



SCHOOL OF BUSINESS
AND MANAGEMENT OF
TECHNOLOGY OF BSU



Innovative ICT Education for Social-Economic Development (IESED)
574283-EPP-1-2016-1-LT-EPPKA2-CBHE-JP

METROLOGY, METHODS AND DEVICES FOR TECHNICAL MEASUREMENTS

Minsk 2017

1. PLAN OF EDUCATIONAL DISCIPLINE

Year of study	Semester	Academic hours					Hours of course work	ECTS	Number of hours
		Total	Lectures	Lab	Practice/ seminar	Independent work			
1	2,3,4	190	66	102	-	22	-	7	Full-time
1	1,2	190	26	20	-	144	-	7	Part-time

2. COMPETENCES

1. Plan and organize automated support of various activities.
2. To be able to apply basic scientific and theoretical knowledge to solve practical problem.

3. COURSE AIMS

Training of a specialist with fundamental knowledge of the principles of construction and operation of measuring converters, devices and systems for automated measurement of production processes.

4. COMPETENCES FORMED DURING THE IMPLEMENTATION OF THE EDUCATIONAL PROGRAM

1. Choose a method of measuring technological parameters
 - calculate the metrological characteristics of measuring instruments;
2. Carry out the selection of the necessary measuring means
 - conduct verification of standard instruments;
3. To be able to apply the basic methods of processing signals of measuring information in modern measuring complexes;
 - determine the sources of errors in the measurement and eliminate the cause of their occurrence,
 - be able to configure the physical and logistic interface of the stripping device.

5. EDUCATIONAL AND METHODOLOGICAL MAP (for full-time education)

Section number	Topics, classes; list of issues to be studied	Number of academic hours				Form of knowledge control
		Total	Lecture	laboratory classes	Independent work	
1.	Introduction	2	2			Testing
2.	Measurement error	6	6			Testing
3.	Processing of measurement results	2	2			Testing
4.	Measuring instruments	36	4	32		Testing, laboratory work
5.	Elements of measuring instruments	52	10	42		
5.1.	Transducers	26	4	22		Testing, Laboratory work
5.2.	Measuring transducers	24	4	20		Testing, Laboratory work

5.3.	Converters	1	1			Testing
5.4.	Secondary measuring instruments	1	1			Testing
6.	Measurement of process parameters in the industrial sector	78	28	50		
6.1.	Methods and means of measuring pressure	22	6	16		Testing, Laboratory work
6.2.	Methods and means for measuring temperature	24	6	18		Testing, Laboratory work
6.3.	Methods and means for measuring the flow of substances	4	4			Testing
6.4.	Methods and means for measuring the level	20	4	16		Testing, Laboratory work
6.5.	Measurement of physico-chemical properties of liquids and gases	4	4			Testing
6.6.	Measurement of the concentration of liquid and gas mixtures	4	4			Testing
7.	Information characteristics measuring means	6	6	0		Testing
8.	Information transmission systems	2	2	0		Testing
9.	Measuring and information systems	6	6	0		Testing
TOTAL		190	66	124		

6. EDUCATIONAL AND METHODOLOGICAL MAP (for part-time education)

Section number	Topics, classes; list of issues to be studied	Number of academic hours				Form of knowledge control
		Total	Lecture	Laboratory classes	Independent work	
1.	Introduction	1	1		1	Testing
2.	Measurement error	2	2		4	Testing
3.	Processing of measurement results	1	1		1	Testing
4.	Measuring instruments	8	2	6	28	Testing, laboratory work
5.	Elements of measuring instruments	12	6	6	40	
5.1.	Transducers	5	2	3	21	Testing, Laboratory work
5.2.	Measuring transducers	5	2	3	19	Testing, Laboratory work
5.3.	Converters	1	1			Testing
5.4.	Secondary measuring instruments	1	1			Testing
6.	Measurement of process parameters in the industrial sector	15	7	8	63	
6.1.	Methods and means of measuring pressure	4,5	1,5	3	17,5	Testing, Laboratory work
6.2.	Methods and means for measuring temperature	4,5	1,5	3	19,5	Testing, Laboratory work
6.3.	Methods and means for measuring the flow of substances	1,5	1,5		2,5	Testing
6.4.	Methods and means for measuring the level	3,5	1,5	2	16,5	Testing, Laboratory work
6.5.	Measurement of physico-chemical properties of liquids and gases	0,5	0,5		3,5	Testing
6.6.	Measurement of the concentration of liquid and gas mixtures	0,5	0,5		3,5	Testing
7.	Information characteristics measuring means	4	4		2	Testing
8.	Information transmission systems	1	1		1	Testing
9.	Measuring and information systems	2	2		4	Testing
TOTAL		46	26	20	144	

7. THEORETICAL CONTENT

№	Topic number	Content
1.	Introduction	Subject and metrology challenges. The structure of the metrology. Basic concepts and definitions metrology. The international system of physical units (SI). Ensuring traceability. Objects of measurements in the industry. Metrological service. Measurement classification. Measurement methods.
2.	Measurement error	Classification of measurement error. Sources arose-novena error. The principles of assessment error. Mathematical models of uncertainty. Accuracy and non-certainty. Systematic errors. Classification. Methods for detecting and eliminating random errors. Probabilistic description of random error. Basic laws of distribution of random variables and their parameters. Confidence level and confidence interval. Rough errors and methods of elimination
3.	Processing of measurement results	Direct single and multiple measurements. Evaluation of uncertainty of indirect measurements. Basic principles and stages of settlement. Guests on the processing results. Summation, availability of error. Rounding off and presentation of results
4.	Measuring instruments	Classification means for metrological measurement purpose, principle and others. Block diagrams of the measurement means. Metrological characteristics measuring means. Static and dynamic character-sticks measuring means. Details of the error measuring means. Principles of valuation metrologicheing characteristics of measuring instruments. Testing and certification of an measurement tool: the types and volume of tests.
5.	Elements of measuring instruments	
5.1	Transducers	Purpose, classification, used physical phenomena, designs, applications. Primary measuring transducers of resistive types. Inductive and capacitive primary measuring transducers.
5.2	Measuring transducers	Electrical measurements of electrical quantities (electro-driving force, current, voltage, phase, power). Measurement of electrical circuit parameters (resistance, capacitance, inductance). Measuring bridge and potentiometer. Measuring amplifier
5.3	Converters	Appointment. Characteristics
5.4	Secondary measuring instruments	Electronic secondary instruments for determining the parameters of electrical signals
6.	Measurement of process parameters in the industrial sector	
6.1	Methods and means of measuring pressure	Units of measurement. Pressure measuring equipment. Classification. Liquid manometers. Difmanometry. Metrological characteristics. Deformation manometers. Elements that perceive pressure. Metrological characteristics. Tensor and piezoresistive manometers. Vacuum meters. Differential pressure measurement
6.2	Methods and means for measuring temperature	Features of temperature measurements. Thermometric properties of substances. Relative and absolute temperature scales. Classification of the means of measuring temperature. Expansion thermometers. Manometric thermometers. Thermoelectric converters. Principle of operation, materials. Methods for measuring thermoelectric. Resistance thermometers. Design. Metrological characteristics. Bridges, logometers, rationing converters. Means for measuring high temperatures. Classification of methods for measuring temperature. Characteristics of thermal radiation, basic physical phenomena and laws. Pyrometers: optical, photoelectric, color, radiation pyrometers. Dynamic characteristics of temperature measuring instruments

№	Topic number	Content
6.3	Methods and means for measuring the flow of substances	<p>Classification of flow measurement methods. Flowmeters of variable differential pressure. Flowmeters with a narrowing device. Flowmeters with a pressure device. Flowmeters flow. Tachometric flowmeters: turbine, ball, chamber.</p> <p>Electromagnetic flowmeters: the principle of action, design, metrological characteristics. Ultrasonic flowmeters: time-impulse, frequency-impulse, Doppler.</p> <p>Vortex and Coriolis flowmeters. Thermal flowmeters.</p> <p>Measurement of small and ultra-small expenses.</p>
6.4	Methods and means for measuring the level	<p>Classification of level measuring instruments. Visual and float level gauges of liquids. Buoyance level gauges. Hydrostatic means of level measurement. Electrical means of level measurement. Acoustic level gauges. Radioisotope level gauges. Measurement of the level of bulk materials.</p>
6.5	Measurement of physico-chemical properties of liquids and gases	<p>Quality indicators. Density, viscosity, humidity, concentration, transparency, refraction of light, etc. Definitions, units of measurement, measurement methods.</p> <p>Means of measuring the density of liquids and gases. Weight, float, hydro and aerostatic, vibrating, hydro-gas-dynamic densitometers. Static and dynamic characteristics of density meters.</p> <p>Means of measuring the viscosity of liquid media. The law of viscous flow, units of viscosity. Capillary viscometers, viscometers with a falling body, rotational viscosimeters.</p> <p>Means of measurement of humidity. Methods for measuring the humidity of gaseous media: psychrometric, dewpoint, sorption. Electrical and optical SI measurements of moisture in loose media. Conductometric, dielectric, optical, microwave, radioisotope, thermal method of moisture measurement.</p>
6.6	Measurement of the concentration of liquid and gas mixtures	<p>Classification. Analyzers of multicomponent, binary and pseudobinary mixtures. Automatic gas analyzers of various types. Chromatography.</p> <p>Means for measuring the concentration of liquids.</p>
7.	Information characteristics of measuring instruments	<p>Fundamentals of Information Theory. Message, symbols, signals. The amount of information for discrete and continuous processes. The speed of creating messages.</p> <p>Measuring information signals. Classification. Ways to specify signals. Quasideterministic signals (constant signal, unit pulse, harmonic signal, periodic sequence of rectangular pulses). Expansion of the functions of these signals into Fourier series. Frequency spectra of signals. The spectral density of the signal. The width of the spectrum.</p> <p>Information transfer channel. Interference. Noises. The speed of information transfer. Bandwidth of the channel.</p> <p>Transformation of signals of the measuring information. Modulation, types of modulations. Spectral analysis of signals of measurement information for various types of modulation</p>
8.	Information transfer systems	<p>Classification by type of information carrier. Types of unified signals.</p> <p>Transducers of the "force-pressure" and "force-to-current" kind of pneumatic and electrical systems. Differential-transformer and magnetic pre-conditioners of displacement. Information transmission systems with a frequency signal</p>
9.	Measuring and information systems	<p>Basic concepts. Classifications and varieties. Functions. Generalized structural scheme of IIS.</p> <p>Interfaces of measuring systems. Functions. Classification. Interface specifications. Varieties of structures. Instrument interfaces.</p> <p>Automatic control systems (SAC). Tasks. Structure. Algorithm of functioning.</p> <p>Systems of technical diagnostics (STD). STD objects. Tasks. Classification of STD.</p> <p>Systems of pattern recognition. Holographic information systems.</p>

8. LABORATORY PRACTICE

№	Topic	Content
1.	Measuring instruments	Metrological characteristics measuring means. Static and dynamic character-sticks measuring means. Details of the error measuring means. Testing and certification of an measurement tool: the types and volume of tests.
2.	Elements of measuring instruments	
2.1.	Transducers	Primary measuring transducers of resistive types. Inductive and capacitive primary measuring transducers.
2.2.	Measuring transducers	Electrical measurements of electrical quantities (electro-driving force, current, voltage, phase, power). Measurement of electrical circuit parameters (resistance, capacitance, inductance). Measuring bridge and potentiometer
3.	Measurement of process parameters in the industrial sector	
3.1.	Methods and means of measuring pressure	Liquid manometers. Deformation manometers. Tensor and piezoresistive manometers. Differential pressure measurement
3.2.	Methods and means for measuring temperature	Expansion thermometers. Thermoelectric converters. Resistance thermometers.
3.3.	Methods and means for measuring the level	Visual and float level gauges of liquids. Hydrostatic means of level measurement. Electrical means of level measurement.

9. ASSIGNMENT FOR INDEPENDENT WORK

№	Tasks
1.	Processing of measurement results and determination of errors.
2.	Calculation of primary measuring transducers.
3.	Calculation of measuring devices for monitoring the parameters of technological processes.

10. SYSTEM OF ASSESSMENT OF KNOWLEDGE AND SKILLS (ACCORDING TO THE NATIONAL REQUIREMENTS)

The evaluation criteria of the results on a ten-point scale.

A ten-point scale, depending on the grade and the mark, includes the following criteria:

10 (ten) points, passed:

- systematized, deep and full knowledge on all sections of the curriculum of the institution of higher education in the academic discipline, as well as on major issues that go beyond its limits;
- accurate use of scientific terminology (including in a foreign language), competent, logically correct statement of the answer to questions;
- perfect mastering of the tools of the academic discipline, the ability to use it effectively in formulation and solution of scientific and professional problems;
- the expressed ability independently and creatively to solve complex problems in non-standard situations;
- complete and profound studying of basic, additional literature on the subject of the discipline;
- the ability to freely navigate in theories, concepts and directions on the discipline and give them an analytical assessment, use the scientific achievements of other disciplines;
- creative independent work on practical, laboratory classes, active creative participation in group discussions, high level of the culture of performance of tasks.

9 (nine) points, passed:

- systematized, deep and full knowledge on all sections of the curriculum of the institution of higher education on the academic discipline;
- accurate use of scientific terminology (including in a foreign language), competent, logically correct statement of the answer to questions;
- mastering of the tools of the academic discipline, the ability to use it effectively in formulation and solution of scientific and professional problems;
- ability independently and creatively to solve complex problems in non-standard situations within the curriculum of the institution of higher education on the academic discipline;
- complete studying of basic, additional literature on the subject of the discipline, recommended by the curriculum of the institution of higher education on the discipline;
- the ability to navigate in theories, concepts and directions on the discipline and give them an analytical assessment;
- Systematic, active independent work on practical, laboratory classes, active creative participation in group discussions, high level of the culture of performance of tasks.

8 (eight) points, passed:

- systematized, deep and full knowledge on all sections of the curriculum of the institution of higher education in the academic discipline in the volume of the curriculum of the institution of higher education on the discipline;
- use of scientific terminology (including in a foreign language), competent, logically correct statement of the answer to questions, the ability to make sound conclusions and generalizations;
- mastering of the tools of the academic discipline (methods of complex analysis, information technology), the ability to use it effectively in formulation and solution of scientific and professional problems;
- ability independently to solve complex problems within the curriculum of the institution of higher education on the academic discipline;
- studying of basic, additional literature, recommended by the curriculum of the institution of higher education on the discipline;
- the ability to navigate in theories, concepts and directions on the discipline and give them an analytical assessment;
- active independent work on practical, laboratory classes, systematic participation in group discussions, high level of the culture of performance of tasks.

7 (seven) points, passed:

- systematized, deep and full knowledge on all sections of the curriculum of the institution of higher education on the academic discipline;
- use of scientific terminology (including in a foreign language), competent, logically correct statement of the answer to questions, the ability to make sound conclusions and generalizations;
- mastering of the tools of the academic discipline, the ability to use it effectively in formulation and solution of scientific and professional problems;
- free possession of generic solutions within the curriculum of the institution of higher education on the academic discipline;
- studying of basic, additional literature, recommended by the curriculum of the institution of higher education on the discipline;
- the ability to navigate in basic theories, concepts and directions on the discipline and give them an analytical assessment;
- independent work on practical, laboratory classes, participation in group discussions, high level of the culture of performance of tasks.

6 (six) points, passed:

- sufficiently full and systematized knowledge in the volume of the curriculum of the institution of higher education on the discipline;
- use of the necessary scientific terminology, competent, logically correct statement of the answer to questions, the ability to make sound conclusions and generalizations;
- mastering of the tools of the academic discipline, the ability to use it effectively in solution of scientific and professional problems;
- ability independently to apply generic solutions within the curriculum of the institution of higher education on the academic discipline;
- studying of basic literature, recommended by the curriculum of the institution of higher education on the discipline;
- the ability to navigate in basic theories, concepts and directions on the discipline and give them a comparative assessment;
- active independent work on practical, laboratory classes, periodic participation in group discussions, high level of the culture of performance of tasks.

5 (five) points, passed:

- sufficient knowledge in the volume of the curriculum of the institution of higher education on the discipline;
- use of scientific terminology, competent, logically correct statement of the answer to questions, the ability to make sound conclusions;
- mastering of the tools of the academic discipline, the ability to use it in solution of scientific and professional problems;
- ability independently to apply generic solutions within the curriculum of the institution of higher education on the academic discipline;
- studying of basic literature, recommended by the curriculum of the institution of higher education on the discipline;
- the ability to navigate in basic theories, concepts and directions on the discipline and give them a comparative assessment;
- active independent work on practical, laboratory classes, periodic participation in group discussions, high level of the culture of performance of tasks;
- independent work on practical, laboratory classes, periodic participation in group discussions, sufficient level of the culture of performance of tasks.

4 (four) points, passed:

- sufficient knowledge within the educational standard of higher education;
- studying of basic literature, recommended by the curriculum of the institution of higher education on the discipline;
- use of scientific terminology, logical statement of the answer to questions, the ability to make sound conclusions;
- ability to draw conclusions without essential errors;
- mastering of the tools of the academic discipline, the ability to use it in solution of standard (typical) tasks;
- ability to solve standard (typical) tasks under the guidance of a teacher;
- ability to navigate in basic theories, concepts and directions on the discipline and give them an assessment;
- work under the guidance of a teacher on practical, laboratory classes, the permissible level of the culture of performance of tasks.

3 (three) points, failed:

- insufficient knowledge within the educational standard of higher education;
- studying of basic literature, recommended by the curriculum of the institution of higher education on the discipline;
- knowledge of a part of the basic literature, recommended by the curriculum of the institution of higher education on the discipline;
- use of scientific terminology, presentation of answers to questions with significant, logical errors;
- weak possession of the tools of the academic discipline, incompetence in solving standard (typical) tasks;
- inability to navigate in basic theories, concepts and directions on the discipline;
- work under the guidance of a teacher on practical, laboratory classes, the permissible level of the culture of performance of tasks.
- passivity on practical, laboratory classes, low level of the culture of performance of tasks.

2 (two) points, failed:

- fragmented knowledge within the educational standard of higher education;
- knowledge of individual literary sources, recommended by the curriculum of the institution of higher education on the discipline;
- inability to use scientific terminology of the academic discipline, the presence in the answer rude, logical errors;
- passivity on practical, laboratory classes, low level of the culture of performance of tasks.

1 (one) point, failed:

- lack of knowledge and (competences) within the educational standard of higher education, failure to answer, failure to appear for attestation without good cause.

11. METHODS AND MEANS OF IMPLEMENTATION OF THE CONTENT OF THE EDUCATIONAL PROGRAM AND TRAINING OF EDUCATIONAL, TRAINING AND METHODOLOGICAL MATERIALS

The training will be conducted using classical methods, project methods and distance learning technologies, реализованных на портале SDO.VSTU.BY. Обучающиеся будут обеспечены доступом к portalу SDO.VSTU.BY.

implemented on the portal SDO.VSTU.BY. Trainees will be provided with access to the SDO.VSTU.BY portal.

In the classroom, students will learn the discipline directly in the laboratory.

The following tools and technologies were used in the preparation of training, teaching and methodological materials:

- Adobe PDF.
- LMS Moodle.
- Programs for recording and editing video.

12. THE INFORMATION-METHODOLOGICAL PART

Main literature

1. Пелевин, В. Ф. Метрология и средства измерений: учебное пособие для студентов учреждений высшего образования по техническим и технологическим спец. / В. Ф. Пелевин,. - Минск: Новое знание ; Москва : Инфра-М, 2013. - 272 с.
2. Миронов, Э.Г. Метрология и технические измерения : учебное пособие / Э.Г. Миронов, Н.П. Бессонов. - Москва : КНОРУС, 2015. - 422 с.

3. Герасимова, Е.Б. Метрология, стандартизация и сертификация : учебное пособие / Е.Б. Герасимова, Б.И. Герасимов. – Москва : ФОРУМ : ИНФРА-М, 2010. – 224с.
4. Лячев, В.В. Метрологические основы теории измерительных процедур : Научное издание – учебное пособие / под ред. В.В. Лячева. – Санкт-Петербург : Элмор, 2011. – 416 с.
5. Раннев, Г.Г. Измерительные информационные системы : учебник для студ. высш. учеб. заведений / Г.Г. Раннев. – Москва : Академия, 2010. – 336 с.

Additional literature

1. Метрология, стандартизация, сертификация и электроизмерительная техника: учебное пособие для студентов вузов, обучающихся по направлениям подготовки в области техники и технологии / К. К. Ким, Г. Н. Анисимов, В. Ю. Барборович, Б. Я. Литвинов; под ред. К. К. Кима. - Москва: Питер, 2006. - 368 с.
2. Измерения в промышленности. Справочник в 3-х книгах. Пер. с нем./ Под ред. Профоса П. - М.: Металлургия, 1990. – 492, 384, 344 с.
3. Джексон, Р.Г. Новейшие датчики / Р.Г. Джексон, пер. с англ. под ред. В.В. Лучинина. – М.: Техносфера, 2007. – 384 с.
4. Котюк, А.Ф. Датчики в современных измерениях / А.Ф. Котюк. – М.: Радио и связь, 2006. – 96 с.
5. Фрайден, Дж. Современные датчики. Справочник / Дж. Фрайден, пер. с англ. под ред. Е.Л. Свинцова. – М.: Техносфера, 2005. – 592 с.
6. Справочник инженера по контрольно-измерительным приборам и автоматике: учебно-практическое пособие / Н.В. Уваров, В.В. Дойников, под ред. А.В. Калиниченко. – М.: Инфра-Инженерия, 2008. – 576 с.