

Measurement Uncertainty

- **Precision** – how small is the variance of the estimates
- **Accuracy** – how close is the estimate to the actual values
- **Bias** – what impacts on precision and accuracy come from the human judgments (or misjudgments)



↑ Accuracy
↑ Precision

↑ Accuracy
↓ Precision

↓ Accuracy
↑ Precision

↓ Accuracy
↓ Precision

Measurement Uncertainty Guide

Les Kirkup



Measurement Uncertainty Guide:

Evaluating the Measurement Uncertainty I Lira, 2002-04-09 It is now widely recognized that measurement data should be properly analyzed to include an assessment of their associated uncertainty Since this parameter allows for a meaningful comparison of the measurement results and for an evaluation of their reliability its expression is important not only in the specialized field of scientific metrology but also in industry trade and commerce General rules for evaluating and expressing the uncertainty are given in the internationally accepted ISO Guide to the Expression of Uncertainty in Measurement generally known as the GUM Evaluating the Measurement Uncertainty details the theoretical framework on which the GUM is based and provides additional material on more advanced topics such as least squares adjustment and Bayesian statistics The book does not require previous knowledge other than elementary calculus and can be read as a complement to the GUM or as a stand alone reference source It stresses fundamental principles and illustrates their applications through numerous examples taken from many different fields of metrology The book includes practical guidance as well as theoretical aspects resulting in an invaluable resource for metrologists engineers physicists and graduate students involved with measurements in academia and industry

Measurements and their Uncertainties Ifan Hughes, Thomas Hase, 2010-07-02 This hands on guide is primarily intended to be used in undergraduate laboratories in the physical sciences and engineering It assumes no prior knowledge of statistics It introduces the necessary concepts where needed with key points illustrated with worked examples and graphic illustrations In contrast to traditional mathematical treatments it uses a combination of spreadsheet and calculus based approaches suitable as a quick and easy on the spot reference The emphasis throughout is on practical strategies to be adopted in the laboratory Error analysis is introduced at a level accessible to school leavers and carried through to research level Error calculation and propagation is presented though a series of rules of thumb look up tables and approaches amenable to computer analysis The general approach uses the chi square statistic extensively Particular attention is given to hypothesis testing and extraction of parameters and their uncertainties by fitting mathematical models to experimental data Routines implemented by most contemporary data analysis packages are analysed and explained The book finishes with a discussion of advanced fitting strategies and an introduction to Bayesian analysis

Evaluating the Measurement Uncertainty Ignacio Lira, 2002 It is now widely recognized that measurement data should be properly analyzed to include an assessment of their associated uncertainty Since this parameter allows for a meaningful comparison of the measurement results and for an evaluation of their reliability its expression is important not only in the specialized field of scientific metrology but also in industry trade and commerce General rules for evaluating and expressing the uncertainty are given in the internationally accepted ISO Guide to the Expression of Uncertainty in Measurement generally known as the GUM Evaluating the Measurement Uncertainty details the theoretical framework on which the GUM is based and provides additional material on more advanced topics such as least squares adjustment and Bayesian statistics

The book does not require previous knowledge other than elementary calculus and can be read as a complement to the GUM or as a stand alone reference source It stresses fundamental principles and illustrates their applications through numerous examples taken from many different fields of metrology The book includes practical guidance as well as theoretical aspects resulting in an invaluable resource for metrologists engineers physicists and graduate students involved with measurements in academia and industry

Measurement Uncertainty in Chemical Analysis Paul De Bièvre, Helmut Günzler, 2013-06-29 It is now becoming recognized in the measurement community that it is as important to communicate the uncertainty related to a specific measurement as it is to report the measurement itself Without knowing the uncertainty it is impossible for the users of the result to know what confidence can be placed in it it is also impossible to assess the comparability of different measurements of the same parameter This volume collects 20 outstanding papers on the topic mostly published from 1999 2002 in the journal Accreditation and Quality Assurance They provide the rationale for why it is important to evaluate and report the uncertainty of a result in a consistent manner They also describe the concept of uncertainty the methodology for evaluating uncertainty and the advantages of using suitable reference materials Finally the benefits to both the analytical laboratory and the user of the results are considered

Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results (rev. Ed.) Barry N. Taylor, 2009-11 Results of measurements and conclusions derived from them constitute much of the technical information produced by the National Institute of Standards and Technology NIST In July 1992 the Director of NIST appointed an Ad Hoc Committee on Uncertainty Statements and charged it with recommending a policy on this important topic The Committee concluded that the CIPM approach could be used to provide quantitative expression of measurement that would satisfy NIST's customers requirements NIST initially published a Technical Note on this issue in Jan 1993 This 1994 edition addresses the most important questions raised by recipients concerning some of the points it addressed and some it did not Illustrations

The Uncertainty of Measurements Shri Krishna Kimothi, 2001-11-01 The uncertainty of measurement results is drawing attention of managers metrologists and customers The accuracy of measurements affects all of us in trade commerce safety health care environmental protection and more The quality of these measurements are regulated by a variety of government agencies Measurement also plays an important role in manufacturing and service organizations Use this book to learn more about metrology and the need for reliable measurements You can also learn about measurement system and quality of measurement systems objectives and methods Statistical techniques in metrology are also explained Examples of measurement data and random variables probability density functions sampling distribution statistical estimation degrees of freedom and regression are included An entire chapter is devoted to measurement errors The book goes in depth into explaining national and international measurement systems and standards and includes a complete chapter on calibration and measurement trace ability Measurement Uncertainty will show how to evaluate various uncertainties in measurements using several approaches

including international consensus Calibration laboratories can look specifically at the chapter on that profession to guide them in their measurement improvements Kimothi also looks at specific industries and their measurement capabilities and includes examples of R R studies A great resource for the CQE CQT CCT CSSBB certification exams **Measurement Errors and Uncertainties** S. G. Rabinovich,2005-08-15 A practical reference on theory and methods of estimating measurement errors and uncertainty for both scientists and engineers in industry and experimental research Building on the fundamentals of measurement theory this book offers a wealth of practical recommendations and procedures It differs from the majority of books in that it balances coverage of probabilistic methods with detailed information on the characterization calibration standardization and limitations of measuring instruments with specific examples from both electrical and mechanical systems In addition to a general updating to reflect current research new material in this edition includes increased coverage of indirect measurements with a new simpler more efficient method for this class of measurements

NIOSH Manual of Analytical Methods: Method finder, user's guide, methods A-D ,1994 **An Introduction to Uncertainty in Measurement Using the GUM (guide to the Expression of Uncertainty in Measurement)** Les Kirkup,2006 This book presents the need for clarity consistency and accuracy when making measurements some of the GUM guidelines are presented in this book A background in first year calculus and some basic statistics is necessary for understanding **Decision Rule Guidance** Henry Zumbrun,Greg Cenker,Dilip Shah , Decision Rule Guidance 1st Edition 2024 is written by Henry Zumbrun of Morehouse Instrument Company Greg Cenker of Indysoft and Dilip Shah of E mc3 Solutions It provides foundational knowledge and practical calculations for using decision rules in measurement uncertainty This guidebook is not just a theoretical exploration of measurement uncertainty metrological traceability and decision rules It is a practical tool that transforms complex concepts into actionable insights It guides technicians engineers and decision makers through measurement decision making with examples and calculations Using this guide you can make choices that improve product and service quality safety and reliability The authors bring over 100 years of combined experience in the metrology field They have addressed common challenges in the community with this guide Henry A Zumbrun has over 25 years of industry experience in Metrology specifically in force and torque measurements Greg Cenker has more experience than Henry and is Senior Metrologist and Calibrations Product Manager at IndySoft Dilip A Shah has more experience than Greg and is a Principal of E mc3 Solutions a consulting practice that provides training and consulting solutions in ISO IEC 17025 ISO 9001 measurement uncertainty and computer applications **A Practical Guide to Basic Laboratory Andrology** David Mortimer,Lars Björndahl,C. L. R. Barratt,José Antonio Castilla,Roelof Menkveld,2022-03-10 Preceded by A practical guide to basic laboratory andrology Lars Björndahl et al 2010 **NIST Technical Note** ,1992 **The ASQ Metrology Handbook** Heather A. Wade,2023-01-04 The ever changing fields of science and technology have made huge leaps thanks in part to improvements in measurements Without metrology these areas may not have experienced exponential

growth Developed by experts in the field as a comprehensive and practical reference The ASQ Metrology Handbook Third Edition provides a foundation for understanding metrology as well as calibration principles and practices This handbook is ideal for not only metrology professionals but also calibration professionals including calibration technicians and technologists quality professionals workers in testing laboratories consultants and instructors Whether you are entering a new phase of your career field investing in your own continuous improvement journey training your fellow calibration practitioners or preparing for ASQ's Certified Calibration Technician CCT exam this handbook provides the information guidance and knowledge to help you achieve your goals New to this Third Edition A thorough explanation of ISO IEC 17025 2017 The 2019 Redefinition of the International System of Units Updated and expanded chapters including information about training and competency software validation statistics decision rules and risk uncertainty in measurement mass and weighing force and chemical and biological measurements and uncertainties

Springer Handbook of Metrology and Testing

Horst Czichos, Tetsuya Saito, Leslie E. Smith, 2011-07-22 This Springer Handbook of Metrology and Testing presents the principles of Metrology the science of measurement and the methods and techniques of Testing determining the characteristics of a given product as they apply to chemical and microstructural analysis and to the measurement and testing of materials properties and performance including modelling and simulation The principal motivation for this Handbook stems from the increasing demands of technology for measurement results that can be used globally Measurements within a local laboratory or manufacturing facility must be able to be reproduced accurately anywhere in the world The book integrates knowledge from basic sciences and engineering disciplines compiled by experts from internationally known metrology and testing institutions and academe as well as from industry and conformity assessment and accreditation bodies The Commission of the European Union has expressed this as there is no science without measurements no quality without testing and no global markets without standards

Quality Assurance in Analytical Chemistry Bernd W.

Wenclawiak, Michael Koch, Evsevios Hadjicostas, 2010-08-05 knowledge This material provided has been collected from different sources One important source is the material available from EURACHEM Eurachem is a network of organisations in Europe having the objective of establishing a system for the international traceability of chemical measurements and the promotion of good quality practices It provides a forum for the discussion of common problems and for developing an informed and considered approach to both technical and policy issues It provides a focus for analytical chemistry and quality related issues in Europe You can find more information about EURACHEM on the internet via Eurachem A Focus for Analytical Chemistry in Europe <http://www.eurachem.org> In particular the site Guides and Documents contains a number of different guides which might help you to set up a quality system in your laboratory The importance of quality assurance in analytical chemistry can best be described by the triangles depicted in Figs 1 and 2 Quality is checked by testing and testing guarantees good quality Both contribute to progress in QA product control and quality and thus to establishing a market

share Market success depends on quality price and flexibility All three of them are interconnected Before you can analyse anything the sample must be taken by someone This must be of major concern to any analytical chemist There is no accurate analysis without proper sampling For correct sampling you need a clear problem definition There is no correct sampling without a clear problem definition

Handbook of Mass Measurement Frank E. Jones, Randall M. Schoonover, 2002-03-26

How much does it weigh seems a simple question To scientists and engineers however the answer is far from simple and determining the answer demands consideration of an almost overwhelming number of factors With an intriguing blend of history fundamentals and technical details the Handbook of Mass Measurement sets forth the details

Forensic Anthropology Max M. Houck, 2016-12-30 Forensic Anthropology serves as a graduate level text for those studying and teaching forensic anthropology as well as an excellent reference for forensic anthropologist libraries or for use in casework Covers taphonomy recovery and analysis identification statistical interpretation and professional issues Edited by a world renowned leading forensic expert the Advanced Forensic Science Series grew out of the recommendations from the 2009 NAS Report Strengthening Forensic Science A Path Forward and is a long overdue solution for the forensic science community Provides the basic principles of forensic science and an overview of forensic anthropology Contains sections on taphonomy recovery analysis pathology and identification Covers statistical interpretation of evidence using the classical frequentist approach and Bayesian analysis measurement uncertainty and standard methods Includes a section on professional issues such as from crime scene to court expert witness testimony and health and safety Incorporates effective pedagogy key terms review questions discussion questions and additional reading suggestions

Forensic Biology Max M. Houck, 2015-01-08 Forensic Biology provides coordinated expert content from world renowned leading authorities in forensic biology Covering the range of forensic biology this volume in the Advanced Forensic Science Series provides up to date scientific learning on DNA analysis Technical information written with the degreed professional in mind brings established methods together with newer approaches to build a comprehensive knowledge base for the student and practitioner alike Like each volume in the Advanced Forensic Science Series review and discussion questions allow the text to be used in classrooms training programs and numerous other applications Sections on fundamentals of forensic science history safety and professional issues provide context and consistency in support of the forensic enterprise Forensic Biology sets a new standard for reference and learning texts in modern forensic science Advanced articles written by international forensic biology experts Covers the range of forensic biology including methods and interpretation Includes entries on history safety and professional issues Useful as a professional reference advanced textbook or training review

NIST Handbook, 1989

Fundamental Principles of Engineering Nanometrology Richard Leach, 2014-05-17 Working at the nano scale demands an understanding of the high precision measurement techniques that make nanotechnology and advanced manufacturing possible Richard Leach introduces these techniques to a broad audience of engineers and scientists involved in

nanotechnology and manufacturing applications and research He also provides a routemap and toolkit for metrologists engaging with the rigor of measurement and data analysis at the nano scale Starting from the fundamentals of precision measurement the author progresses into different measurement and characterization techniques The focus on nanometrology in engineering contexts makes this book an essential guide for the emerging nanomanufacturing nanofabrication sector where measurement and standardization requirements are paramount both in product specification and quality assurance This book provides engineers and scientists with the methods and understanding needed to design and produce high performance long lived products while ensuring that compliance and public health requirements are met Updated to cover new and emerging technologies and recent developments in standards and regulatory frameworks this second edition includes many new sections e g new technologies in scanning probe and e beam microscopy recent developments in interferometry and advances in coordinate metrology Demystifies nanometrology for a wide audience of engineers scientists and students involved in nanotech and advanced manufacturing applications and research Introduces metrologists to the specific techniques and equipment involved in measuring at the nano scale or to nano scale uncertainty Fully updated to cover the latest technological developments standards and regulations

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