Course: Fundamentals of Metrology

Instructors: Harris, Miller, additional

Successful Completion requirements:

- 100 % attendance;
- Active Participation – measured by total points given during the week; immediate feedback when points are awarded;
- Highlight Cards and Application Cards – time provided in each module to make application notes and highlights.   Reviewed as a group, with examples provided to others and points for sharing; instructors periodically review them with feedback given.
- "Exam Topics at a Glance" are provided as a handout on Thursday evening for students to "study for the final exam". Covers "know" and "do".

Module and Learning Objectives
Course terminal objectives and format covered. After covering basic concepts, you will be able to • identify and use reference materials to ensure good quality, accurate, traceable measurement results • explain highlights and key concepts of each topic to each other and to your managers and show how these topics fit into a management system like ISO/IEC 17025 • You will have and know how to implement several simple tools, job aids, and references to use and improve your laboratory operations
Measurement Systems and Units - **Learning Objectives** At the end of this module, you will be able to: • Describe the International System of Units (SI) and the seven base units • Recognize various national and international organizations from which we get many of our metrology references, resources, and standards; • Identify the correct reference documents for measurement units; • Identify and apply correct symbols, abbreviations, and units for all measurements in this course; • Apply dimensional analysis concepts correctly by looking up reference values for unit conversions, accurately perform associated mathematics, and present final values with the correct units/symbols.
Laboratory Management Systems - **Learning Objectives** At the end of this session, you will be able to:

Module and Learning Objectives
- Identify key components of ISO/IEC 17025, "General requirements for the competence of testing and calibration laboratories" and how they relate to the laboratory workflow; - Identify how the module topics in this course relate to ISO/IEC 17025; - Identify the laboratory administrative infrastructure (documents, records, auditing); - Describe the difference between Documents and Records and be able to give examples of Objective Evidence; and - Describe the value of implementing and following a management system (and the impact of failures). Note: two additional modules in this course will focus on special topics from this section. They are the Management Review and the Calibration Report.
Measurement Activity – Learning Objectives At the end of this session, you will be able to: - Safely perform some simple measurements and record observations; - Make measurements and record observations at a variety of measurement stations; and - Identify sources of measurement variability. Steps in the measurement activity/scenario: 1. Consider laboratory "Scope" 2. Research Specifications 3. Assess "Laboratory" 4. Conduct Initial Inspection (and note what goes on a calibration report) 5. Gather data and evaluation Measurement Capabilities 6. Discuss/Agree on Measurement Procedure (Validation) 7. Measure Submitted Items (including PTs) for Mass and Dimensional 8. Determine Volume 9. Perform calculations 10. Prepare calibration report
Learning Objectives - Traceability At the end of this session, you will be able to: - Identify the essential components of metrological traceability; - Prepare a traceability statement for a calibration report; - Diagram a simple traceability hierarchy; - Apply traceability analysis forms in your laboratory; - Document the traceability of measurement standards used in your laboratory to comply with the definition for each measurement area on your

Module and Learning Objectives
laboratory Scope.

Statistics – Learning Objectives

At the end of this module, you will be able to:

• Define "what is statistics?"

• Identify, define, and explain accuracy, precision, coverage factors (confidence intervals), and some additional terminology

• Given previous class data and your calculated values from current team, describe applications for calculating mean, standard deviation, F-test, t-test, and correctly identify each of these statistics/tests and their applications

• Successfully calculate the mean, standard deviation, F-test, t-test, of your measurement data explain the meaning of the results

• Analyze, interpret, and present measurement data from your measurement experiments

Measurement Assurance

Learning Objectives

At the end of this module, you will be able to:

- Define and Describe measurement assurance philosophy
- Evaluate a control chart that uses your measurement data
- Assess data against a "normal distribution"
- Identify the essential requirements for check standards
- Identify in-control and out-of-control status using job aids
- Identify possible assignable causes for out-of-control situations and possible action steps to
- regain measurement process control
- After the seminar, you should be able to assess your measurement assurance methods for each measurement area on their laboratory Scope.

Uncertainties - Learning Objectives

At the end of this module, you will be able to:

- Define "what is uncertainty" and "who says?"
- Implement uncertainty analysis and reporting methods consistent with the Guide to the
- Expression of Uncertainty in Measurement (GUM) and the 8 step process of sop 29. This
- means, to correctly :
- Specify the measurement equation and describe the measurement process;
- Identify sources of variability, error, and uncertainties (go back to list of inspection
- list from penny experiment and consider what we have already measured)
- Quantify major uncertainty components and consider what might be significant or
- negligible (consider class data an previous measurement results)
- Assess bias

Module and Learning Objectives
• Convert values to standard uncertainties that represent a standard deviation (in • correct units) • Identify/select the correct distribution • Combine uncertainty components • Expand the uncertainty using correct coverage factors (requires considering the • degrees of freedom and looking up the k value) • Evaluate the uncertainty (does it comply with stated customer expectations? Are • there uncorrected errors? Is it acceptable? How can it be reduced if needed?), • Include Pn and tolerance assessments • Report the uncertainty as a value and a statement, report the measurement value • with correctly rounded measured values and uncertainties • Round measurement values correctly
Proficiency Tests - Learning Objectives At the end of this module, you will be able to: • Define "what is a PT?" And "who says?" • Identify where, when, and why PTs are performed • Assess the PT data from the penny experiments using correct PT statistics • Implement a follow-up and corrective action form for PT results • Conduct a simple root cause analysis exercise
Software Verification and Validation - Learning Objectives At the end of this module, you will be able to: • Define "what is V and V?" And "who says?" • Identify software engineering practices beyond use of "data sets" • Identify potential measurement problems with spreadsheets that have been used during the class • Evaluate software used in the laboratory using Form A • Apply the tools provided to design better quality spreadsheets • Document software inventory as a part of document control; document verification and validation.
Management Systems Focus: Management Reviews - Learning Objectives At the end of this module, you will be able to: • IDENTIFY the key requirements of a Management Review • Provide examples that we have identified during the week that should be included in a Management Review • List the Benefits of a Management Review and each of its components

Module and Learning Objectives
Management Systems Focus: Calibration Reports - Learning Objectives At the end of this module, you will be able to: • IDENTIFY and DESCRIBE the key requirements that must be on calibration reports. • EVALUATE sample calibration reports for completeness, accuracy, unit representation. • CREATE calibration reports for the penny exercise and the penny proficiency test (as a team).
Final Exam