MICRO-428 **Metrology**

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Cursus	Sem.	Type
Microtechnics	MA2, MA4	Obl.

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

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.