

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet: Tehniške meritve
Course title: Technical Measurement

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Tehnologije in sistemi – prva stopnja	/	drugi	tretji
Technologies and systems – 1st cycle	/	second	third

Vrsta predmeta / Course type

obvezni/obligatory

Univerzitetna koda predmeta / University course code:

TS 2 UN 4

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Laboratorijske vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
45			30		93	6

Nosilec predmeta / Lecturer:

prof. dr. Ivan Bajsić

Jeziki / Languages:
slovenski/
slovenian

Predavanja / Lectures: Slovenski/Slovenian
Vaje / Tutorial: Slovenski/Slovenian

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

- vpis v drugi letnik študija,
- študent mora pred izpitom opraviti laboratorijske vaje in zagovarjati seminarsko nalogo.

Prerequisites:

- enrollment in the second year of study,
- before the exam, the student must complete the laboratory exercises and defend the seminar assignment.

Vsebina:

- *Uvod.* Osnovni metrološki pojmi. Merski sistemi (merilne veličine, organiziranost meroslovja: OIML, BIMP, USM, EA, standardi).
- *Osnove tehniških meritev in merilnih metod.* Splošni merilni sistem. Elementi merilnih verig. Načrtovanje eksperimenta. Kalibracije (umerjanje). Teorija merilnih pogreškov.

Content (Syllabus outline):

- *Introduction.* Basic metrological terms. Measurement systems (measuring quantities, organisation of metrology: OIML, BIMP, USM, EA, standards).
- *Basics of technical measurements and measurement methods.* General measurement system. Elements of measurement chains. Design of experiments. Calibrations. Theory of measurement errors.

- *Statične in dinamične značilnice merilnih signalov.* Analogni in diskretni merilni signali. Periodični in neperiodični signali. Naključni signali in motnje. Fourirejeva analiza in frekvenčni spekter.
- *Dinamične značilnice merilnih pretvornikov in merilnih instrumentov.* Prenosna funkcija. Merilni sistemi nič-tega, prvega in drugega reda. Fazno–frekvenčne značilnice.
- *Verjetnost in statistika.* Porazdelitvene funkcije verjetnosti. Normalna porazdelitev verjetnosti. Studentova porazdelitev verjetnosti. Regresijska analiza. Testi zavračanja izmerkov.
- *Analiza merilne negotovosti.* Tipi in vrste merilnih negotovosti. Merilna negotovost neposredno in posredno merjenih veličin. Prikaz merilnih rezultatov (tabelarično, grafično in aproksimacijsko).
- *Električni merilni instrumenti, procesiranje signalov in zajemanje signalov.* Značilnice signalov. Analogni in digitalni merilni instrumenti. Ojačevalniki. Filtri. DAQ sistemi (virtulani merilni instrumenti).
- *Merilna zaznavala in sodobni merilni sistemi za merjenje neelektričnih fizikalnih veličin (metrološke lastnosti, zaznavala, vgradnja, uporaba):*
 - *merjenje pomikov,*
 - *merjenje mase, sil in mehanskih napetosti,*
 - *merjenje temperature,*
 - *merjenje tlakov,*
 - *merjenje hitrosti tekočin,*
 - *merjenje pretokov tekočin.*

- *Static and dynamic properties of measurement signals.* Analog and discrete measurement signals. Periodic and non-periodic signals. Random signals and interference. Fourier analysis and frequency spectrum.
- *Dynamic properties of transducers and measuring instruments.* Portable function. Zero, first and second order measurement systems. Phase-frequency properties.
- *Probability and statistics.* Probability distribution functions. Normal probability distribution. Student's probability distribution. Regression analysis. Sample rejection tests.
- *Analysis of measurement uncertainty.* Types and kinds of measurement uncertainties. Measurement uncertainty of directly and indirectly measured quantities. Presentation of measurement results (tabular, graphical and approximation).
- *Electrical measuring instruments, signal processing and signal acquisition.* Properties of signals. Analog and digital measuring instruments. Amplifiers. Filters. DAQ systems (virtual measuring instruments).
- *Measurement detectors and modern measurement systems for measuring non-electrical physical quantities (metrological properties, detectors, installation, application):*
 - *displacement measurement,*
 - *measurement of mass, forces and mechanical stresses,*
 - *temperature measurement,*
 - *pressure measurement,*
 - *measurement of velocity of fluids,*
 - *fluid flow measurement.*

Temeljni literatura in viri / Readings:

Figliola, R. S., Beasley, D. E. (1991) *Theory and design for mechanical measurements*. New York etc.: John Wiley & Sons, Inc.

Doebelin, E. O. (2004) *Measurement systems*. Boston etc.: McGraw-Hill Book Co.

Holman, J. P. (2001) *Experimental methods for engineers*. Boston etc.: McGraw-Hill Book Co.

BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML (1995) *Guide to the Expression of Uncertainty in Measurement*. Geneva: ISO, first edition.

Bentley, J. P. (2005) *Principles of measurement systems*. Harlow: Pearson Prentice Hall Construction Press.

Cilji in kompetence:

Učna enota prispeva predvsem k razvoju naslednjih splošnih in specifičnih kompetenc:

- seznaniti se z osnovnimi metrološkimi pojmi,
- spoznati zgradbo splošnega merilnega sistema in njegovih elementov,
- spoznati teorijo merilnih odstopanj,
- spoznati statične in dinamične značilnice analognih in diskretnih merilnih signalov,
- spoznati dinamične značilnice merilnikov in merilnih pretvornikov, še posebej dinamičnih merilnih sistemov 1. reda,
- spoznati veljavno proceduro za ocenjevanje merilne negotovosti in spoznati načine prikaza merilnih rezultatov,
- spoznati delovanje A/D kartic za zajemanje podatkov,
- spoznati se z virtualnimi merilnimi instrumenti in spoznati grafični način programiranja (LabVIEW),
- prvi stik s samostojnim delom v laboratoriju dela s področja merilne tehnike,
- spoznati različna merilna zaznavala (senzorje) za merjenje nekaterih fizikalnih neelektričnih veličin.

Objectives and competences:

The learning unit mainly contributes to the development of the following general and specific competences:

- get acquainted with basic metrological terms,
- learn about the structure of the general measurement system and its elements,
- learn about the theory of measurement deviations,
- get to know the static and dynamic characteristics of analog and discrete measurement signals,
- learn about the dynamic characteristics of meters and measuring transducers, especially dynamic measuring systems of the 1st order,
- learn about the valid procedure for assessing measurement uncertainty and learn about the ways of displaying measurement results,
- learn about the operation of A/D cards for data capture,
- learn about virtual measuring instruments and get to know the graphical way of programming (LabVIEW),
- first contact with independent work in the laboratory, work in the field of measurement technique,
- get to know different measurement detectors (sensors) for measuring some physical non-electric quantities.

Predvideni študijski rezultati:

Znanje in razumevanje:

Študent:

- zna prikazati merilne rezultate,
- zna oceniti merilno negotovost,
- prepozna elemente merilne verige,
- spozna osnove A/D kartic za zajemanje merilnih podatkov,
- spozna in uporabi osnove virtualne instrumentacije,
- prepozna motnje in napake v merilni tehniki,
- spozna merilne metode in merilna zaznavala za merjenje neelektričnih fizikalnih veličin,
- sinteza znanja, ki je bilo pridobljeno pri drugih učnih predmetih,
- uporaba domače in tuje literature ter drugih virov, zbiranja in interpretiranja podatkov s področja merilne tehnike, uporaba različnih postopkov, poročanje (ustno in pisno).:
- uporaba instrumentov, tudi virtualnih,
- meriti obravnavane neelektrične fizikalne veličine,
- uporabljati osnovne merilne metode,
- uporabljati grafično programiranje,
- kritično in pravilno predstaviti rezultate meritev.

Intended learning outcomes:

Knowledge and understanding:

Student:

- can represent measurement results,
- can estimate the uncertainty of measurement,
- recognizes the elements of the measurement chain,
- learns the basics of A/D cards for measurement data acquisition,
- learns and uses the basics of virtual metrology,
- recognizes disturbances and errors in measurement technique,
- learns measurement techniques and measurement detectors for measuring non-electrical physical quantities,
- synthesises the knowledge acquired in other subjects,
- uses domestic and foreign literature and other sources, collects and interprets data from the field of measurement techniques, applies various procedures, reports (orally and in writing),
- uses instruments, including virtual ones,
- measures the non-electrical physical quantities under consideration,
- applies basic measurement techniques,
- uses graphical programming,
- presents measurement results critically and correctly.

Metode poučevanja in učenja:

- *predavanja* (razlaga, diskusija, vprašanja, primeri, reševanje problemov),
- *vaje* – laboratorijske vaje,
- *seminar* – samostojno delo.

Learning and teaching methods:

- *lectures* (explanation, discussion, questions, examples, problem solving),
- *tutorials* – laboratory tutorials,
- *seminar* – independent work.

Načini ocenjevanja:

Način (pisni izpit, ustno izpraševanje, naloge, projekt):

- kolokvij
- laboratorijske vaje

Delež (v %) /

Weight (in %) **Assessment:**

Type (examination, oral, coursework, project):

- colloquium
- laboratory tutorials

30% ocene

30% ocene

<ul style="list-style-type: none">• seminar• ustni izpit Ocenjevalna lestvica: ECTS.	20% ocene 20% ocene	<ul style="list-style-type: none">• seminar• verbal exam Grading scale: ECTS.
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