ABEN 482/682: Instrumentation & Measurements

3 credits, Spring 2022

Meets in **ABEN 201** & **GHILL 228** on MW 9:00-9:50 AM (Lecture) & TH 2:00 – 4:50 PM (Laboratory)

Instructor and contact information:
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Office hours: T/W/F 2:00 PM – 5:00 PM and by appointment via an email.

Bulletin description:
Application of instrumentation and sensor concepts to measurement and control of environmental, biological, and mechanical parameters. Includes sensor principles, signal conditioning, data collection, and data analysis methods. 2 lectures, 1 three-hour laboratory. Prerequisites: PHYS 252. S or ECE 301 or EE 206

Course objectives:

After completing the course, the students will be able to:

1) design an experiment, conduct the experiment, collect experimental data, analyze the collected data, and draw conclusions from the analyzed data (ABET 6) - [A, student outcome 6 (Table 1)]
2) understand the use of equipment to measure and record data (ABET 6) - [A, student outcome 6 (Table 1)]
3) apply engineering knowledge of statics, strength of materials, fluids, and electricity to understand their experiments (ABET 1) - [A, student learning outcome 1 (Table 1)]
4) communicate acquired information professionally (ABET 3) [B, Student outcome 3 (Table 1)]
5) understand basic principles of control systems and programmable control units in the example of (Arduino), (ABET 1) - [A, student learning outcome 1 (Table 1)].

Companies hire engineers to solve problems. Testing and measurement are complex issues that require fundamental and hands-on skills to work with various sensors, data loggers and data acquisition and processing. An understanding of fundamental principles of sensors and analog-to-digital and digital-to-analog converters can help you understand operational principles of sensors and data acquisition tools.

Table 1. Program educational objectives and supporting student outcomes. *

	Graduates are expected to have established themselves as practicing engineers who, within a few years of graduation:
A	Successfully address emerging engineering challenges in the design or evaluation of machine systems, processing systems, and natural resources and environmental systems

	affecting the production of food, feed, and other biobased products. Technical learning outcomes include student outcomes (1), (2), and (6): 1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics 2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors 6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
B	Effectively use professional communication, critical thinking, and interpersonal skills as team leaders and team members. Communicational learning outcomes include student outcomes (3) and (5): 3. an ability to communicate effectively with a range of audiences 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
C	Responsibly serve the public and their employers by participating in professional development and by maintaining the highest standard of professional ethics. Contextual learning outcomes include student outcomes (4) and (7): 4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts 7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

* See https://www.ndsu.edu/aben/about/abet_accredited/ for the current ABEN program educational objectives. See https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2021-2022/ for information on ABET student outcomes 1-7, effective as part of the "Criteria for Accrediting Engineering Programs, 2021-2022."

Note: The table shows how course contributes to program outcomes, and how assessment is carried out to continually improve the course. The course is estimated to consist of 2 credits of "Instrumentation and data analysis" and 1 credit of "experimentation."

Required student resources:
Students are expected to have daily access to the course Blackboard website for access to course announcements, assignments, project, including the on-line sources, and other reading materials. **A personal computer (laptop) with MATLAB/Simulink installed is needed.**

Useful resources are:

(1) Wheeler, A. J., Ganji, A. R., 1996. Introduction to Engineering Experimentation. Simon & Schuster, Upper Saddle River, NJ.

(2) Morris, A. S., Langari, R., 2020. Measurement and Instrumentation: Theory and Application, 3rd Edition.

Assignment Overview

- **10 in-class quizzes** based on in-class covered materials, reading assignments, and self-study exercises. Out of 10 quizzes, **randomly chosen 5 quizzes** will be graded.
- **10 lab reports** based on the learned outcomes and collected data from the laboratory materials.
- **Tests**. There will be two in-class tests: **Test 1** on Week 6 and **Test 2** on Week 12/13. Prior to tests, there will be pre-test reviews of the questions included in Tests.
- There will be **one project** and **its presentation** during the Finals week.
- **One 6-page long research paper** based on the **project** (**ABEN 682**).
- **No homework assignments** except for reading assignments and self-study exercises.
- **No make-up Tests or Quizzes**.
- **Active participation** during in-class discussions is strongly encouraged. Note that you will earn extra credits by actively participating in-class discussions.

Table 2. Course Outline* (Tentative):

Week	Topics/Events
Week 1: 01/10 -01/14	Course introduction, syllabus, policy, and assignments Introduction to Instrumentation and Measurement
Week 2: 01/17-01/21	**Unit 1.** Applications of Engineering Experimentation and Measurement. Basic concepts, Units, Tools **Laboratory Work # 1**
Week 3: 01/24-01/28	**Unit 2.** General Characteristics of Measurement systems
Week 4: 01/31-02/04	**Unit 3.** Analog and Digital Signal Measurement Instruments **Laboratory Work # 2**
Week 5: 02/07-02/11	**Unit 4.** Analog -to- Digital and Digital -to- Analog converters. Temperature Measurement **Laboratory Work # 3**
Week 6: 02/14-02/18	**Unit 5.** Data Sampling and Filtering Review of week 1-5 materials: **Test 1**
Week 7: 02/21-02/25	**Unit 5.** Uncertainty in Measurements. Errors. Measuring strain and displacement **Laboratory Work # 4**
Week 8: 02/28-03/04	**Unit 6.** Errors and Calibration of Sensors. Measuring Stress **Laboratory Work # 5**
Week 9: 03/07-03/11	**Unit 7.** Statistical Analysis of Experimental Data. Fourier Analysis. Measurement and analysis of Force and Acceleration. **Laboratory Work # 6**
Week 10: 03/14-03/18	Spring Break

Week 11: 03/21-03/25	**Unit 8.** Correlation of Experimental Data: Curve Fitting and Least Squares Criterion. **Laboratory Work # 7**
Week 12: 03/28 – 04/01	**Unit 9.** Correlation of Experimental Data: Curve Fitting and Least Squares Criterion Review of week 6-11: **Test 2**
Week 13: 04/04 – 04/08	**Unit 10.** Data Acquisition with different systems: Arduino IDE, MATLAB, LabVIEW **Laboratory Work # 8**
Week 14: 04/11 -01/15	**Unit 10.** Data Acquisition with different systems: Arduino IDE, MATLAB, LabVIEW **Laboratory Work # 9**
Week 15: 04/18-04/22	**Unit 11.** Signal Processing
Week 16: 04/25-04/29	**Unit 12.** Low- and High-pass Analog and Digital Filters **Laboratory Work # 10**
Week 17: 05/02-05/06	**Unit 13.** Measuring Temperature, Humidity, Sound, Force, Acceleration, etc.
Week 18: 05/09-05/13	Project presentation

Disclaimer
The course outline is subject to change.

Grade Distribution: ABEN 482
Your grade in this course will be based on the following point breakdown.

Assessment	Number	Point Value	Total Points
Quiz	10 (5 graded)	2	10
Test 1	1	20	20
Test 2	1	20	20
Laboratory report (Lab Procedures, *Data presentation*, Executive Summary)	10	2.5	25
Project	1	15	15
Project Presentation	1	10	10
Total Course Points			**100**

Grade Distribution: ABEN682
Your grade in this course will be based on the following point breakdown.

Assessment	Number	Point Value	Total Points
Quiz	10 (5 graded)	1	5
Test 1	1	20	20
Test 2	1	20	20
Laboratory report (Lab Procedures, *Results and Discussion*, Executive Summary)	10	2.5	25
Project	1	10	10
Research paper	1	10	10
Project presentation	1	10	10
Total Course Points			**100**

Grades will follow the standard UJ grading scale:
A: 100-90% B: 80-89% C: 70-79% D: 60-69% F: <60%

Late Policy
No late submissions accepted without a prior permission of the instructor.
No makeup Tests and Quizzes.

Attendance: According to NDSU policy 333 - https://www.ndsu.edu/fileadmin/policy/333.pdf, attendance in classes is expected. *Your attendance and full participation is expected,* through classroom discussions, volunteering answers to questions, asking appropriate questions, thoughtful evaluation of a team oral presentation, evaluating of team member's participation in project, and by helping to create a spirit of cooperation within the class. The mode of instruction is face-to-face. You are required to attend lectures, project, and lab demonstrations in-person. However, there will be a zoom option for lectures only if you get sick and need to quarantine because of COVID. You must notify me at least an hour before class because I expect to see you in-person, especially during project demonstrations.

Students who exceed two absences for the semester should provide documentation of a valid excuse, such as from a medical professional or advisor of an NDSU student organization, to avoid a grade penalty of 2 point per unexcused absence.

Mask Guidance: Masks will be required in all classroom settings whether such classes are credit, non-credit, training sessions, etc. Faculty members who are able to maintain social distance from students may remove their masks during the class for purposes of being more easily heard. In addition, individuals should feel authorized to kindly ask other people who

are visiting their workspace (*e.g.*, offices, cubicles, etc.) to wear a mask. (Sources: https://www.osha.gov/coronavirus/safework, https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html, https://www.health.nd.gov/ndhelps).

Students with Special Needs and/or Circumstances: Any students with disabilities or other special needs, who need special accommodations in this course are invited to share these concerns or requests with the instructor and contact the Disability Services Office as soon as possible. Recorded lectures will be made available. Veterans and student soldiers with special circumstances or who are activated are encouraged to notify the instructor in advance.

COE Honor Pledge: "On my honor I will not give nor receive unauthorized assistance in completing assignments and work submitted for review or assessment. Furthermore, I understand the requirements in the College of Engineering Honor System and accept the responsibility I have to complete all my work with complete integrity. Students who are suspected of academic dishonesty may not withdraw from the course in which dishonesty is suspected while the case is under review by the Honor Commission (NDSU Policy 335, 5b)."

Last updated: August 19, 2021