



# SYLLABUS

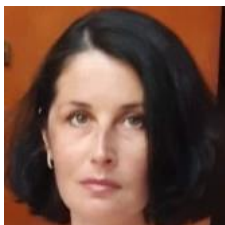
## EDUCATIONAL DISCIPLINE



### « Fundamentals of Metrology and Electrical Measurements »

Code and name of specialty	141 – Electric Power Engineering, Electrical Engineering and Electromechanics	Institute/Faculty	Institute of Education and Science in Power Engineering, Electronics and Electromechanics
Name of program	Electric Power Engineering, Electromechanics, Electric drive, mechatronics, robotics	Department	Information and Measuring Technologies and Systems
Type of program	Educational and professional	Language	English
Higher education level	First (Bachelor)	Type of discipline	Professional training; mandatory

### LECTURER



**Chunikhina Tetiana**, [tetiana.chunikhina@khpj.edu.ua](mailto:tetiana.chunikhina@khpj.edu.ua)

PhD, Associated Professor of the “Information and Measuring Technologies and Systems” department.

Experience – 20 years.

Author of more than 70 scientific publications and educational-methodological works (4 of them-with indexation in Scopus).

Leading lecturer in disciplines: “Uncertainty of Measurement”, “Metrological Assurance of the Measuring Transducers”

### GENERAL INFORMATION ABOUT THE DISCIPLINE

<b>Abstract</b>	The discipline is devoted to study the basic terms of the metrology and measuring technique, fundamentals of the theory of the measurement errors and errors of the measuring instruments, principles of the development of the analog and digital measuring devices.
<b>Objective</b>	Training the students the basic terms and determination of the metrology and measuring technique, fundamentals of the theory of the errors and measurement uncertainty, methods of the processing of the measurement results, provide recognizing about construction of the different types of the measuring devices. Form at the students the skills to performe the single and multiple measurements of the electrical quantities, master the methods of the processing of the results of the multiple measurements, define measurement errors, taking into account the accuracy classes of the analog and digital measuring instruments and correct present the measurement result. Master the methods of the performing direct and indirect measurements.
<b>Format</b>	Lectures, laboratory classes, individual calculated tasks, consultations. Semester control – exam.
<b>Semester</b>	The discipline is taught in the III semester.
<b>Volume</b>	Total volume of discipline 150 hours: Lecture – 32 hours, Laboratory classes – 32 hours, Individual work – 86 hours.

<b>Previous disciplines</b>	“Introduction to the discipline. Introductory practice”, “Higher mathematics”, “Physics”, “Fundamentals of the electric power industry”
<b>Learning outcomes</b>	To be able to correctly use the terms, established by actual standards in the field of the metrology, analyse the reasons of the appearance the measurement errors, reasonably choose methods and measuring instruments, qualitatively plane and perform the measuring experiment, evaluate the measurement errors and measurement uncertainty.
<b>Requirements from the teacher</b>	The student should to attend all classes according to the schedule, not to be late. Observe ethical behavior. Work with educational and additional literature, with literature on electronic media and on the Internet. If the lecture is missed, an verbal interview on the topic is held. Practice laboratory classes with the teacher's permission. In order to the necessary quality of education of the discipline, a regular preparation for classes is required. Final control is not able without the personal presence of the student.

## STRUCTURE OF THE DISCIPLINE

<b>Lecture 1 (2 hours)</b>	Introduction to the discipline. The basic terms and determination of metrology.	<b>Laboratory class 1 (6 hours)</b>	Measurements the direct current and voltage (verification of the micro ammeter; expanding the measurement ranges by current and voltage).	<b>Individual work</b>	Table, containing base quantities of the SI and symbols for dimension. Table, containing base quantities of the SI and base units.
<b>Lecture 2 (2 hours)</b>	The systems of the physical quantities. The International System of Quantities (ISQ). The base and derived physical quantities of the ISQ. The International System of Units (SI). Quantity dimension.	<b>Laboratory class 2 (8 hours)</b>	Measurements with using the combine device (measurements the direct and alternative current and voltage; measurements the resistance; processing of the results of the indirect measurements; researches the logical elements).		Table on the SI prefixes for multiples of units and submultiples of units. Rules of the Quantity dimension. Solving the tasks on the determination the dimension of the physical quantity, using the dimension of the quantities, that are included in the physical formula.
<b>Lecture 3 (2 hours)</b>	Measuring operations. Classification of the measuring instruments by functional purposes.	<b>Laboratory class 3 (6 hours)</b>	The digital frequency meter (researches the impulse counter; measurements of the frequency and period of the signal; measurements of the relation of the two frequencies).		The presentation of the measurement result. Rules for rounding off.
<b>Lecture 4 (2 hours)</b>	The influence quantities. Measurement conditions (conditions of the exploitation of the measuring instruments). The reference conditions, the operating conditions, the limitary conditions.	<b>Laboratory class 4 (6 hours)</b>	Measurements with using the oscilloscope (measurements the parameters of the periodical signals; researches the characteristics of the ferromagnetic materials).		Solving the tasks on the presentation of the measurement result and comparing the results of the measurements by accuracy.

<b>Lecture 5 (2 hours)</b>	Classification of the measurements.	<b>Laboratory class 5 (6 hours)</b>	Verification of the single-phase electricity meter.	Measurement model. Input quantities in a measurement model. Output quantities in a measurement model.
<b>Lecture 6 (2 hours)</b>	The principle of the operating of the electromechanical measuring devices. Designations on the devices' scales.			The construction of the electromechanical measuring devices of the magnetoelectric system. Shunts and additional resistances.

<b>Lecture 7 (2 hours)</b>	Classification of the errors of the measurements (instrumental error, operator's error, error of the measurement method; systematic error and random error; absolute error and relative error). Accuracy of the measurements.			<b>Individual work</b>	The construction of the electromechanical measuring devices of the electromagnetic system.
<b>Lecture 8 (2 hours)</b>	The error of the interaction at the switching in the electrical circle ammeter and voltmeter.				The construction of the electromechanical measuring devices of the electrodynamic system.
<b>Lecture 9 (2 hours)</b>	Classification of the errors of the measuring instruments (absolute error, relative error, fiducial error, hysteresis of the measuring instrument, permissible error; systematic error and random error; static error and dynamic error; intrinsic error and complementary errors; additive error and multiplicative error).				Solving the tasks on the determination the error of the interaction at the switching in the electrical circle ammeter and voltmeter.
<b>Lecture 10 (2 hours)</b>	Probabilistic and statistical characteristics of the measurement results and measurement errors. Integrative law of the probability's distribution and probability density functions.				Normal distribution and rectangle distribution of the random values. The numeric characteristics of the laws.
<b>Lecture 11 (2 hours)</b>	Evaluation of the error and result of the direct measurements (measurements with one and repeated observations). Evaluation of the error and result of the indirect measurements.				Solving the tasks on the determination the absolute error of the indirect measurements.
<b>Lecture 12 (2 hours)</b>	The metrological characteristics of the measuring instruments. The metrological characteristics, defining the measurement result and the metrological characteristics, defining the measurement error.				The standardization of the metrological characteristics of the measuring instruments.
<b>Lecture 13 (2 hours)</b>	The methods of the establishing the accuracy classes of the measuring instruments. The established raw for values, used for setting of the accuracy classes.				Solving the tasks on the accuracy classes of the measuring devices, that have different methods of the establishing the accuracy class.
<b>Lecture 14 (2 hours)</b>	Measurement uncertainty. The type A standard measurement uncertainty. The type B standard measurement uncertainty. The combined standard measurement uncertainty. The expanded uncertainty of the measurement. The presentation of the measurement result with account the expanded uncertainty.				Solving the tasks on the calculation the measurement uncertainty of type A and measurement uncertainty of type B for measuring devices with different methods of the establishing the accuracy class.
<b>Lecture 15 (2 hours)</b>	The digital measuring instruments. The basic terms. The digital frequency meter.				Verification of the measuring instruments (practical realization

	Measurements of the frequency and period of the signal, measurements of the relation of the two frequencies.				the verification of the measuring channels at the nuclear power plant "Kozloduy", Bulgaria).
<b>Lecture 16 (2 hours)</b>	The electronic oscilloscope. Principle of the operating. The structural scheme. Measurements with using the oscilloscope.				

## LITERATURE AND EDUCATION MATERIALS

### Basic literature

1. Chynkov V.M. Osnovy metrologii ta vymiruvanoi tekhniky: Navch. posibnyk. – 2 vyd. , pererob. i dop. - Kharkiv: NTU «KhPI», 2005. – 524. s.
2. JCGM 200:2008. International vocabulary of metrology-Basic and general concepts and associated terms (VIM).
3. Chynkov V.M. Tsifrovy vymiruvalni prylady Navch. posibnyk. – Kharkiv: NTU «KhPI», 2008. – 508. s.
4. Dorozhovets M., Motalo V., Stadnyk B., Vasyluk V., Borek R., Kovalchik A Osnovy metrologii ta vymiruvanoi tekhniky: Navch. posibnyk. – u 2 tomah. - Lviv: vydavnytstvo Natsionalnogo universytetu «Lvivska Politehnika», 2005.
5. OIML R-34 Accuracy classes of measuring instruments. Edition 1979. International recommendation. .
6. Guide to the Expression of Uncertainty in Measurement.-Geneva: ISO, 1993.-101 p. COOMET R/GM/21:2011.
7. COOMET R/GM/21:2011. Vycorystannya ponyat' "pohybka vymiruvannya" ta "nevyznachenist' vymiruvannya ". Zagalny pryntsypy.
8. Zabezpechennya ednosty electroradiovymiruvan// za red. P.F. Pavlenka (Navch. posibnyk). - Kharkiv: NTU «KhPI», 2011. – 232. s.
9. Semyon G. Rabinovich. Measurements errors and uncertainties. Theory and practice. Third edition. Springer Science and Media, Inc. USA. – 2005. - 308 p.

### Auxiliary literature

## LIST OF QUESTIONS FOR EXAM

The International System of units. Base and derived quantities. The method of the setting the accuracy class in the case, when the additive error is prevailing. The physical quantity. The dimension. Measuring operations. Classification of the measuring instruments by functional purposes. Classification of the measurements. The metrological characteristics of the measuring instruments. The main purpose of the verification of the measuring instruments. Expanding the measurement ranges by current and voltage. The method of the setting the accuracy class in the case, when the multiplicative error prevailing. Influence values. 4 groups of the conditions of the measurements. Intrinsic error and complementary errors The established raw for values, used for setting of the accuracy classes. The method of the setting the accuracy class in the case, when the additive and multiplicative errors are comparable. Classification of the errors of the measurements by the behavior from measurement to measurement. The error of the interaction at the switching in the electrical circle ammeter and voltmeter. Classification of the errors of the measurements by the method of the expression. The additive and multiplicative errors (figures). Classification of the errors of the measurements by the source of the origin. The gauging characteristic of the IMT. Measurement uncertainty. The type A standard measurement uncertainty. The type B standard measurement uncertainty. The digital frequency meter. (measurements of the frequency and period of the signal, measurements of the relation of the two frequencies). The electronic oscilloscope (principle of the operating).

## LIST OF EQUIPMENT



The laboratory stands contain the laboratory equipment (analog and digital devices) of the laboratory of the electrical quantities' measurements.



## EDUCATION METHODS

To study of the discipline in order to activate the educational and cognitive activity of students during the study of the discipline on the lectures, laboratory classes and consultations, the following complex of teaching methods are used: explanatory and illustrative, reproductive, problem presentation, partially research, research.

## DISTRIBUTION OF MARKS

Tests	Laboratory works	Individual tasks	Exam	Sum
40	20	20	20	100

## ASSESSMENT SCALE

Rating points	Rating ECTS	Rating national scale	Evaluation criteria	
			positive	negative
90-100	A	Excellent	<ul style="list-style-type: none"> <li>– a deep level of knowledge of the main and additional content;</li> <li>– answers to questions are logical and consistent;</li> <li>– the ability to solve complex practical problems.</li> </ul>	<ul style="list-style-type: none"> <li>– answers to questions may contain minor inaccuracies</li> </ul>
82-89	B	Good	<ul style="list-style-type: none"> <li>– a deep level of knowledge in the scope of mandatory content;</li> <li>– ability to give reasoned answers;</li> <li>– the ability to solve complex practical problems.</li> </ul>	<ul style="list-style-type: none"> <li>– the answers to the questions contain certain inaccuracies</li> </ul>
75-81	C	Good	<ul style="list-style-type: none"> <li>– Strong knowledge of the studied material and its practical application;</li> <li>– ability to give reasoned answers;</li> <li>– ability to solve practical problems.</li> </ul>	<ul style="list-style-type: none"> <li>– answers to questions contain inaccuracies;</li> <li>– inability to solve complex practical problems</li> </ul>
64-74	D	Satisfactorily	<ul style="list-style-type: none"> <li>– knowledge of the fundamental points of the studied content and its practical application;</li> <li>– the ability to solve simple practical problems.</li> </ul>	<ul style="list-style-type: none"> <li>– inability to give reasoned answers to questions;</li> <li>– inability to solve practical problems</li> </ul>
60-63	E	Satisfactorily	<ul style="list-style-type: none"> <li>– knowledge of the fundamental provisions of the studied content;</li> <li>– the ability to solve the simplest practical problems</li> </ul>	<ul style="list-style-type: none"> <li>– ignorance of certain questions from the content;</li> <li>– inability to consistently express an opinion;</li> <li>– inability to solve practical problems</li> </ul>
35-59	FX	Unsatisfactory refolding	<ul style="list-style-type: none"> <li>– additional study of the content can be completed in the terms provided by the curriculum</li> </ul>	<ul style="list-style-type: none"> <li>– ignorance of the basic points of the educational content;</li> <li>– significant errors in answering questions;</li> <li>– inability to solve simple practical problems</li> </ul>
1-34	F	unsatisfactory with compulsory re-examination of discipline	–	<ul style="list-style-type: none"> <li>– complete lack of knowledge of a significant part of the content;</li> <li>– significant errors in answering questions;</li> <li>– ignorance of the main fundamental provisions;</li> <li>– inability to navigate when solving simple practical problems</li> </ul>

## THE ACADEMIC ETHICS NORMS

The student must follow to the "Code of Ethics of Academic Relations and Integrity of NTU "KhPI"": keep a discipline, education, benevolence, honesty, responsibility. Conflict situations should be openly discussed in the study groups with the teacher, and if the conflict cannot be resolved, it should be brought to the attention of the department and institute employees.

The content of the syllabus completely corresponds to the working program of educational discipline.