NAME OF THE COURSE	Electrical measurements					
Code	PMT259	Year of study	3. (undergraduate)			
Course teacher	Ph. D. Sc. Vedran Boras	Credits (ECTS)	5,0			
Associate teachers	-	Type of instruction (number of hours)	L	S	E	F
			30		30	
Status of the course	compulsory	Percentage of application of e-learning	30%			

COURSE DESCRIPTION	
Course objectives	Enabling students to: - acquisition of basic theoretical knowledge in the field of electrical measurements, - The permanent adoption and deepening of knowledge in the field of electrical measurements, - Understanding of the electrical measurement, properties and possibilities of electromechanical and electronic measuring instruments and measuring methods, - Performing independent measurements, - Acquisition of knowledge for the application of optimal methods of measurement, - Developing the ability to work in small groups (teamwork) and - Acquisition of knowledge for the reporting of measurement results.
Course enrolment requirements and entry competences required for the course	Courses completed - the basics of the electrical Engineering or the equivalent course.
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to after successfully mastering the subject: 1. Interpret and explain the concept of measurement uncertainty. 2. Apple model of measurement uncertainty at simple examples. 3. To analyse the measurement problem and perceive sources of systematic and random errors. 4. Implement measures to eliminate errors in electrical measurement. 5. Describe measurement methods for measurement of electrical quantities. 6. Apply measurement methods for measuring electrical quantities. 7. Describe the operation measuring instruments (analogue and digital). 8. Apply measuring instruments for electric measurements. 9. Prepare comprehensive report measurements, to analyse and interpret the measured data. 10. Apply the acquired knowledge in other courses as well as in future teaching practice.
Course content broken down in detail by weekly class schedule (syllabus)	Week 1: Introductory lecture. Introducing students to the rules, literature and teaching assignments. Getting to know with the content of the course. Lecture: Measuring systems, units, natural constants. Basic physical quantities and units. Definitions of base SI unit. Redefining the SI physical unit. Derived SI units. Exercises: Introduction to the Guidelines for laboratory practice as well as the rules of behaviour in the laboratory, and the regulations for electrical measuring instruments. Week 2: Lecture: Concepts measurement error and measurement uncertainty. The absolute, relative and percentage error. Systematic errors. Random errors. Grave mistakes. Measurement uncertainty and limits errors. Exercises: Determination of instrument constant and check the resistance resistive decade Week 3: Lecture: Overview of electric measuring instruments with direct indication. Torque and anti-torque. The scale and the pointer. Attenuation. Constant instrument. The regulations for electrical measuring instruments.

	Exercises: Calibration of voltmeter. Week 4: Lecture: Electrical Instruments with moving coil and permanent magnet. Extending the current measurement range. Extending the voltage measuring range. Measurement of ohmic resistance by means of instrument with moving coil. Instruments with moving-coil and rectifier. Instruments with moving coil and thermal converter. Exercises: Calibration of ammeter. Week 5: Lecture: Instruments with movable magnet. Instruments with a hot wire. Instruments with cross-coils. Instruments with moving iron. Electrodynamic instruments. Exercise: Extending the measurement range of ammeters. Week 6: Lecture: Induction instruments. Electrostatic instruments. Bimetallic instruments. Contact instruments. Thermal transducer. Exercise: Extend the measuring range voltmeter. Week 7: Lecture: Measuring resistance. Performance of measuring resistance. Methods of measuring the ohmic resistance: U-I method, method of comparison, ohm-meter method, method of constant current, method loss of charge. Measuring the resistance of insulating materials. Earth resistance. Measuring bridges. Exercises: Resistance measurement U-I method. Week 8: Lecture: 1. Colloquium Exercises: Resistance measurement using a voltmeter. Week 9: Lecture: Measuring bridges. Wheatstone bridge for DC. Thomson bridge. Wheatstone bridge for AC. Classification of Bridges for AC. Exercises: Measuring resistance by means of Wheatstone bridge. Week 10: Lecture: The measurement using method of compensation. Compensators for DC. Compensators for AC. Measuring power in DC circuits. Exercises: The measurements of electrical power. Week 11: Lecture: Measurement of active and reactive power in AC circuits. Exercises: Determination of measurement uncertainty at measurements using power digital wattmeter. Week 12: Lecture: Basic measurements in AC. Adjusting the current. Measuring resistors, capacitors and inductors. Measurements of inductance, capacitance and loss angle. Measurement of frequency. Electricity meters in DC and AC circuits. Exercises: Metering of electricity (testing single-phase electricity meter using wattmeter and stopwatch). 13th week: Lecture: Voltage measuring transformers. Current measuring transformers. Exercises: Determination of measurement uncertainty for the measurement of electrical Energy using wattmeter and a stopwatch. 14th week: Lecture: Magnetic measurements. Measuring converters. Oscilloscopes. Exercise: Analysis submitted exercises, evaluating students and compensate not worked exercises.

	15th week: Lecture: 2nd Colloquium Exercise: Analysis submitted exercises, evaluating students and compensate not worked exercises.

Format of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ *on line* in entirety ☒ partial e-learning ☒ field work	☒ independent assignments ☒ multimedia ☒ laboratory ☒ work with mentor ☐ (other)
Student responsibilities	- Regular attendance and active participation in lectures. - Performing laboratory exercises. - Self-learning and studying, accessing colloquia and/or written and oral examination. - For laboratory practice the student needs to come ready so that he repeated part of the material related to the exercise and study the instructions for practice and made preparations for the exercise. Any student exercises at the end of the block-hours should submit a brief written report on exercises.	

Screening student work *(name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	2	Research		Practical training	
	Experimental work		Report		Attendance at laboratory exercises:	1
	Essay		Seminar essay		Independent learning:	2
	Tests		Oral exam		(Other)	
	Written exam		Project		(Other)	

Grading and evaluating student work in class and at the final exam	To check and assessment of evaluation of students' work are planned: - Two preliminary exams during semester or oral examination in the examination period. - Practical work in the laboratory; - Reports on the carried-out laboratory exercises. Success of the students in exercises is evaluated based on the application of the student's knowledge in performing exercises, manifested skills, independence, use of instruments and other devices, the application of protective measures and preparing reports on the exercise. Positive evaluation of practical exercises is a prerequisite for a positive evaluation of this course. Students who pass both colloquiums (achieve more than 50% points from each tests) released a written and oral exam. Other students should to access written and oral exam. Depending on the achieved percentage of the oral and written part of the exam is determined by the final score: 50 - 62% - sufficient (2) 63-75% - good (3) 76-87% - very good (4) 88-100% - excellent (5)

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	1. Predavanja – Električna mjerenja - online		
	2. Bego V.: Mjerenja u elektrotehnici, Tehnička knjiga Zagreb, 1990.		
	3. Vujević, D.: Mjerenja u elektrotehnici, Laboratorijske vježbe, Sveučilište u Zagrebu, Zagreb, 1993.		

Optional literature (at the time of submission of study programme proposal)	1. Vujević D., Ferković B.: Osnove elektrotehničkih mjerenja I, Školska knjiga, Zagreb, 1994. 2. Carr J.: Elements of Instrumentation and Measurement, Prentice Hall, 1986. 3. Mlakar F.: Opća elektrotehnička mjerenja, Tehnička knjiga, Zagreb, 1987. 4. Thomas Mühl: Einführung in die elektrische Messtechnik Grundlagen, Messverfahren, Geräte Grundlagen, Messverfahren, Geräte, Teubner Verlag, 2006. 5. The International System of Units (SI), BIPM, 1991.		
Quality assurance methods that ensure the acquisition of exit competences	- Taking attendance at lectures; - The annual analysis of the success of the examination; - Student survey in order to evaluate teachers; - Feedback from students who have already graduated from the relevance of the course content, - Self-evaluation.		
Other (as the proposer wishes to add)			