 3 / January 30-February 3 | Calibration. Thermometry.  
Lab # 2 – Data loggers – multiple sensors (Friday) |
| Week 4 / February 6-10 | Thermometry (cont.), Barometry. |
| Week 5 / February 13-17 | Lab # 3 – Instrument introduction (NLAE) (Monday)  
Barometry (cont.). Hygrometry.  
Lab # 4 – Barometry (Friday) |
| Week 6 / February 20-24 | Hygrometry (cont.)  
Radar (NWS guest lecture and field trip) (Wednesday, Friday) |
| Week 7 / February 27-March 3 | Hygrometry (cont.). Dynamic sensor performance – First-order systems. Anemometry.  
Lab # 4 (cont.) – Barometry – discussion (Friday) |
| Week 8 / March 6-10 | **Exam # 1** (Monday)  
Anemometry/Profilers (cont.) |
|---------------------|--------------------------------------------------|

**March 13-17**  
**Spring Break**

| Week 9 / March 20-24 | **Lab # 5** – Sonic anemometers (NLAE) (Monday)  
Anemometry/Profilers (cont.). Precipitation.  
Severe Storms & Doppler Radar Conference (Friday) |
|---------------------|--------------------------------------------------|
**Lab # 6** – Time constants (Friday) |
| Week 11 / April 3-7 | Dynamic sensor performance – Second-order systems (cont.)  
Visibility and clouds. Upper-air measurements. |
| Week 12 / April 10-14 | **Lab # 7** – Remote sensing (NLAE) (Monday)  
Upper-air measurements (cont.)  
**Lab # 6 (cont.)** – Time constants – discussion (Friday) |
| Week 13 / April 17-21 | Signal processing: quantization, sampling, spectral analysis, filtering |
| Week 14 / April 24-28 | Signal processing (cont.)  
**Lab # 8** – Field site with 50’ tower (NLAE) (Friday) |
| Week 15 / May 1-5 | **Student presentations** (Monday and Wednesday)  
Signal processing (cont.) |

**Week of May 8-11**  
**Final Exam**