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

#### 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**