EPFL

MICRO-428

Metrology

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Cursus	Sem.	Type
Microtechnics	MA2, MA4	Obl.

Language of teaching	English
Credits	3
Withdrawal	Unauthorized
Session	Summer
Semester	Spring
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Courses	3 weekly
Number of positions	

It is not allowed to withdraw from this subject after the registration deadline.

Summary

Course introduces the concept of measurement in electrical, optical, and microscale domains, dealing with accuracy, and resolution. Weâ##ll introduce techniques to handle intrinsic and extrinsic limitations of the measurement in these domains. Course ends with a quantum perspective.

Content

The topics covered by the course are summarized as follows:
- Deconstruction class (W 1.1)

Classical metrology, current definitions (kg, C, A, V), Système International (W 1.2)
HW Series 1 (W 1.3)
- Basic statistics: random variables, random processes, probability distribution functions, moments, statistical independence, correlation, wide-sense stationary processes, ergodicity, Gaussian and Poisson processes, Central Limit Theorem, time series analysis, elements of estimation theory. Concepts of accuracy, precision, and resolution of a measurement

(W 2 – W 3)
HW Series 2, 3 (W 2.3, W 3.3)
- Electrical metrology: currents, voltages, charges, noise sources (1/f, RTS, shot, thermal, KT/C), averaging techniques, accuracy, precision, error estimation, time estimation. Tools for electrical metrology (lock-in, PLL, DLL, network analyser, etc.).

(W 4 – W 5 – W 6.1)
HW Series 4, 5 (W 4.3, W 5.3)
- Time

(W 6.2 – W 7.1)
HW Series 6 (W 6.3)
- Optical metrology: photons & wavelengths, intensity, photon flux, image sensor parameters (optical gain, quantum efficiency, PRNU, etc.). Tools for optical metrology. Optical system evaluation (aberration, concentration factors, refraction, diffraction, vignetting, Abbe’s limit).

(W 7.2-W 8-W 9)
HW Series 7, 8, 9 (W 7.3, W 8.3, W 9.3)
- Microscale metrology: SPM/AFM, SEM, interferometry, measurement of micro/nanoscale forces and distances, nanomechanical properties, fundamental issues of nanomechanical metrology instruments.

(W 10 – W 11)
HW Series 10, 11 (W 10.3, W 11.3)
- Redefinition of SI, METAS.

(W 12)
- Quantum perspective: the f-U-I triangle, measuring randomness, photon counting, single-electron detection, qubit metrology, micro-temperature measurements and cryogenic limits.

(W 13 – W 14)

HW Series 12, 13 (W 13.3, W 14.3)

Keywords

Accuracy, precision, resolution, reproducibility, reliability, fidelity of the measurement

Learning Prerequisites

Required courses

Basic mathematics/physics

Recommended courses

Design of experiments

Learning Outcomes

By the end of the course, the student must be able to:

- Develop measurement setups that yield reproducible results
- Analyze the accuracy and precision of a measurement for a certain resolution
- Interpret the quality of data from measurements

Assessment methods

Self-assessment (ungraded homework, exercise session presence verified); final exam during exam sessions.

Resources

Notes/Handbook

Specialized labs, references TBD.