**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:  ‐ 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 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 * 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 |
| **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** |
|  |