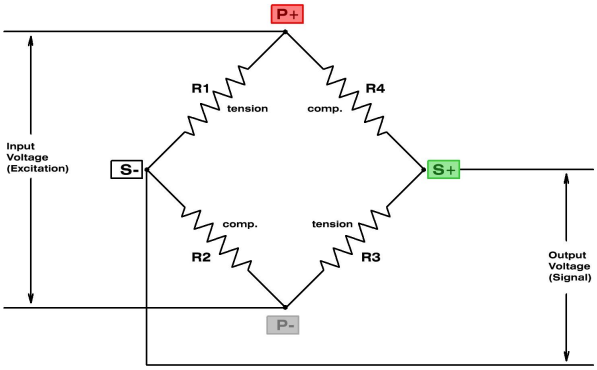
3 Day Short Course in
Engineering Measurements and Data Acquisition



Course Goals and Objectives

1) Develop a working knowledge of commonly used sensors and transducers in terms of principles of operation, design, performance, and application to specific measurement problems.

2) Understand, interpret, and apply transducer specifications and calibration information.

3) Learn the theory and operating principles of strain gages and the Wheatstone bridge including bridge output, calibration, thermal response, and the influence of lead wires.

4) Understand signal conditioning and digital data acquisition system architecture.

5) Learn how to properly record data using digital data acquisition systems including the selection of sample rates, anti-aliasing filter settings, full scales, resolution, etc.

6) Study fundamental digital signal processing and data validation techniques.

7) Use digital filtering to successfully solve problems that require integration and/or differentiation of digitally recorded data.

8) Apply course concepts to the task of recording engineering data in the field.

9) Learn how to design, build, and calibrate strain gage based load transducers (bending, shear, torsion, and axial) and apply the concepts to create custom transducers and instrumented components.

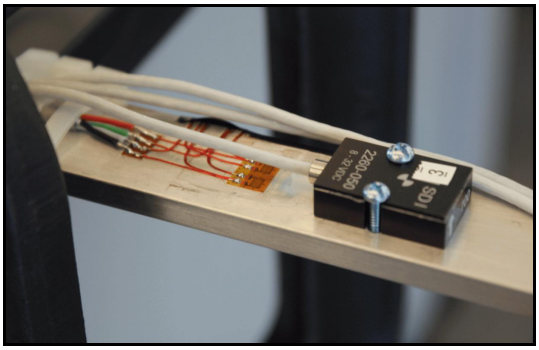
10) Learn how to determine bridge outputs for custom designed load transducers (mv/V or Shunt) and to correct crosstalk to improve accuracy.

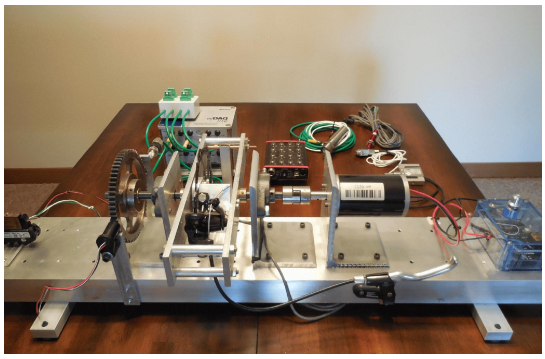
11) Use Mohr's circle to calculate multiaxial stresses from measured strain gage rosette data.

Who Should Attend

The course is targeted for test engineers and senior technicians, but CAE engineers, design engineers, and engineering managers will also benefit.

Course Content/Schedule





Day 1:

Transducers and Sensors

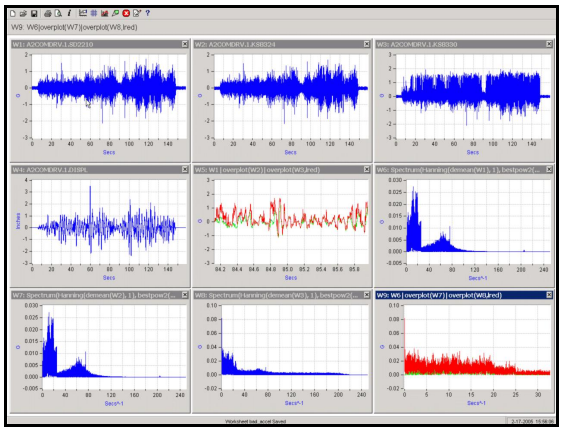
- Concepts and Definitions
- Accuracy, Precision, and Resolution
- Interpreting Specifications
- Natural Frequency vs. Frequency Response
- Selection of Sensors for Various Measurements
- Transducer Design, Construction, Implementation
- Calibration

Instrumentation

- Understanding Signal Conditioning
- Signal Conditioning Types and Performance
- Frequency Response and Phase Shifts
- Using and Configuring Slip Rings
- Telemetry Considerations
- Data Acquisition System Architecture

Strain Gage Fundamentals

- Strain Gage Physics
- Wheatstone Bridge
- Bridge Output Calculations
- Calibration
- Thermal Effects
- Understanding and Preventing Lead Wire Errors



Day 2:

Strain Gage Fundamentals (continued)

Digital Data Acquisition and Analysis

- Signal Types Commonly Encountered in Practice
- Digital Signal Processing Concepts
- Time Domain vs. Frequency Domain Analysis
- FFT, Leakage, Windows, FRF
- Filters and Application of Filters to Signal Analysis
- Integration and Differentiation of Signals
- Correctly Recording Signals with Digital Systems
- Sample Rate Selection and Prevention of Aliasing
- Data Validation

Data Acquisition in the Field

- Challenges of Recording Data in the Field
- Capturing the Duty Cycle
- Test Correlation
- Portable Equipment
- Installing Instrumentation
- Verifying the Setup
- Tips for Collecting Field Data
- Validating Data in the Field

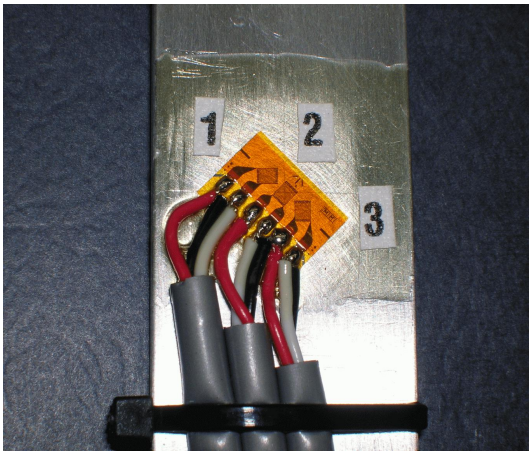
Day 3:

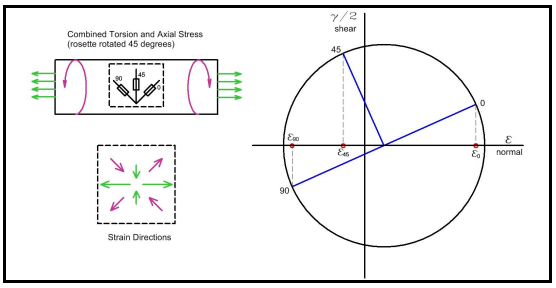
Strain Gage Advanced Topics

- Strain Gage Selection and Installation
- Strain Gages for Stress Analysis versus Transducers
- Wiring and Soldering
- Excitation Voltage Optimization
- Calibration Errors Due to Lead Wires
- Using Rosettes for Stress Analysis
- Calculation of 3D Stresses from Measured Strains

Build Custom Strain Gage Load Transducers

- Design of Multi-Axis Load Transducers
- Load Cases
- Bridge Design
- Calculation of Bridge Output for Various Designs
- Selection of Materials
- Transducer Fabrication
- Bridge Protection
- Thermal Output
- Calibration Techniques and Fixtures
- Crosstalk Correction Techniques
- Matrix Transducers





Live Equipment Demos and Hands-On Workshops

What sets this course apart is the use of **live demos and hands-on workshops** to illustrate and reinforce key concepts of instrumentation, strain gages, and transducers. You will not just sit through a lengthy barrage of PowerPoint slides. **Participants will experience a mix of presentations, discussions, and quizzes combined with hands-on exercises using real equipment.** Six individual sets of instrumentation are used for the workshops and attendees will work in pairs and learn by doing. This course is truly an interactive and hands-on learning experience!

Examples of Live Equipment Demonstrations:

Learn first-hand about a wide variety of sensors installed on a small motor dynamometer and connected to a commercial data acquisition system. View the measurements in real time.

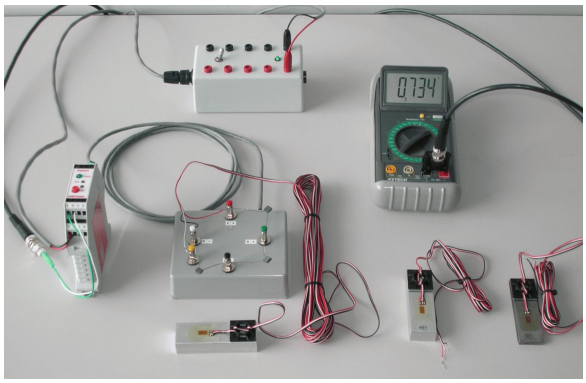
Investigate the difference between a transducer's natural frequency and its frequency response using a strain gaged cantilever beam, impact hammer, and accelerometers.

Evaluate the bandwidth and filter characteristics of a strain gage amplifier using a function generator and an oscilloscope.

Double integrate acceleration data and compare to measured displacements and double differentiate displacement data and compare to measured accelerations.

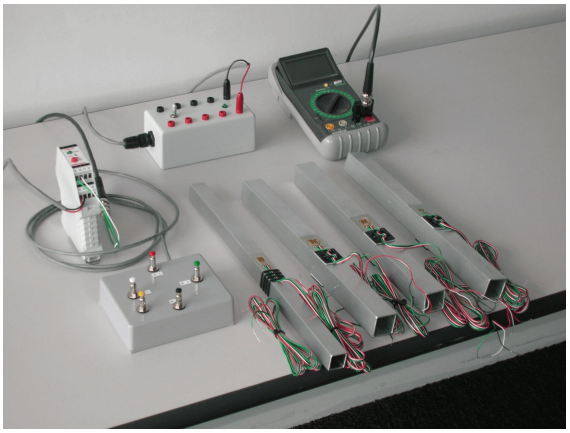
See the powerful advantage of using frequency domain digital signal processing tools to analyze data.

Hands-On Workshops

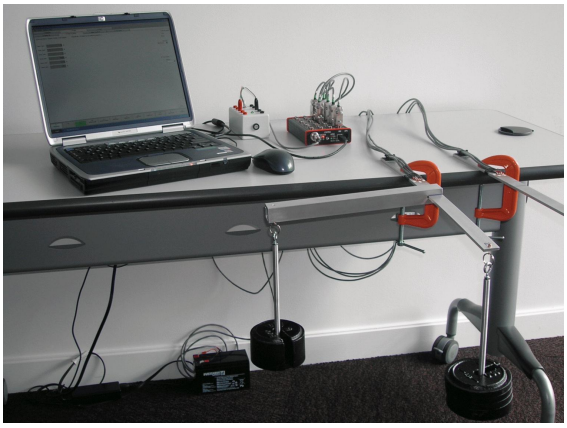


Investigate Wheatstone Bridge behavior, thermal compensation, lead wire effects, and shunt calibrations.

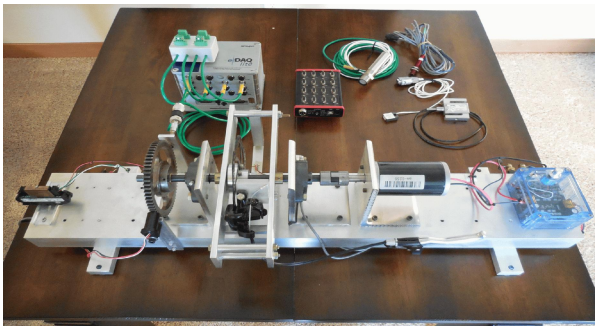
Calibrate a cantilever beam weigh scale and calculate the shunt cal resistor equivalent force value.



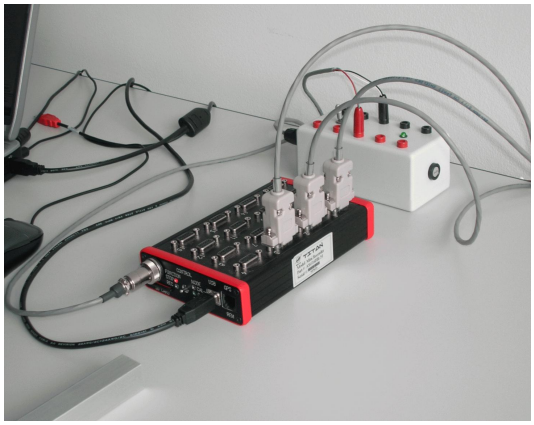
Wire full bridges to measure axial, torsion, transverse shear, and bending loads.



Measure rosette strain gage responses from beams under combined loads and calculate the resulting multiaxial stresses.



This small motor dynamometer is used as a data acquisition platform to demonstrate gear tooth/mag pickups, F/V converter, current shunt, and accelerometers.



Commercial data acquisition systems, instrumentation, and software are used throughout the course.

About the Instructor

Michael Messman, P.E., has 36 years of engineering experience in testing, teaching, and product development. His experience includes 21 years of major OEM measurement and test engineering divided equally between the General Motors Proving Ground and the John Deere Technical Center. He has an additional 8 years of experience as a Research Engineer at the Clemson University International Center for Automotive Research, and is a registered Professional Engineer in the State of Iowa. He has also been active in SAE, formerly serving as chairman of an SAE task force on Tire Testing for Tire Model Parameter Identification and chairman of the Fatigue Life Prediction Division of the SAE Fatigue Design and Evaluation Committee. He has also taught in-house corporate continuing education courses in the areas of measurements and fatigue analysis. Mike has spent significant time in the field and on proving grounds, collecting engineering data on vehicles and machinery. While in industry, he developed and implemented several successful wheel force transducer designs for both on-road and off-road vehicles, managed an instrumentation group, and developed tire testing and terrain measurement techniques in support of CAE loads predictions. At Clemson University, he developed and taught a graduate level university course in vehicle testing and assisted with other courses through teaching labs and equipment demonstrations. In 2016, Mike joined the Mechanical Engineering faculty at Iowa State University as an Associate Teaching Professor teaching Dynamics and Mechanical Engineering Design at the sophomore and senior (capstone) levels. Mike retired from ISU in December 2022 and is now focused on Midwest Dynamics full time.

Engineering Measurements and Data Acquisition Course Philosophy

You know the importance of engineering test data in the product development process. Valid data is essential. Errors in measurements can be costly and lead to design errors, program delays, wasted time and materials, even recalls and litigation. Midwest Dynamics understands the importance of making sure your data is valid and properly analyzed. To that end, we offer comprehensive training in measurement engineering, data acquisition, and signal processing.

This course thoroughly covers the entire measurement process from understanding and selecting sensors, to setting up data acquisition systems, to collecting data in the field, and analyzing the data in the office. You will also receive in-depth training in strain gages and will be taught how to design, build, and calibrate your own custom strain gage force transducers from the actual components of your vehicles and machines.

With many years of experience and expertise in the areas of durability, fatigue, in-field data acquisition, wheel force transducer design, laboratory testing, and CAE correlation, we know how data is used throughout the product development process and offer custom tailored training to serve your measurement engineering needs.

Given today's highly automated "turn-key" data acquisition and analysis systems, it is tempting to rely on modern technology to give you the answers, but we would argue that with increased automation, it is more important than ever to know what is going on behind that complex software interface. You need to understand how your system is operating and how those software settings affect your data. We teach you to think critically about engineering measurements and emphasize those timeless fundamentals that are crucial to the successful utilization of any transducer or data acquisition system.

Midwest Dynamics offers customized training delivered at your facility. Please visit www.mwdynamics.com to learn more and to contact us about this training option.

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