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:	**Prerequisits:**
• vpis v drugi letnik študija, • študent mora pred izpitom opraviti laboratorijske vaje in zagovarjati seminarsko nalogo.	• enrollment in the second year of study, • before the exam, the student must complete the laboratory exercises and defend the seminar assignment.

Vsebina:	**Content (Syllabus outline):**
• *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.	• *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:

Temeljna literatura/Basic literature

Hribernik, Aleš (2017). *Tehniške meritve* (zbrano gradivo). Maribor: Univerzitetna založba Univerze v Mariboru. ISBN 978-961-286-022-6.

Priporočljiva literatura/Recommended

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:	**Intended learning outcomes:**
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.	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:	**Learning and teaching methods:**
• *predavanja* (razlaga, diskusija, vprašanja, primeri, reševanje problemov), • *vaje* – laboratorijske vaje, • *seminar* – samostojno delo.	• *lectures* (explanation, discussion, questions, examples, problem solving), • *tutorials* – laboratory tutorials, • *seminar* – independent work.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): • kolokvij • laboratorijske vaje	 30% ocene 30% ocene	Type (examination, oral, coursework, project): • colloquium • laboratory tutorials

• seminar • ustni izpit Ocenjevalna lestvica: ECTS.	20% ocene 20% ocene	• seminar • verbal exam Grading scale: ECTS.