

Detailed Learning Objectives for Fundamental of Metrology

Course: Fundamentals of Metrology

Instructors: Isabel Chavez Baucom

Requirements for Successful Completion

- 100 % attendance
- Participate in group and session activities, demonstrations, and interim quizzes (demonstrated by points)
- Complete Two Cards: Concepts & Applications
- Complete homework (track time)
- Demonstrate learning objectives for each module (70 %) – default is 100 % unless students do NOT meet objectives and the instructor documents detailed gaps
- Complete Data Sheets, Spreadsheet, and Calibration Certificate (70 % passing) - graded
- Final examination (70 % passing) - graded
- NOTE: “Exam Topics at a Glance” are provided in the notebook.

Module	Learning Objectives
	After covering concepts, using your notes and resources, you will be able to:
Overall Course	<ul style="list-style-type: none"> • DEFINE many metrology related acronyms and terminology • IDENTIFY and APPLY 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 an ISO/IEC 17025 management system • IMPLEMENT several tools, job aids, and references for the case study measurements and calculations; then use these resources to improve your laboratory operations
Integrity and Data Management	<ul style="list-style-type: none"> • DEFINE personal integrity, data management, data integrity, verification, and validation • IDENTIFY ISO/IEC 17025 criteria observe related to document/record and data management, including “electronic” (software) resources • IDENTIFY failures and risks related to data management • DESCRIBE the impact of document and record control failures (including software) • LIST and DESCRIBE techniques used in software verification and validation

Module	Learning Objectives After covering concepts, using your notes and resources, you will be able to:
	<ul style="list-style-type: none"> • EXPLAIN the importance of personal integrity, confidentiality impartiality, data integrity, document/record management, and software verification and validation • EXPLAIN your role in ensuring integrity and data integrity • APPLY data management and integrity concepts during this seminar – in the classroom and in the laboratory: Mise en place for document/records management, software V&V, and integrity
Who's Who in the World of Metrology	<ul style="list-style-type: none"> • IDENTIFY acronyms of National Metrology Institutes and Accreditation Bodies • DESCRIBE who/what/why of the Arrangements of the: <ul style="list-style-type: none"> • International Committee on Weights and Measures (CIPM) • International Laboratory Accreditation Cooperation (ILAC) • DESCRIBE roles of international and national participants and recommended pathways in traceability • EXPLAIN impact of these arrangements on your laboratory (Why is it important to you? What are the risks?)
Traceability and Risk	<ul style="list-style-type: none"> • DEFINE Metrological Traceability, Calibration, Measurand, Measurement Standard, Measurement Uncertainty • DESCRIBE why traceability matters • LIST seven essential elements of metrological traceability • EXPLAIN seven essential elements and the risks of failing to ensure traceability and impact on measurement results • APPLY concept of traceability hierarchies, essential elements, and risk/gap analysis to the seminar case study measurement activity as we complete each step
Measurement Case Study	<p>OVERALL for Case Study</p> <ul style="list-style-type: none"> • RESEARCH information about new measurement parameters for your laboratory Scope • COMPLETE data/observation sheets with data integrity (comply with ALCOA+) • USE laboratory instruments and standards carefully and properly to measure • APPLY concept of traceability hierarchies and essential elements • APPLY method validation concepts • APPLY statistical analysis tools, calculate, and present statistics

Module	Learning Objectives After covering concepts, using your notes and resources, you will be able to:
	<ul style="list-style-type: none"> • APPLY measurement assurance methods with check standards • PARTICIPATE in and ANALYZE a proficiency test • APPLY uncertainty analysis • CREATE compliant calibration certificates <p>Related to Instruments:</p> <ul style="list-style-type: none"> • You will be able to apply these concepts during discussions regarding method validations and uncertainty evaluations.
Statistics	<ul style="list-style-type: none"> • DEFINE “what is statistics?” • IDENTIFY, DEFINE, and EXPLAIN • Normal distribution, accuracy, precision, coverage factors, confidence levels • CALCULATE mean, standard deviation, F-test, t-test • DESCRIBE, ANALYZE, INTERPRET, and EXPLAIN statistics/tests and their applications for example scenarios and for laboratory measurements
Method Validation	<ul style="list-style-type: none"> • DEFINE verification and validation • DESCRIBE characteristics of a method validation process • PARTICIPATE in the method validation process for the case study
Traceability Case Study	<ul style="list-style-type: none"> • RESTATE the definition of traceability and the essential elements of metrological traceability; • DIAGRAM a simple traceability hierarchy to illustrate an unbroken chain of calibrations for the seminar Case Study; • EVALUATE example certificate traceability statements; and • PREPARE a traceability statement for your seminar calibration certificate.
Calibration Certificates	<ul style="list-style-type: none"> • IDENTIFY compliance with required components of a calibration certificate • IDENTIFY gaps/non-conformities on calibration certificates • IDENTIFY errors in units and symbols used on certificates • APPLY knowledge of the SOP 1 and SP 811 checklists and review your certificates • EVALUATE certificates from your peers during this seminar and PROVIDE constructive feedback

Module	Learning Objectives After covering concepts, using your notes and resources, you will be able to:
	<ul style="list-style-type: none"> • CREATE and UPDATE your compliant calibration certificate that will be turned in for this seminar
Measurement Assurance	<ul style="list-style-type: none"> • DESCRIBE Measurement Assurance and give some examples of what we regularly do to ensure validity, and identify possible problems when it is absent from a laboratory and procedures • REFERENCE applicable sections of ISO/IEC 17025 that relate to ensuring validity and measurement assurance • IDENTIFY and MATCH activities with different techniques used to ensure validity in our measurement results • IDENTIFY control charts and components • Variables • Standard deviation • Title, Axis, Statistical Control Limits • RECOGNIZE control charts that are out of control, SHARE ideas about causes and potential actions • DESCRIBE check/control standards and some key points about their use • APPLY measurement assurance concepts and practices to the penny activities
Uncertainties (Parts I and II)	<p>Part I</p> <ul style="list-style-type: none"> • DEFINE and DESCRIBE “uncertainty” • DEFINE standard uncertainty, combined uncertainty, expanded uncertainty and k values • IDENTIFY two methods (A and B) for determining uncertainty components <p>Part II</p> <ul style="list-style-type: none"> • 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 measurand and measurement equation • IDENTIFY uncertainty components • QUANTIFY each component in appropriate units • CONVERT to standard uncertainties • COMBINE using appropriate equation (often Root Sum Square)

Module	Learning Objectives After covering concepts, using your notes and resources, you will be able to:
	<ul style="list-style-type: none"> • EXPAND using appropriate coverage factor • EVALUATE the result for accuracy, suitability, compliance, fit for purpose • REPORT the result, rounded to two significant digits, with an explanatory Statement that includes the components and how determined, coverage factor, degrees of freedom, and confidence interval
Competency, Proficiency Tests	<ul style="list-style-type: none"> • DESCRIBE requirements for defining, monitoring, and authorizing staff competency • REFLECT or IDENTIFY your laboratory procedures and records related to staff competency • DESCRIBE purposes of an Interlaboratory Comparison • DEFINE an Interlaboratory Comparison and Proficiency Test • DESCRIBE where, when, and why PTs are performed • CALCULATE and EVALUATE Normalized Error and Precision Test results • ASSESS your PT data from the penny experiments using the Normalized Error and Normalized Precision calculation results
Calibration Programs	<ul style="list-style-type: none"> • DEFINE “calibration program” • IDENTIFY critical components in a “calibration program;” • IDENTIFY applicable section(s) of ISO/IEC 17025 related to calibration program requirements; • DESCRIBE supplier evaluation requirements and components; • IDENTIFY factors to be considered in setting and adjusting calibration intervals; and • IDENTIFY risks and costs associated with poor supplier evaluation, setting inappropriate intervals, having inadequate laboratory documentation and objective evidence or failing to obtain suitable and timely calibrations